Center for Research and Exploration in Space Science and Technology (CRESST)
NNGO6EO90A

Quarterly Technical Report (Year 11)

For the 2nd Quarter Ending 4/30/17

Submitted to the NASA/Goddard Space Flight Center

Lakeshia Robinson, Grants Officer &
Frank Marshall, Cooperative Agreement Technical Officer

By the CRESST Team:
University of Maryland, College Park
University of Maryland, Baltimore County, and
The Universities Space Research Association

Dr. Lee Mundy
Director

April 28, 2017
Date

CRESST 2nd Quarter Technical Report (Year 11)

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EXECUTIVE SUMMARY

This is the second quarter technical report for the 11th year of CRESST. Funding for this quarter was in-line with the expectations of the extension proposal. Changes in funding of tasks drove some changes in personnel. Throughout the quarter, CRESST scientists contributed to the instrumental and science activities at Goddard, contributed to a number of Goddard PI-led proposals, and submitted a number of CRESST PI proposals.

Outstanding accomplishments this quarter include:

- 70 refereed papers were authored or co-authored by CRESST scientists.
- 1 science proposal was awarded funding in the quarter. CRESST scientists participated in 49 submitted grant/observing proposals during the quarter.
- A deep search for volcanic gases (OCS and SO2) in the atmosphere of Mars by Dr. Khayat and colleagues yielded a strong upper limit of the absence of these molecules and hence an upper limit on current volcanic activity on Mars. There is no evidence for major volcanic outgassing on current Mars, which implies little current atmosphere production on Mars.
- Work continues on the successful LISA pathfinder mission. Dr. Slutsky is utilizing existing data to characterize the thruster systems and plan experiments for the remaining extended mission timeline. The results from this mission are fundamental to the design of the full LISA mission to come.
- The Cassini spacecraft is entering the final phase of its 13 year mission as it prepares to dive through the gap in the rings of Saturn. Cassini and its Huygens probe have provided incredible pictures and scientific results for Saturn and Saturn's moon Titan. The plan is for the spacecraft to dive through the rings 22 times and then plunge into Saturn's atmosphere. The "up-close" encounter with the rings will provide an entirely new level of details on the ring structure and composition.
- The loss of the Hitomi spacecraft was a tragedy for science. CRESST scientists, Drs. Harrus, Lowenstein, Yamaguchi, and Yaqoob, support calibration and publication of the limited data that were obtained before the loss. These data show what could have been the amazing success of this mission, and have motivated JAXA and NASA to move forward with planning for a "recovery" mission: a re-plan and launch of a spacecraft to "recover" the lost science. Dr. Soong is working in the lab on improving mirror surface quality in preparation fabricating two mirrors for the "recovery" mission.

The body of this report is organized into sections following the structure of the Annual Research Program Plan for Year Ten, as presented to NASA/GSFC on July 31, 2015, and modified by our "extension proposals." The science is organized into the sections and sub-sections set out in that Research Program Plan and refer to the milestones therein. The activities of the individual scientists are presented in paragraphs within the sections appropriate to their science.

Brief Summary of Activities & Progress on Milestones:

CRESST scientists obtained and analyzed data, and published papers utilizing a broad range of space and ground-based instrumentation including Cassini, Chandra, Fermi, HST, INTEGRAL, LIGO, LRO, MAVEN, MLS, NuSTAR, SuperTIGER, Suzaku, Swift, and XMM-Newton. Our scientists contributed as lead authors or co-authors to 70 refereed papers and 9 Astronomy Telegrams or similar circulars.

In terms of programmatic activities, CRESST scientists contributed to, for example:

- The Swift Science Support Center
- The HEASARC
- Education and public outreach for the HEASARC, and the ASD overall
- Swift operations
- Development and characterization of Gamma-ray and X-ray detectors
- Development and testing of X-ray mirrors and lenses
- Support of the Fermi LAT instrument
- Support for the continuing development of the NICER mission
- Post-launch activities for JAXA Hitomi mission
- Fermi Science Support Center
- Cassini CIRS instrument support
- Support for the SAM instrument on MSL

Significant progress was made toward the following CRESST milestones in the year ten annual research program plan during this quarter:

Detector Development: (660.002)
Continued development of diffractive X-ray/Gamma-ray optics
Collaborating on building prototype counters for the NICHE Array
Swift/MIDEX: (661.011)
Continued work on spectral analysis of GRBs
RIMAS instrument integration and testing in the lab is continuing
Continue to support daily operation of BAT GRB processing
Exploring improvements in GRB detection capability
Various research projects using BAT data continuing
BESS: (661.028)
Continued work on BESS data and instrument
AdEPT: (661.029)
Working on development of front-end electronics for AdEPT detectors
Developing algorithms for track recognition in AdEPT
Swift/Fermi Research: (661.030)
Continued preparation for possible Swift follow-ups on LIGO detections

Research continued on gamma-ray loud southern hemisphere AGNs

Fermi LAT: (661.032)

Continued support of Fermi LAT Anti-coincidence system
Continued research on gamma-ray burst sources
Continued work on measurements of cosmic ray protons with the LAT
Discovered spatially extended gamma-ray emission from Fornax A

Cosmic Ray Balloon Program: (661.036)

Testing Super TIGER electronics
Analyzing SuperTIGER-1 data
Continue work on measuring ultra-heavy cosmic ray composition

CALET: (661.037)

Participating in various modeling & simulation projects
Participated in CALET telecons and Skype meetings
Developing framework for calibration software

ISS – Cream: (661.041)

Contributed to instrument description paper
Worked on documentation for instrument
Began work on data analysis software

ComPair APRA (661.047)

Worked on science case for mission
Developing calorimeter detector in collaboration with Brookhaven

Fast Radio Bursts (661.048)

Working on identifying high-energy counterparts to Fast Radio Bursts

Next Generation X-ray Optics: (662.002)

Continued development of lightweight, high-throughput X-ray optics
Demonstrated lightweight single crystal silicon mirror fabrication concept

X-ray Binaries (662.030)

Paper on long thermonuclear helium flash accepted for publication
Contributed to several other papers
PI on NuSTAR proposal
Contributed to science case for STROBE-X Probe proposal

X-ray Spectroscopy: (662.031)

Characterizing TES arrays geared for Athena X-ray Observatory
Continued development of multiplexed readout for TES arrays
Continue work and testing of the EBIT TEMS platform

Atomic Data for Photoionized Plasma (662.033)

Paper submitted on MHD simulations of AGN torus
Started work to include self-gravity in AGN accretion disk code

UV, X-ray and Gamma Ray Data Analysis: (662.034)

Submitted observing proposals for NuSTAR and Chandra
Submitted major paper on modeling of Chandra X-ray spectra of 14 X-ray binaries
Working on analysis of NuSTAR data for nearby galaxies

Astro-H SEO Data Center: (662.036)

Continued work with Software and Calibration Team for Hitomi
Supported SXS instrument team and science teams working with limited data
Supported Hitomi Science Data Center
Collaborated with Japanese colleagues on aspects of data, software, and hardware

Completed invited review paper on X-ray emission from accreting white dwarfs
Continued research on a range of high energy data

Soft X-ray Instrumentation: (662.037)
Continued analysis of 2015 DXL flight
Working on measuring PSF of “lobster eye” optic for DXL sounding rocket mission

X-Ray Optics R&D for Flight Projects: (662.038)
Working on multi-layer coatings onto Silicon wafers

NuSTAR: (662.039)
Preparing for NuSTAR Cycle 3 peer review
Worked on NuSTAR webpages and attended support telecons
Conducted research on X-ray binaries with multiple high energy observatories
Involved in a number of projects utilizing NUSTAR data
Submitted observing proposals for NuSTAR and Fermi

NICER Background Simulations: (662.040)
Continued development of simulations of the NICER instrument
Continuing development of MGEANT-based models of the NICER background radiation
Studying instrument response function and data analysis methodologies

Astro-H Science Support: (662.042)
Working on reducing optics error level in Soft X-ray telescopes based on Astro-H design
Continue maintenance and development of X-ray calibration sources
Participating in data analysis for Hitomi
Working on X-ray mirrors in preparation for ASTRO-H “recovery” mission.

NICER Science Support: (662.043)
Participated as member of science team “General Observatory” Working Group
Continued work in characterizing diffuse astrophysical background

PCOS Science Support: (662.045)
Continued research in X-ray binaries in low metallicity star-forming galaxies

Suzaku Source Catalog: (662.046)
No activity reported this quarter

Gravitational Relativity: (663.002)
Continued studies of supermassive black holes and binary black hole mergers

LISA Pathfinder & LISA Instrument Characteristics: (663.006)
Analyzing data from LISA Pathfinder initial mission
Planning experiments for Pathfinder extended mission
Continued a range of collaborative activities with JPL and European colleagues

Pulsar Pair Cascades: (663.007)
Continued work on pulsar magnetosphere models

Gravitational Wave Technology Support: (663.008)
Worked on design, prototyping and testing of optical telescope for eLISA mission
Testing confirming that prototype telescope meets wave front specifications

Laboratory Support for MAHI (663.009)
Investigated sources of noise in MAHI
Preparing MAHI system for vacuum operations

CMB Polarization: (665.006)
Continued work on adiabatic demagnetization refrigerator
Began developing mirror transport system
Working the thermal mitigation electronics

Working on papers related to PIXIE and thermal dust

Cosmic Evolution of Dust: (665.010)

Conducted research on supernova remnants

Far Infrared Interferometry, Instrumentation, and Astrophysics: (665.012)

Collaborating with WFIRST to fly H4RG detectors on future BETTII flight

Repaired dewar

Tested detector arrays

Working on improvements to BETTII in preparation for June 2017 flight

Development of Large Format Arrays for Astrophysics Instrumentation: (665.014)

Continued work on fabrication of fine wire metallic magnetic calorimeter devices\

Performed test on detectors for Euclid mission

GALEX, Spitzer, and FUSE Analysis: (665.015)

Worked on radio observations of UV-selected galaxies

Micro-X: (665.019)

Working on paper describing thermal models and results

Continued work on micro-spec instrument design and optimization

Euclid-LIBRAE: (665.020)

Working on IR and X-ray backgrounds and their cross-correlations

Completed validation of self-calibration procedure

HIRMES (665.022)

Developed design for instrument

Prepared for Preliminary Design Review

Worked on software for HIRMES data

WFIRST Science (665.023)

Developing Monte Carlo simulations for WFIRST science case

Optical/UV Detectors: (667.001)

No report on work under this task

Extrasolar Planetary Studies (667.004)

Completed equivalent width analysis for simulated WFIRST exoplanet data

WFIRST Microlensing (667.008)

Analyzing microlensing events

Developed new method for interpreting high angular resolution follow-up observations

Working on several papers on microlensing events

Co-leader of WFIRST Detector Requirements and Characterization Working Group

Visible Nulling Coronography (667.009)

Continued laboratory development of instrumentation

Submitted SAT/TCOR proposal

Fermi/SSC: (661.001)

Continued management support duties for Fermi Science Support Center

Continued support of FSSC operations, tools, and community access to Fermi data

Updated operations scripts and responded to help desk queries

Planning for shifting of duties as DOE ramps down funding in future

Oversaw science outreach and documentation

Continued conduct of research on a broad variety of Fermi datasets

Pursued radio observations to complement Fermi work on pulsars

Participated in NANOGrav collaboration

HEASARC: (662.007)
- Continued support of HEASARC archive and associated software
- Continued enhancement of database content and web information
- Continued maintenance and updating of the HEASARC calibration database (CALDB)
- Continued to write and maintain HEASARC Picture of the Week website
- Continued scientific research on a wide variety of topics
- Continued maintenance of INTEGRAL and NuSTAR public data archives
- Continued maintenance and upgrading of the XSPEC software package
- Published paper WR 140 long period massive binary system

Swift Science Center: (662.020)
- Updated documentation and webpages
- Served as burst advocate
- Supported Swift help-desk
- Continue research in GRBs utilizing a range of instruments

ASD Communications: (660.004)
- Continued to coordinate EPO activities for ASD Education and Communication Team
- Re-launching NASA Blueshift – NASA ASD's social media presence
- Supported ASD communication efforts

APOD: (662.032)
- Continued to create new Astronomy Picture of the Day pages and maintained archive

Heliophysics, Astrophysics and Solar System Education (670.009)
- Worked with the Heliophysics Education Consortium on content
- Updated Afterschool Universe curriculum support materials
- Updated NASA Family Science Night curriculum support materials
- Conducted workshop for educators

Solar Probe Plus: (672.004)
- Worked with Caltech collaborators and participated in telecons

SPASE Model Development: (690.004)
- Continued work on the Space Physics Archive Search and Extract (SPASE) project
- Continued work on Radio Jove education and outreach
- Interacting with Heliophysics Education Consortium on Radio Jove
- Preparing for observations of the Great American Eclipse Aug 21, 2017

DREAM, LRO, VISIONS Science: (691.003)
- Collecting data on desorption kinematics of water, carbon dioxide and argon
- Submitted two papers for publication
- Determining optical constants for HCNm C2N2m and HC3N thin-ice mixtures

Cassini CIRS: (693.001)
- Continued to monitor seasonal change on Saturn and Titan using Cassini CIRS
- Continued studies of Titan's atmosphere
- Continued support of CIRS operations

LRO/LEND Epithermal Neutron Flux Measurements: (693.002)
- Continuing work on exploration of hydrogen and water on the Moon
- Developing proposal for instrument as NASA contribution to Korean mission

Investigation of Exoplanet Atmospheres Using Keck: (693.003)
- Continuing work on super Earth 55 Cancri e and possible volcanic activity

Voyager IRIS Data Restoration: (693.004)

Submitted Space Smallsat Study proposal for Venus UV mapping spectrometer
Started work on design of an instrument to investigate water in Titan's stratosphere

Mars Atmosphere Radiative Transfer Modeling: (693.008)
Completed ground-based campaign studying volcanic gases in Mars atmosphere
Submitted paper with first results

Titan's Particulate & Thermal Properties: (693.010)
Investigating massive cloud system that has developed on Titan

Analysis of Solar Radio Emission and Plasma Waves: (695.001)
Investigating in-situ wave phenomena in vicinity of interplanetary shocks

Science Support for Particle and Soft X-ray Instrumentation: (695.002)
Worked on neutral atom imaging instrument for VISIONS II
Preparing to assemble and test detectors for instrument

Dust Scattering in the Lunar Exosphere: (695.003)
Continued simulations of light scattering by lunar exospheric dust
Paper submitted for publication

Juno and MAVEN Scientific Support: (695.005)
Analyzing magnetic field and plasma data to understand loss of Mars atmosphere
Expanding work to magnetospheres of Jupiter and Mercury
Continued work with and support of MAVEN magnetometer instrument team
Supporting data calibration and data quality control for Juno
Developing new tools for scientific analysis of MAG data

Analysis of LOLA, LRO, and GRAIL Data: (698.002)
Using tracking data from several missions to derive high resolution gravity field models
Co-author on publication about small-scale density variation at the Moon

Planetary Ocean Dynamics and Magnetics: (698.003)
No activity reported

Studies in Planetary Volcanology: (698.004)
Continued studies of volcanic deposit morphologies
Contributed to team developing LiDAR concept for landing on Europa
Submitted two proposals for new projects
Working on two papers

MOMA-MS: (699.001)
Submitted paper about LDI mode of MOMA instrument
Continued experiments to validate instrument concepts for SPECIES proposal
Supported integration and testing of MOMA mass spectrometer

SAM (699.002)
Supporting SAM instrument and MSL mission
Developing new protocols for analysis of heavy noble gases
Continuing to develop new protocols for noble gases
Analyzing data acquired with the quadrupole mass spectrometer (QMS)
Designing calibration experiments for SAM
Provided SAM instrument support and development of methodologies
Analyzing Mars analog materials relevant to interpreting MSL sample analysis

MATISSE/LTMS (699.003)
Working on Mars Organic Molecule Analyzer for ExoMars rover
Continuing development of AtmOMA prototype instrument

Working on developing miniature linear ion trap mass spectrometer (LITMS)
Developing next generation miniature ion trap mass spectrometer
Providing support for EMILI breadboard instrument
Collecting data on plasma recombination of C and N bearing species

MAVEN/NGIMS: (699.004)

Supporting operations of MAVEN
Producing data products for the NGIMS instrument on MAVEN
Improving process for creation of data products and documentation
Supporting NGIMS operations, software and real time data
Comparing data from similar instruments on MAVEN and MOM mission

Sellers Exoplanets Environment Center (699.005)

Continuing work on simulating presence of methane on Mars
Building atmosphere retrieval tools for future observations with JWST
Modeling the atmospheres of highly irradiated exoplanets in preparation for JWST
Working in simulations of methane and other trace gases in Martian atmosphere
Developing photochemical models to validate Mars photochemistry
Using 3-D climate models to determine the inner edge of the habitable zone
Co-authored two papers currently under review

Contributions to Meetings:

Special Projects Team supported 11 Astrophysics Science Division Colloquia, and 11 Goddard Scientific Colloquia.

Visitors:

During the first quarter, the CRESST Special Projects Team supported 36 visitor-related activities (relative to 44 the previous quarter) in addition to supporting ~ 15 continuing and new consultants, plus non-salaried scientists who received living allowances, visa and medical insurance support, etc.

Personnel Matters:

The CRESST staff experienced a few changes this quarter. Twelve scientists: Dr. Zaven Arzoumanian, Dr. Natalia Buzulukova, Dr. Heather Franz, Dr. Caroline Freissinet, Dr. Andrei Hanu, Dr. Gabrielle Hellio, Dr. Omid Noroozian, Dr. Daisuke Suzuki, Dr. Andrew W. Smith, Dr. Francesco Tombesi, Ms. Tomomi Watanabe, and Dr. Brian Williams resigned from CRESST during the quarter. One scientist: Dr. Regina Caputo joined CRESST during the quarter. There were also two graduate students, Alexander Walts and Michael Aitken that joined CRESST during the quarter.

CRESST Office at GSFC:

The CRESST office at GSFC operated well during the quarter. The Program Manager, Mr. Holdridge and the Program Coordinator, Ms. Peles, were on-site full time in the Bldg. 28 offices. The Business Manager, Ms. Benton, has still ably been keeping up with her responsibilities, utilizing a telecommuting arrangement. The Meeting Coordinator, Ms. Queen, also onsite in Bldg. 28, has been handling all meeting requirements as well as most all visitor/travel requirements for CRESST special projects. She is backed-up by USRA administrative staff members located at USRA headquarters.

CRESST PUBLICATIONS

Refereed Publications:

1. "A Massive Shell of Supernova-formed Dust in SNR G54.1+0.3"; Temim, T.; Dwek, E.; Arendt, R. G.; Borkowski, K. J.; Reynolds, S. P.; and 3 coauthors; 2/2017; 2017ApJ...836..129T.
2. "A Search for Blazar-Like Radio-Loud Narrow-Line Seyfert 1 Galaxies"; Miller, H.; Maune, J.; Eggen, J.; Turner, C.; Ferrara, E.; and 2 coauthors; 3/2017; 2017Galax...5...20M.
3. "A Search for Spectral Hysteresis and Energy-dependent Time Lags from X-Ray and TeV Gamma-Ray Observations of Mrk 421"; Abeysekara, A. U.; Archambault, S.; Archer, A.; Benbow, W.; Bird, R.; and 218 coauthors including Becerra Gonzalez, J.; 1/2017; 2017ApJ...834....2A.
4. "All-sky Search for Short Gravitational-wave Bursts in the first Advanced LIGO Run"; Abbott, B. P.; Abbott, R.; Abbott, T. D.; Abernathy, M. R.; Acernese, F.; and 983 coauthors including Davis, D. S.; Fulda, P. J.; 2/2017; 2017PhRvD..95d2003A.
5. "ALMA and RATIR Observations of GRB 131030A"; Huang, K.; Urata, Y.; Takahashi, S.; Im, M.; Yu, P.-C.; and 20 coauthors including Kutyrev, A. S.; Troja, E.; 1/2017; 2017PASJ..tmp..119H.
6. "Asymmetric Expansion of the Youngest Galactic Supernova Remnant G1.9+0.3"; Borkowski, K. J.; Gwynne, P.; Reynolds, S. P.; Green, D. A.; Hwang, U.; Petre, R.; Willett, R.; 3/2017; 2017ApJ...837L...7B.
7. "Automated Force-free Flux Rope Identification"; Smith, A. W.; Slavin, J. A.; Jackman, C. M.; Fear, R. C.; Poh, G.-K.; and 3 coauthors including DiBraccio, G. A.; 1/2017; 2017JGRA..122..780S.
8. "Binary Source Microlensing Event OGLE-2016-BLG-0733: Interpretation of a Long-term Asymmetric Perturbation"; Jung, Y. K.; Udalski, A.; Yee, J. C.; Sumi, T.; Gould, A.; and 53 coauthors including Bennett, D. P.; Bhattacharya, A.; Suzuki, D.; Koshimoto, N.; 3/2017; 2017AJ....153..129J.
9. "Broad-lined Supernova 2016coi with a Helium Envelope"; Yamanaka, M.; Nakaoka, T.; Tanaka, M.; Maeda, K.; Honda, S.; and 36 coauthors including Suzuki, D.; 3/2017; 2017ApJ...837....1Y.
10. "Challenging the Forward Shock Model with the 80 Ms Follow up of the X-ray Afterglow of Gamma-Ray Burst 130427A"; De Pasquale, M.; Page, M.; Kann, D.;

Oates, S.; Schulze, S.; and 10 coauthors including Troja, E.; 1/2017; 2017Galax...5....6D.

11. “Chandra Reveals Heavy Obscuration and Circumnuclear Star Formation in Seyfert 2 Galaxy NGC 4968”; LaMassa, S. M.; Yaqoob, T.; Levenson, N. A.; Boorman, P.; Heckman, T. M.; and 4 coauthors; 1/2017; 2017ApJ...835...91L.
12. “Characterization of Turbulence in the Mars Plasma Environment with MAVEN Observations”; Ruhunusiri, S.; Halekas, J. S.; Espley, J. R.; Mazelle, C.; Brain, D.; and 7 coauthors including DiBraccio, G. A.; 1/2017; 2017JGRA..122..656R.
13. “Comparative Study of the Martian Suprathermal Electron Depletions Based on Mars Global Surveyor, Mars Express, and Mars Atmosphere and Volatile EvolutioN Mission Observations”; Steckiewicz, M.; Garnier, P.; André, N.; Mitchell, D. L.; Andersson, L.; and 14 coauthors including Soobiah, Y. I.; 1/2017; 2017JGRA..122..857S.
14. “Comparing Submillimeter Polarized Emission with Near-infrared Polarization of Background Stars for the Vela C Molecular Cloud”; Santos, F. P.; Ade, P. A. R.; Angilè, F. E.; Ashton, P.; Benton, S. J.; and 25 coauthors including Thomas, N. E.; 3/2017; 2017ApJ...837..161S.
15. “Cyclotron Resonant Scattering Feature Simulations. I. Thermally Averaged Cyclotron Scattering Cross Sections, Mean Free Photon-path Tables, and Electron Momentum Sampling”; Schwarm, F.-W.; Schönherr, G.; Falkner, S.; Pottschmidt, K.; Wolff, M. T.; and 9 coauthors including Marcu-Cheatham, D. M.; 1/2017; 2017A&A...597A...3S.
16. “Development of a Multi-element Microdosimetric Detector Based on a Thick Gas Electron Multiplier”; Anjomani, Z.; Hanu, A. R.; Prestwich, W. V.; Byun, S. H.; 3/2017; 2017NIMPA.847..117A.
17. “Environmental Temperature Effect on the Far-infrared Absorption Features of Aromatic-based Titan’s Aerosol Analogs”; Gautier, T.; Trainer, M. G.; Loeffler, M. J.; Sebree, J. A.; Anderson, C. M.; 01/17; 2017Icar..281..338G.
18. “Exploring the Sensitivity of Next Generation Gravitational Wave Detectors”; Abbott, B. P.; Abbott, R.; Abbott, T. D.; Abernathy, M. R.; Ackley, K.; and 718 coauthors including Fulda, P. J.; 2/2017; 2017CQGra..34d4001A.
19. “Feeding and Feedback in the Powerful Radio Galaxy 3C 120”; Tombesi, F.; Mushotzky, R. F.; Reynolds, C. S.; Kallman, T.; Reeves, J. N.; and 6 coauthors including Leutenegger, M. A.; Williams, B. J.; 3/2017; 2017ApJ...838...16T.
20. “Fermi-LAT Observations of High-energy Behind-the-limb Solar Flares”; Ackermann, M.; Allafort, A.; Baldini, L.; Barbiellini, G.; Bastieri, D.; and 84 coauthors including Troja, E.; Magill, J. D.; 2/2017; 2017ApJ...835..219A.

21. “First Multi-wavelength Campaign on the Gamma-ray-loud Active Galaxy IC 310”; Ahnen, M. L.; Ansoldi, S.; Antonelli, L. A.; Arcaro, C.; Babic, A.; and 158 coauthors including Magill, J. D.; Becerra Gonzalez, J.; 3/2017; 2017arXiv170307651A (Accepted for publication in A&A).
22. “Gamma-Ray Blazars within the First 2 Billion Years”; Ackermann, M.; Ajello, M.; Baldini, L.; Ballet, J.; Barbiellini, G.; and 121 coauthors including Green, D.; Troja, E.; Ojha, R.; Magill, J. D.; Ferrara, E. C.; Becerra Gonzalez, J.; 3/2017; 2017ApJ...837L...5A.
23. “Global Distribution and Parameter Dependences of Gravity Wave Activity in the Martian Upper Thermosphere Derived from MAVEN/NGIMS Observations”; Terada, N.; Leblanc, F.; Nakagawa, H.; Medvedev, A. S.; Yigit, E.; and 11 coauthors including Elrod, M.; Benna, M.; 2/2017; 2017JGRA..122.2374T.
24. “He Bulge Revealed: He and CO_2 Diurnal and Seasonal Variations in the Upper Atmosphere of Mars as Detected by MAVEN NGIMS”; Elrod, M. K.; Bougher, S.; Bell, J.; Mahaffy, P. R.; Benna, M.; and 3 coauthors; 2/2017; 2017JGRA..122.2564E.
25. “Hitomi Constraints on the 3.5 keV Line in the Perseus Galaxy Cluster”; Aharonian, F. A.; Akamatsu, H.; Akimoto, F.; Allen, S. W.; Angelini, L.; and 213 coauthors including Arnaud, K. A.; Hamaguchi, K.; Krimm, H. A.; Loewenstein, M.; Leutenegger, M. A.; Mori, H.; Mukai, K.; Pottschmidt, K.; Sakai, K.; Soong, Y.; Tombesi, F.; Yaqoob, T.; Yamaguchi, H.; Williams, B J.; 3/2017; 2017ApJ...837L..15A.
26. “Hydrogen Distribution in the Lunar Polar Regions”; Sanin, A. B.; Mitrofanov, I. G.; Litvak, M. L.; Bakhtin, B. N.; Bodnarik, J. G.; and 15 coauthors including Livengood, T. A.; 2/2017; 2017Icar..283...20S.
27. “Identification of the Hard X-Ray Source Dominating the E > 25 keV Emission of the Nearby Galaxy M31”; Yukita, M.; Ptak, A.; Hornschemeier, A. E.; Wik, D.; Maccarone, T. J.; and 13 coauthors including Lien, A. Y.; Pottschmidt, K.; Williams, B. J.; 3/2017; 2017ApJ...838...47Y.
28. “IGR J17062--6143 Is an Accreting Millisecond X-Ray Pulsar”; Strohmayer, T. E.; Keek, L.; 2/2017; 2017ApJ...836L..23S.
29. “Insight Into "Changing-Look" AGN Mrk 1018 from the Fe Kα Line: The Reprocessing Gas Has Yet to Fully Respond to the Fading of the AGN”; LaMassa, S. M.; Yaqoob, T.; Kilgard, R.; 3/2017; 2017arXiv170307410L (accepted for publication in ApJ).
30. “Longitudinal Structures in Mars' Upper Atmosphere as Observed by MAVEN/NGIMS”; Liu, G.; England, S.; Lillis, R. J.; Mahaffy, P. R.; Elrod, M.; Benna, M.; Jakosky, B.; 1/2017; 2017JGRA..122.1258L.

31. “Luminosity-dependent Changes of the Cyclotron Line Energy and Spectral Hardness in Cep X-4”; Vybornov, V.; Klochkov, D.; Gornostaev, M.; Postnov, K.; Sokolova-Lapa, E.; and 3 coauthors including Pottschmidt, K.; 2/2017; 2017arXiv170206361V (accepted for publication in A&A).
32. “MAGIC Detection of Very High Energy Gamma-ray Emission from the Low-luminosity Blazar 1ES 1741+196”; MAGIC Collaboration; Ahnen, M. L.; Ansoldi, S.; Antonelli, L. A.; Antoranz, P.; and 157 coauthors including Becerra Gonzalez, J.; 2/2017; 2017arXiv170206795M (Accepted for publication in MNRAS).
33. “Magnetic Origin of Black Hole Winds Across the Mass Scale”; Fukumura, K.; Kazanas, D.; Shrader, C.; Behar, E.; Tombesi, F.; Contopoulos, I.; 3/2017; 2017NatAs...1E..62F.
34. “MAVEN NGIMS Observations of Atmospheric Gravity Waves in the Martian Thermosphere”; England, S. L.; Liu, G.; Yigit, E.; Mahaffy, P. R.; Elrod, M.; Benna, M.; and 3 coauthors; 2/2017; 2017JGRA..122.2310E.
35. “MAVEN Observations of a Giant Ionospheric Flux Rope near Mars Resulting from Interaction Between the Crustal and Interplanetary Draped Magnetic Fields”; Hara, T.; Brain, D. A.; Mitchell, D. L.; Luhmann, J. G.; Seki, K.; and 11 coauthors including DiBraccio, G. A.; 1/2017; 2017JGRA..122..828H.
36. “MAVEN Observations of Dayside Peak Electron Densities in the Ionosphere of Mars”; Vogt, M. F.; Withers, P.; Fallows, K.; Andersson, L.; Girazian, Z.; and 12 coauthors including Benna, Mehdi; Elrod, Meredith K.; 1/2017; 2017JGRA..122..891V.
37. “MAVEN Observations on a Hemispheric Asymmetry of Precipitating Ions Toward the Martian Upper Atmosphere According to the Upstream Solar Wind Electric Field”; Hara, T.; Luhmann, J. G.; Leblanc, F.; Curry, S. M.; Seki, K.; and 8 coauthors including DiBraccio, G. A.; 1/2017; 2017JGRA..122.1083H.
38. “Mercury's Cross-tail Current Sheet: Structure, X-line Location and Stress Balance”; Poh, G.; Slavin, J. A.; Jia, X.; Raines, J. M.; Imber, S. M.; and 5 coauthors including DiBraccio, Gina A.; 1/2017; 2017GeoRL..44..678P.
39. “Multiband Observations of the Quasar PKS 2326--502 during Active and Quiescent Gamma-Ray States in 2010--2012”; Dutka, M. S.; Carpenter, B. D.; Ojha, R.; Finke, J. D.; D'Ammando, F.; and 10 coauthors; 2/2017; 2017ApJ...835..182D.
40. “Nanograin Density Outside Saturn's A Ring”; Johnson, R. E.; Tseng, W.-L.; Elrod, M. K.; Persoon, A. M.; 1/2017; 2017ApJ...834L...6J.
41. “Observations of M31 and M33 with the Fermi Large Area Telescope: A Galactic Center Excess in Andromeda?”; Ackermann, M.; Ajello, M.; Albert, A.; Baldini, L.; Ballet, J.; and 101 coauthors including Green, D.; Troja, E.; Caputo, R.; 2/2017; 2017ApJ...836..208A.

42. “OGLE-2012-BLG-0950Lb: The First Planet Mass Measurement from Only Microlens Parallax and Lens Flux”; Koshimoto, N.; Udalski, A.; Beaulieu, J. P.; Sumi, T.; Bennett, D. P.; and 40 coauthors including Bhattacharya, A.; Suzuki, D.; 1/2017; 2017AJ....153....1K.
43. “Optical/UV-to-X-Ray Echoes from the Tidal Disruption Flare ASASSN-14li”; Pasham, D. R.; Cenko, S. B.; Sadowski, A.; Guillochon, J.; Stone, N. C.; and 2 coauthors including Cannizzo, J. K.; 3/2017; 2017ApJ...837L..30P.
44. “Photometric Observations of Supernova 2013cq Associated with GRB 130427A”; Becerra, R. L.; Watson, A. M.; Lee, W. H.; Fraija, N.; Butler, N. R.; and 16 coauthors including Kutyrev, A. S.; Troja, E.; 3/2017; 2017ApJ...837..116B.
45. “Probing the Magnetic Field Structure in Sgr A* on Black Hole Horizon Scales with Polarized Radiative Transfer Simulations”; Gold, R.; McKinney, J. C.; Johnson, M. D.; Doeleman, S. S.; 3/2017; 2017ApJ...837..180G.
46. “Resolved, Expanding Jets in the Galactic Black Hole Candidate XTE J1908+094”; Rushton, A. P.; Miller-Jones, J. C. A.; Curran, P. A.; Sivakoff, G. R.; Rupen, M. P.; and 13 coauthors including Krimm, H. A.; 3/2017; 2017arXiv170302110R (accepted in MNRAS).
47. “Search for Cosmic-Ray Electron and Positron Anisotropies with Seven Years of Fermi Large Area Telescope Data”; Abdollahi, S.; Ackermann, M.; Ajello, M.; Albert, A.; Atwood, W. B.; and 90 coauthors including Moiseev, A. A.; Green, D.; Magill, J. D.; Troja, E.; 3/2017; 2017PhRvL.118i1103A.
48. “Searching the Gamma-Ray Sky for Counterparts to Gravitational Wave Sources: /Fermi GBM and LAT Observations of LVT151012 and GW151226”; Racusin, J. L.; Burns, E.; Goldstein, A.; Connaughton, V.; Wilson-Hodge, C. A.; and 139 coauthors including Ferrara, E. C.; Green D.; Magill, J. D.; Troja, E.; Caputo, R.; 1/2017; 2017ApJ...835...82R.
49. “Summary of the Results from the Lunar Orbiter Laser Altimeter after Seven Years in Lunar Orbit”; Smith, D. E.; Zuber, M. T.; Neumann, G. A.; Mazarico, E.; Lemoine, F. G.; and 22 coauthors including Goossens, S. J.; 2/2017; 2017Icar..283...70S.
50. “Suzaku and Chandra Observations of CIZA J1700.8-3144, A Cluster of Galaxies in the Zone of Avoidance”; Mori, H.; Maeda, Y.; Ueda, Y.; Nakazawa, K.; Tawara, Y.; 2/2017; 2017PASJ...69....3M.
51. “Swift Monitoring of NGC 4151: Evidence for a Second X-ray/UV Reprocessing”; Edelson, R.; Gelbord, J.; Cackett, E.; Connolly, S.; Done, C.; and 39 coauthors including Krimm, H. A.; 3/2017; 2017arXiv170306901E (To appear in ApJ April 2017).

52. “Testing the Universality of the Stellar IMF with Chandra and HST”; Coulter, D. A.; Lehmer, B. D.; Eufrasio, R. T.; Kundu, A.; Maccarone, T.; and 6 coauthors including Basu-Zych, A.; 2/2017; 2017ApJ...835..183C.

53. “The 2014 X-Ray Minimum of eta Carinae as Seen by Swift”; Corcoran, M. F.; Liburd, J.; Morris, D.; Russell, C. M. P.; Hamaguchi, K.; and 8 coauthors; 3/2017; 2017ApJ...838...45C.

54. “The Candidate Progenitor of the Type IIn SN 2010jl Is Not an Optically Luminous Star”; Fox, O. D.; Van Dyk, S. D.; Dwek, E.; Smith, N.; Filippenko, A. V.; and 6 coauthors including Arendt, Richard G.; 2/2017; 2017ApJ...836..222F.

55. “The Chandra Deep Field-South Survey: 7 Ms Source Catalogs”; Luo, B.; Brandt, W. N.; Xue, Y. Q.; Lehmer, B.; Alexander, D. M.; and 21 coauthors including Basu-Zych, A. R.; 1/2017; 2017ApJS..228....2L.

56. “The High-Eddington NLS1 Ark 564 has the Coolest Corona”; Kara, E.; Garcia, J. A.; Lohfink, A.; Fabian, A. C.; Reynolds, C. S.; and 2 coauthors including Tombesi, F.; 3/2017; 2017arXiv170309815K (Accepted to MNRAS).

57. “The Implications of Tides on the Mimas Ocean Hypothesis”; Rhoden, A. R.; Henning, W.; Hurford, T. A.; Patthoff, D. A.; Tajeddine, R.; 2/2017; 2017JGRE..122..400R.

58. “The Origin of the Iron-rich Knot in Tycho's Supernova Remnant”; Yamaguchi, H.; Hughes, J. P.; Badenes, C.; Bravo, E.; Seitenzahl, I. R.; and 3 coauthors; 1/2017; 2017ApJ...834..124Y.

59. “The Statistical Mechanics of Solar Wind Hydroxylation at the Moon, within Lunar Magnetic Anomalies, and at Phobos”; Farrell, W. M.; Hurley, D. M.; Esposito, V. J.; McLain, J. L.; Zimmerman, M. I.; 1/2017; 2017JGRE..122..269F.

60. “The Structure and Variability of Mars Dayside Thermosphere from MAVEN NGIMS and IUVS Measurements: Seasonal and Solar Activity Trends in Scale Heights and Temperatures”; Bougher, S. W.; Roeten, K. J.; Olsen, K.; Mahaffy, P. R.; Benna, M.; and 8 coauthors including Elrod, M.; 1/2017; 2017JGRA..122.1296B.

61. “The Structure of the Local Hot Bubble”; Liu, W.; Chiao, M.; Collier, M. R.; Cravens, T.; Galeazzi, M.; and 12 coauthors including Thomas, N. E.; 1/2017; 2017ApJ...834...33L.

62. “Thermonuclear Burst Observations for Model Comparisons: A Reference Sample”; Galloway, D. K.; Goodwin, A. J.; Keek, L.; 3/2017; 2017arXiv170307485G (accepted by PASA).

63. “Uniform Contribution of Supernova Explosions to the Chemical Enrichment of Abell out to R_{200}”; Ezer, C.; Bulbul, E.; Ercan, E. N.; Smith, R. K.; Bautz, M. W.; Loewenstein, M.; and 2 coauthors; 2/2017; 2017ApJ…836..110E.
64. “Variations of the Martian Plasma Environment during the ICME Passage on 8 March 2015: A Time-dependent MHD Study”; Ma, Y. J.; Russell, C. T.; Fang, X.; Dong, C. F.; Nagy, A. F.; and 10 coauthors including Benna, M.; 2/2017; 2017JGRA..122.1714M.
65. “Very-high-energy Gamma-ray Observations of the Type Ia Supernova SN 2014J with the MAGIC Telescopes”; MAGIC Collaboration; Ahnen, M. L.; Ansoldi, S.; Antonelli, L. A.; Antoranz, P.; and 147 coauthors including Becerra Gonzalez, J.; 2/2017; 2017arXiv170207677M (Accepted for publication in A&A).
66. “VizieR Online Data Catalog: Planck Catalogue of Galactic Cold Clumps (PGCC) (Planck+, 2016)”; Planck Collaboration; Ade, P. A. R.; Aghanim, N.; Arnaud, M.; Ashdown, M.; and 219 coauthors including Jaffe, T. R.; 1/2017; 2017yCat..35940028P (Originally published in: 2016A&A...594A..28P).
67. “VizieR Online Data Catalog: Planck Sunyaev-Zeldovich Sources (PSZ2) (Planck+, 2016)”; Planck Collaboration; Ade, P. A. R.; Aghanim, N.; Arnaud, M.; Ashdown, M.; and 255 coauthors including Jaffe, T. R.; 1/2017; 2017yCat..35940027P (Originally published in: 2016A&A...594A..27P).
68. “VizieR Online Data Catalog: Second Planck Catalogue of Compact Sources (PCCS2) (Planck+, 2016)”; Planck Collaboration; Ade, P. A. R.; Aghanim, N.; Argueso, F.; Arnaud, M.; and 238 coauthors including Jaffe, T. R.; 1/2017; 2017yCat..35940026P (Originally published in: 2016A&A...594A..26P).
69. “X-ray Emissions from Accreting White Dwarfs: a Review”; Mukai, K.; 3/2017; 2017arXiv170306171M (an invited review for Publications of the Astronomical Society of the Pacific (accepted)).
70. “X-Ray Reflection and an Exceptionally Long Thermonuclear Helium Burst from IGR J17062-6143”; Keek, L.; Iwakiri, W.; Serino, M.; Ballantyne, D. R.; in't Zand, J. J. M.; Strohmayer, T. E.; 2/2017; 2017ApJ...836..111K.

NON-Refereed Articles and Proceedings:

1. “Be-Phenomenon in Neutron Star X-ray Binaries”; Kühnel, M.; Kretschmar, M. K. P.; Fürst, F.; Pottschmidt, K.; Hemphill, P.; and 4 coauthors; 2/2017; 2017ASPC..508..385K (The B[e] Phenomenon: Forty Years of Studies. Proceedings of a Conference held at Charles University, Prague, Czech Republic 27 June - 1 July 2016).
2. “Molecular Analyzer for Complex Refractory Organic-rich Surfaces (MACROS)”; Getty, S.; **Li**, **X.;** Grubisic, A.; Cornish, T.; Elsila, J.; and 4 coauthors; 3/2017; IEEE

Aerospace Conference 2017 (3rd International Workshop on Instrumentation for Planetary Mission, held 24-27 October, 2016).

3. “SIRENA Software for Athena X-IFU Event Reconstruction”; Ceballos, M. T.; Cobo, B.; Peille, P.; Wilms, J.; Brand, T.; and 3 coauthors including Smith, S. J.; 3/2017; 2017hsa9.conf..703C (Highlights on Spanish Astrophysics IX, Proceedings of the XII Scientific Meeting of the Spanish Astronomical Society held on July 18-22, 2016).

A-Tels, IAUs, and Circulars: IN CARS

1. “Confirmation with the SALT Telescope of a Young Type Ia Supernova at z=0.046 Discovered During the "Deeper Wider Faster" Program”; Andreoni, I.; Cooke, J.; Pritchard, T. A.; Kotze, M.; Miszalski, B.; and 50 coauthors including Lien, A. Y.; 2/2017; 2017ATel10078....1A.
2. “Discovery of 4 Possible Supernovae During the "Deeper, Wider, Faster" Program Observations”; Andreoni, I.; Cooke, J.; Pritchard, T. A.; Spiewak, R.; Plant, K.; and 49 coauthors including Lien, A. Y.; 2/2017; 2017ATel10072....1A.
3. “Dramatic Change in the X-ray Spectrum of Symbiotic Recurrent Nova T CrB”; Luna, G. J. M.; Mukai, K.; Sokoloski, J. L.; Lucy, A.; Nelson, T.; Nunez, N.; 2/2017; 2017ATel10046....1L.
4. “Fermi LAT Detection of a New Gamma-ray Source Fermi J0713+5739”; Carpenter, B.; Ojha, R.; 3/2017; 2017ATel10149....1C.
5. “Fermi LAT Detection of an Increase in Gamma-ray Activity of the FSRQ S5 1044+71”; Ojha, R.; Carpen, B.; 1/2017; 2017ATel.9928....1O.
6. “MAXI J1807+132: Swift/XRT Localization”; Kennea, J. A.; Evans, P. A.; Beardmore, A. P.; Krimm, H. A.; Romano, P.; and 3 coauthors; 3/2017; 2017ATel10215....1K.
7. “MAXI J1807+132: UV/Optical Counterpart, Further XRT Observations”; Kennea, J. A.; Siegel, M. H.; Evans, P. A.; Beardmore, A. P.; Krimm, H. A.; and 4 coauthors; 3/2017; 2017ATel10216....1K.
8. “Optical Flare Observed in the Flaring Gamma-ray Blazar S5 1044+71”; Pursimo, T.; Blay, P.; Telting, J.; Ojha, R.; 1/2017; 2017ATel.9956....1P.
9. “Swift XRT and UVOT Flares Accompany Brightest Ever Gamma-ray Flare of CTA 102”; Ojha, R.; Carpenter, B.; D'Ammand, F.; 1/2017; 2017ATel.9924....1O.

CRESST RESEARCH & PROGRAM REPORTS

Astroparticle Physics

Detector Development (660.002)

Dr. John Krizmanic continued his research on developing diffractive X-ray/gamma-ray Phase Fresnel Lenses (PFLs) and related technologies. During the past quarter, activities included working with Mr. Neerav Shah (Code 591) and Prof. Steve Stochaj (New Mexico State University) on activities under the funded EPSCoR proposal entitled "Virtual Telescope for X-ray Observations" (Prof. Patricia Hynes, NMSU, PI). The proposal is focused on developing a formation-flying CubeSat mission using PFLs in the virtual X-ray telescope. Dr. Krizmanic and Mr. Shah are the GSFC 'NASA partners' on the VTXO proposal, and Dr. Krizmanic is the lead on the X-ray telescope development. In the past quarter, Dr. Krizmanic continued to work with the team to define the internships for the summer of 2017 and provided input to NMSU students working on VTXO, particularly regards the X-ray telescope development. Regarding PFL development, Dr. Krizmanic worked with Dr. Mahmooda Sultana (Code 553) to discuss with Northeastern University the test results regarding an initial array of PFLs developed with nano-fabrication techniques at Northeastern University. The group decided that fabrication artifacts compromised the lens performance and detailed a work plan to assess the cause of the artifacts. This work is funded under a Center Innovation Fund (CIF) award led by Dr. Takashi Okajima.

Dr. Krizmanic continued his collaboration with Prof. Doug Bergman (University of Utah) and Prof. Yoshiki Tsunesada (Tokyo Tech) on developing prototype counters for the Non-Imaging CHErenkov (NICHE) Array. Activities in the past quarter involved participating in regular telecon discussions on the development effort and the design and test results from the prototype NICHE detectors, which are currently being fabricated at Utah. Dr. Krizmanic traveled to the University of Utah the week of March 6th to work on the hardware development while also giving the University of Utah Department of Physics and Astronomy colloquium on results from the CALorimetric Electron Telescope (CALET) experiment on the ISS.

On January 29 2017, Dr. Krizmanic also gave a presentation "The Non-Imaging CHErenkov (NICHE) Array: A TA/TALE extension using Cherenkov radiation to measure Cosmic Ray Composition to sub-PeV energies" at the 2017 APS April Meeting held in Washington, DC.

Dr. Krizmanic submitted an abstract "Prototype HNX/TIGERISS Silicon Strip Detector Response to Nuclei Measured in a Lead Test Beam" to the 2017 ICRC paper call. The paper discusses the 2016 CERN test beam experiment and results, and in particular, the results showing the resolution of the individual elements from carbon (Z=6) to lead (Z=82) in lead and lead-fragmenting beams. These results demonstrate that the HNX silicon strip detectors have the baseline performance needed for the HNX mission. Dr. Krizmanic was also an ad hoc reviewer for two NSF Particle Astrophysics proposals and a referee on a paper submitted to Advances in

Space Research. Dr. Krizmanic continues to serve as the 'custodian' of the GSFC High-Energy Cosmic Ray group while Dr. John Mitchell recovers from medical issues.

Swift/MIDEX (661.011)

Dr. Amy Lien continued to work on the joint spectral analysis of the GRBs detected by both the Swift/BAT and Suzaku/WAM, in collaboration with Drs. Hans Krimm and Kazutaka Yamaoka. Dr. Amy Lien and the intern, Austin Kim, have finished determining the criteria for systematic time interval selections. Dr. Amy Lien then implemented the criteria and finished making and fitting spectra for the WAM-BAT joint-trigger GRBs. Dr. Amy Lien presented the preliminary results at the WAM team meeting in the Nagoya University in late March, 2017.

Dr. Lien continued to work on the project led by Dr. Eleonora Troja to investigate the cosmic short GRB rate using the Swift/BAT trigger simulator. Dr. Amy Lien has finished further simulations using different input assumptions, and continued to investigate possible ways to improve this approximation. Dr. Lien continues to participate in the GRB rate project with Dr. John Baker and Anjali Mittu. Dr. Lien produced new sets of training data for the machine-learning algorithm. Dr. Lien continues to provide assistance to the project on fast radio bursts with Dr. Brad Cenko and Ginny Cunningham. Dr. Lien finished analyzing the data for FRB131104 for a cross-check with the results from the work of DeLaunay et al. (2016).

Dr. Lien participated in the BAT data analysis for the “Deeper, Wider, Faster” (DWF) astronomical survey, led by the team in Swinburne University of Technology in Australia. This survey is to search for transients with prompt multi-wavelength observations/follow-ups. Dr. Amy Lien participated in the observations of DWF in late January and early February. The observation was coordinated with Swift and many other ground-based observatories to search for coincidental detection of fast radio bursts. Dr. Lien also continued to assist with the BAT data analysis for the DWF joint observations, and to perform BAT data search for LIGO triggers, and published the results in team webpage and circulars. Furthermore, Dr. Lien continued to improve the script that automatically searches for BAT counterparts of transient discovered by other observatories (e.g., LIGO). Specifically, this script determines whether the BAT field of view overlaps with the field of view of the other instrument at any specific time, searches for possible detections of unknown sources in BAT data, and presents the summary result on a webpage. Dr. Lien continued to perform simulations of GRBs detected by the proposed new GRB mission, the Transient Astrophysics Observatory (TAO). She performed simulations using different input distributions of GRB properties, and with different telescope specs. For the task regarding the daily BAT GRB process, Dr. Lien continued to (1) maintain the auto-scripts used for prompt GRB analysis; (2) maintain the public BAT GRB website and keep the burst analysis result up-to-date; and (3) maintain the transient monitor scripts developed by Hans Krimm. In particular, Dr. Amy Lien finished the 2017 BAT Crab calibration analysis. The results are presented on the team webpage. Dr. Lien fixed some bugs in the transient monitor scripts and re-generated the results that were missing due to these bugs.

RIMAS (The Rapid IMAger-Spectrometer) is an instrument to quickly determine redshifts, followed by high resolution spectroscopic studies of gamma-ray burst (GRB) afterglow appearing in the near-infrared. Continuous operation will allow measurements beginning minutes

after the prompt emission. RIMAS is designed for use on the 4.3 meter Discovery Channel Telescope at Lowell observatory. The optical design has been developed and the fabrication of detectors and integration test is ongoing. Dr. Kenichi Sakai has worked with RIMAS since March of 2016. He contributed by writing a C++ server program for data acquisition (DAQ) and data storage on Linux. The program established the asynchronous communication between Windows 7 and Linux, and the DAQ was successfully performed with commands from the remote client. Regarding hardware, he concentrated on the design and assembly of the electronic box for controlling step motors. In fact, once the fabrication of the box was completed, he found a problem with drivers during stability testing. To reduce the power supply for the driver from the maximum of 24V to 12V, he re-designed the box while replacing the damaged drivers. The fabrication of the new box was almost done, and it was nearly ready to install. The four individual filter wheels and three focusing stages were controlled well by Arduino devices.

Dr. Alexander Kutyrev leads the RIMAS instrument development. The instrument has been tested for spectral performance with the low resolution and cross-disperser VPH gratings on a number of lab gas discharge sources. The baffles for the primary filter/gratings wheels have been designed and built. The data acquisition software in its full data acquisition configuration has been tested. The fabrication of the high-resolution grisms is in the process of the facility preparation. The instrument has been tested with all the primary filters, low-resolution YJ grating and the cross dispersing gratings for both arms. During the quarter, Dr. Kutyrev made a trip to the Lowell observatory to discuss the instrument installation issues on the telescope and the deployment plan.

BESS (661.028)

BESS (Balloon-borne Experiment with a Superconducting Spectrometer) measurements have defined the study of cosmic ray antiprotons and the search for cosmic ray antimatter. The most recent results on both, using data from BESS-Polar II, were published in Physical Review Letters (Abe, et al. 2011; 2012). Dr. Kenichi Sakai has performed analyses for precision measurement of the proton and helium fluxes. To optimize the measurement of the magnetic rigidity of incident particles, obtained from the curvature of their trajectories in a solenoidal magnetic field of 0.8 Tesla, an improved calibration of the central JET-type drift chamber and two inner drift chambers was developed by Dr. Sakai. The results of proton and helium measurements on BESS-Polar I and II were published in The Astrophysical Journal in 2016 (http://iopscience.iop.org/article/10.3847/0004-637X/822/2/65/meta). Astrophys.J. 822 (2016) no.2, 65 (2016-05-05) DOI: 10.3847/0004-637X/822/2/65. Dr. Sakai summarized the scientific results from BESS-Polar experiment including antiparticles and primary cosmic rays. The results were recently published in Advances in Space Research (http://dx.doi.org/10.1016/j.asr.2016.11.004). Since then, he has concentrated on calibrating a thin plastic scintillator middle-TOF (MTOF) hodoscope installed on the lower surface of the magnet bore to measure low-energy particles that cannot reach the LTOF. The MTOF further lowers the threshold energy to about 120 MeV for antiproton or proton measurements.

In this reporting period, Dr. Makoto Sasaki focused on other projects.

ADEPT (661.029)

At the request of Dr. Stan Hunter and due to financial issues, Dr. John Krizmanic's work on AdEPT was minimized during this past quarter.

In this reporting period, Dr. Makoto Sasaki worked on the development of the front-end electronics (FEE) board for the micro-well detector used in AdEPT. He has designed the FPGA for the FEE board and implemented it on the Spartan-6 FPGA SP601 Evaluation board, especially for a communication block in the FPGA to transfer the data through Ethernet.

Dr. Andrey Timokhin has been working on developing algorithms for track recognition in the AdEPT instrument. He was also working on predictions for detectability of polarization of gamma-radiation from pulsars.

Swift/Fermi Research (661.030)

Dr. John Cannizzo continued working with Dr. Scott Barthelmy and Dr. Kasliwal, analyzing the latest iPTF galaxy catalog, as well as the GLADE catalog, for use during LIGO's current observing run in the context of follow-up observations by Swift.

Dr. Roopesh Ojha provided scientific leadership for the TANAMI program monitoring gamma-ray-loud southern hemisphere AGN across the spectrum as well follow-up campaigns when these sources flare. During this period. he scheduled and observed 5 epochs of VLBI observations and participated in calibration and imaging of VLBI data. Dr. Ojha served as AGN group coordinator of the Fermi/LAT Collaboration, chairing its meetings and organizing internal review of papers, talks and conference proceedings. Dr. Ojha supervised graduate student Bryce Carpenter. He also worked with other graduate students in the TANAMI collaboration. Dr. Ojha worked on multiple publications with his students and colleagues. One was published during this period: "Gamma-Ray Blazars within the First 2 Billion Years" Ackermann et al., 2017, ApJ, 835, 182. Dr. Ojha delivered a talk and presented a poster at the APS meeting in January held in Washington DC. He also participated in a Press Conference to announce the discovery of the highest redshift Fermi blazars. Dr. Ojha also co-organized the Multiwavelength and Multimessenger sessions at the Fermi Collaboration meeting held at CERN Mar 27-30th. He also co-wrote a talk on the Fermi-MICA animation program. Dr. Ojha delivered popular-level talks at STEM night at Takoma Park Middle School and Career Day at Viers Mill Elementary School. Dr. Ojha served as the Fermi/LAT Flare Advocate or Deputy Advocate for two weeks which led to 4 Astronomer's Telegrams during this quarter.

Fermi LAT (661.032)

Dr. Alexander Moiseev continued his support of the regular on-board tests and calibration of the Fermi LAT AntiCoincidence System and analysis of its performance. The ACD is performing well within the requirements. Dr. Moiseev contributed to the discussions in the Fermi-LAT Cosmic Ray Science Working Group.

During the past quarter, Dr. David Green, a University of Maryland postdoctoral researcher, has been working with Dr. Elizabeth Hays on a spectral measurement of protons using the Fermi LAT. Dr. Green is also working with collaborators at University of Wisconsin on a dedicated cosmic-ray proton anisotropy measurement. Dr. Green (who graduated with a doctorate in philosophy from the University of Maryland College Park Physics Department in November 2016) is currently a short-term postdoctoral researcher under Dr. Julie McEnery at Goddard. He has developed an event class for high-energy cosmic-ray protons with Fermi-LAT data and simulations and has improved the energy resolution of the LAT for protons through a series of physically motivated data cuts. He is also currently working to fully study systematic errors associated with the effective area, energy measurement of the LAT, and the reliability of GEANT4 simulations for protons. A proton spectrum study is currently being worked on using this new Proton event class. Mr. Donggeun Tak, a UMCP grad student, has been working on the GRB 160709A, which is in the class of short and bright bursts. This burst has both thermal and non-thermal component. Also, it has an extra power-law component compared to the usual GRB models. The power-law component is almost constant during the prompt emission. The team is going to publish a paper regarding this burst. Finally, Mr. Tak recently started working on Cal-only analysis. Cal-only analysis refers to an analysis that reproduces very high energy events with LAT calorimeter information only. From this project the team expects to get more high energy events and to obtain better understanding of high-energy sources such as GRBs.

Mr. Jeff Magill, a UMCP grad student, used Pass 8 Fermi-LAT data to discover spatial extension of gamma-ray emission from the nearby radio galaxy Fornax A. This discovery has been described in an article now published in the Astrophysical Journal (https://iopscience.iop.org/article/10.3847/0004-637X/826/1/1). Mr. Magill has begun a gamma-ray analysis of the core region of Centaurus A, which has recently been shown to contain a never-before-seen spectral component at high energies. He was collaborating with scientists from H.E.S.S. on a study of this spectral component. A journal paper describing this analysis is in development.

Cosmic Ray Balloon Program (661.036)

Dr. Jason Link tested SuperTIGER electronics and PMTs during this quarter until a problem with the TCU pump stopped the testing until it could be repaired. He prepared the chamber for testing once the pump is replaced and is working to ensure SuperTIGER can be integrated in time for flight, in December 2017. Dr. Link continued to work with Dr. Mitchell on the TIGER-ISS proposal. Ultimately, NASA Goddard requested that the proposal be delayed a year so they could provide proper support and reviews for such a large and complex mission. They have agreed to do so and plan to continue their efforts on the proposal throughout the year.

SuperTIGER is a very-large-area instrument for measurement of the composition of galactic cosmic rays that is flown on high-altitude balloon flights over Antarctica. Super-TIGER-1 had a highly successful 55-day flight in December 2012-January 2013. Dr. Kenichi Sakai and the team are now analyzing the data obtained on this flight. The data quality is excellent, enabling them to clearly resolve nuclei up to Z=40. Additionally, although statistics are low, there appears to be clear resolution of elements in the Z=50-60 range. The instrument performances, including charge identification on the flight, were published in The Astrophysical Journal

(http://iopscience.iop.org/0004-637X/788/1/18). SuperTIGER-2 will measure, for the first time, the energy spectra of the more abundant ultra-heavy nuclei in the charge range of Z=30-38 over the energy range 0.8 to 10 GeV/nucleon with much larger statistics. To check the new PMTs for SuperTIGER-2 scintillator counters, thermal/vacuum tests are in progress. Dr. Sakai has developed the software for recording current time fluctuations during the test.

Dr. Makoto Sasaki has worked on the SuperTIGER experiment seeking to measure the ultra-heavy cosmic-ray composition, which probes the source material of cosmic rays. In this reporting period, Dr. Sasaki worked on the preparation for the SuperTIGER-2 flight. For the Cherenkov detectors, some of the aerogel radiators were taken out from the detector to check their performances after the SuperTIGER-1 flight. Also, the acrylic radiators needed to be applied with soda blasting to reduce angle-dependent effect. After these operations, all radiators have been re-installed into the detector boxes. For the gondola, some of the parts were damaged during the landing of SuperTiger-1. Dr. Sasaki arranged the repair and replacement of the damaged parts and supported the gondola re-assembly.

CALET (661.037)

Dr. John Krizmanic, along with Dr. John Mitchell (Institutional-PI) and fellow CRESST scientists Drs. Alex Moiseev, Thomas Hams, Makoto Sasaki, and Kenichi Sakai, is a Co-Investigator on the CALorimetric Electron Telescope (CALET) experiment. CALET is a Japanese-led mission to measure the electronic component of the cosmic radiation over an energy range of 1 GeV to 10 TeV that was launched and attached on the International Space Station in August 2015. Drs. Krizmanic and Moiseev serve as co-chairs of the US CALET modeling group. During the past quarter, Dr. Krizmanic continued to convene and lead bi-weekly CALET telecons, working with the CALET Modeling and Simulation (M&S) and Data Handling and Analysis (DHA) groups to continue CALET simulation studies, assisting the US CALET group in analyzing flight data, and discussing and understanding the results. Dr. Krizmanic also continued to organize and lead the weekly GSFC CALET meetings. Dr. Krizmanic used the ADAPT cloud computing cluster to generate simulated CALET spectra in support of the US group's Cosmic Ray proton spectrum analysis. Dr. Krizmanic continued to represent the US CALET group on international CALET telecons. Dr. Krizmanic travel to the University of Utah and gave a presentation titled "The CALorimetric Electron Telescope (CALET) on the International Space Station: Results from the First Year of Operation" at the University of Utah Department of Physics and Astronomy colloquium on March 9, 2017.

The CALET mission will investigate the high-energy universe, as a next generation experiment to build upon discoveries made by Fermi, PAMELA, AMS, Atmospheric Cherenkov Telescopes (ACT) and balloon instruments. CALET is a calorimeter-based instrument which will have superior energy resolution and excellent separation between hadrons and electrons and between charged particles and gamma rays. Since the CALET instrument was successfully launched in the H-IIB Launch Vehicle No.5 (H-IIB F5) to ISS at 8:50:49 p.m. on August 19, 2015 from the Tanegashima Space Center, it has completed its commissioning phase on and has been observing the highest energy cosmic electrons along with cosmic ray nuclei and gamma rays. Dr. Kenichi Sakai regularly attended group meetings to discuss CALET analysis.

In this reporting period, Dr. Makoto Sasaki developed a framework for analysis software to calibrate the CALET flight data of Level1 in ROOT format. The pedestal calibrations, gain calibrations, position dependence calibrations have been applied to the data set and enabled creation of the initial DST to investigate the detector status.

ISS - CREAM (661.041)

During this quarter Dr. Jason Link assisted in the editing of an ISS-CREAM instrument paper being prepared by the collaboration and worked with his Boronated Scintillation Detector (BSD) colleagues in drafting a BSD instrument paper. Dr. Link also participated in a collaboration meeting in January reporting on the status of the BSD. He also provided input and documentation to the instrument manager as well as started to work on planning on data analysis prior to the upcoming ISS-CREAM launch in August.

ComPair APRA (661.047)

Dr. Elizabeth Ferrara has been working on high-level Compton Pair-Production Space Telescope (compare) documentation, developing the science case for the mission, and generating presentations to communicate these. She was actively involved in the probe-scale concept pre-proposal (AMEGO, the All-sky Medium Energy Gamma-ray Observatory) and presented a poster on the mission design at the winter AAS meeting in Grapevine, TX. She has also been working with Dr. Alice Harding to determine how a medium-energy gamma-ray mission would contribute to our understanding of the subclasses of neutron stars (low-energy peaked pulsars and magnetars) that are most prevalent in this energy range. With Dr. Harding, she presented preliminary results at the APS meeting in Washington, D.C

Within the APRA-funded project to develop the prototype for ComPair, Dr. Alex Moiseev is working on the drift-bar CdZnTe calorimeter in cooperation with BNL scientists. He completed the tests of the 4-bar CZT detector prototype with a Cs137 radioactive source and was working on the test data analysis. The next step is to design and fabricate a flight-like design of the single 16-bar detector module. This work is being conducted with support from the team engineers. This module will be tested in environmental tests and on the photon beam at Triange University at the end of 2017/beginning of 2018. Dr. Moiseev also submitted an abstract of a paper to present at the ICRC

Fast Radio Bursts (661.048)

Ms. Ginny Cunningham is currently a second-year astronomy graduate student at the University of Maryland College Park. She is working with Dr. Stephen Bradley Cenko as her advisor. Her project is identifying possible high-energy counterparts to Fast Radio Bursts (FRBs) by using the Swift BAT and Fermi LAT/GBM. She is planning to publish her results within the next few months.

X-ray Astrophysics

Next Generation X-ray Optics (662.002)

To mature the technology of integrating lightweight silicon mirrors into “meta-shells,” Dr. Kai-wing Chan continued to improve the precision of silicon mirror alignment and bonding. Silicon mirrors are planned for the future high resolution x-ray optics at NASA/GSFC. The development was aimed specifically for: (1) a possible selection of the STAR-X proposal, which is an Astrophysics MIDEX proposal submitted to NASA HQ in December 2016. (2) The OGRE program (Off-Place Grating Rocket Experiment), a rocket flight led by Penn State to demonstrate high spectral resolution spectroscopy. Dr. Chan is also responsible for the metrology of the silicon mirrors.

For the integration of the silicon mirrors, Dr. Chan carried out experiments to demonstrate the validity of the mirror mounting and to improve the technology readiness level (TRL) in two aspects: the preservation of the mirror figure and the preservation of alignment. The preservation of the mirror figure was demonstrated with full surface measurement of bonded mirrors. In another series of experiments, Dr. Chan demonstrated the precision of the alignment and bonding of single mirrors, each of which was kinematically mounted at 4 points, to < 2 arc-seconds. To demonstrate the accuracy and necessary control of mirror alignment, Dr. Chan started two further types of tests: (1) To validate the feedback algorithm using a platform with adjustable supports, and (2) To demonstrate the accuracy of in-situ mechanical spacer modification.

In March, Dr. Chan served as the Chair of the Legacy Assessment Review of the X-ray Mirror Assembly (XMA) for the Hitomi recovery mission XARM. He reviewed the strengths and shortcomings of the Hitomi Soft X-ray Telescope (SXT) and authored the official report of the review. Dr. Chan also served as a technical reviewer for a paper on metallic thin film coating, submitted for publication to the CEAS Space Journal (Council of European Aerospace Societies).

Dr. Raul Riveros and the Next Generation X-ray Optics (NGXO) team have demonstrated their lightweight single-crystal silicon X-ray mirror fabrication concept by producing true Wolter-I mirrors made of single-crystal silicon. An intense ongoing effort has gone into demonstrating this technology’s readiness for the STAR-X mission proposal submitted in mid-December. Various kinks in the mirror fabrication process are being resolved. Multiple X-ray testable pairs have been produced which, have the potential to produce X-ray images with <10 arcsec HPD. Dr. Riveros and the team are investigating the ion beam figuring technique as a post process figure correction technique. This ion beam figuring, combined with their manufacturing process has the potential to produce sub-arcsecond HPD optics. Currently, they are working to produce a matched pair of mirrors for an X-ray imaging test in mid-2017.

X-ray Binaries (662.030)

Dr. Laurens Keek's paper on a long thermonuclear helium flash observed with MAXI and Swift/XRT (also including data from Chandra and NuSTAR) has been accepted for publication in the Astrophysical Journal. Dr. Keek coauthored a paper on the pulsar-nature of the same X-ray

source, which was accepted by the Astrophysical Journal Letters. Furthermore, the Publications of the Astronomical Society of Australia accepted a paper on a reference sample of X-ray bursts for comparison to nucleosynthesis simulations and nuclear rate studies; Dr. Keek contributed a light curve of a thermonuclear carbon flash, derived from RXTE observations. A paper is in preparation presenting numerical models of X-ray bursts with short recurrence times, a phenomenon that was previously unexplained. Moreover, Dr. Keek started a project to search for coherent signals in X-ray pulsars, and he is currently developing a software stack to perform this analysis on archival RXTE data. In addition, he was the PI of a submitted NuSTAR proposal. Dr. Keek had previously contributed to the science case of the STROBE-X proposal for a Probe class mission, and this proposal was selected by NASA for further study. For the OHMAN proposal, Dr. Keek assisted in responding to questions from the review committee. Dr. Keek also participated in a review panel for the Guest Observer program of the NuSTAR mission. and took part in a meeting of an International Team at the International Space Science Institute in Bern, Switzerland, where he presented his recent work on X-ray bursts. Finally, Dr. Keek was awarded a travel grant by AHEAD (Integrated Activities for the High Energy Astrophysics Domain) for a 2-week collaboration visit to SRON Netherlands Institute for Space Research.

X-Ray Spectroscopy (662.031)

Dr. Antoine Miniussi continued to test TES arrays in order to deliver the Demonstration Model of the Athena/X-IFU to SRON. The experiment he ran gave the best spectral resolution of about 1.7 eV, never before reached for this type of TES x-ray detector. Also, Dr. Miniussi modeled a new shielding to reduce magnetic field and a new type of coil that will be implemented in the next cryostat to test the Athena focal plane. He also started to model AC loss within the TES absorber with the software known as Comsol.

Dr. Kazuhiro Sakai has been characterizing TES performance with a-few-MHz AC bias using the frequency-division multiplexing readout to optimize the TES design towards the ATHENA mission. Dr. Sakai was also optimizing the microwave SQUID multiplexer readout system to multiplex TES signals without any energy resolution degradation.

Over the last quarter Dr. Joe Adams spent a significant amount of time on the Micro-X sounding rocket experiment, including travel to Northwestern for some integration work. Progress has been significant on the payload, and the team has been successful in reducing the noise contributions from several sources.

Dr. Stephen Smith and Dr. Adams have been continuing their work and testing of the EBIT TEMS platform in preparation for delivery of the instrument to LLNL. Current work has focused on the operation of the instrument in a multiple column mulitplexed mode. Dr. Adams along with the entire calorimeter group has been heavily involved with the support of the Athena program in several areas. Dr. Adams and Dr. Sakai have continued work on the development of flight qualified electronics for SQUID multiplexing.

Atomic Data for Photoionized Plasma (662.033)

Dr. Anton Dorodnitsyn reported that he achieved the following milestones: (1)the results of three-dimensional magneto-hydrodynamics simulations of AGN torus were presented in a paper that is now under review by ApJ., and (2) he has started to work on a new significant improvement of the numerical framework that will include self-gravity of the parsec-scale AGN accretion disk.

UV, X-ray and Gamma Ray Data Analysis (662.034)

Dr. Neven Vulic submitted the last paper based on his Ph.D. thesis and is currently working on the referee's report. Dr. Vulic also submitted observing proposals as PI for NuSTAR and Chandra. Dr. Vulic has completed NuSTAR/Chandra data analysis and diagnostic plots for IC 342 and NGC 253 and has finished preliminary data analysis for 10 other galaxies in his synthesis paper. Dr. Vulic participated in the NuSTAR TAC as a facilitator and is involved in writing an ADAP proposal as a Co-I. This has involved searching the entire NuSTAR archive for nearby galaxies (<100 Mpc, non-AGN) and creating a table of their properties derived/calculated from currently published values in the literature.

A major paper on modeling the Chandra X-ray spectra of 14 Galactic X-ray binary stars has been submitted to the Monthly Notices of the Royal Astronomical Society, with Dr. Panayiotis Tzanavaris as lead author. The paper includes self-consistent modeling of narrow iron K-alpha emission in 56 individual observations of 14 Galactic X-ray binaries with the Chandra High Energy Transmission Gratings. All the fitted spectra and line-related contours were included and discussed in the paper in detail.

Hitomi SEO Data Center (662.036)

The joint US-Japanese X-ray astronomy mission ASTRO-H swas successfully launched on 2016 February 17, and renamed "Hitomi" shortly thereafter. After collecting check-out data for about one month, contact with Hitomi was lost and efforts to restore the mission officially ceased about six weeks later. Given these circumstances, the mandate of the Software and Calibration Team (SCT) is to update and verify the Hitomi software tasks and calibration products, provide processed data to the Hitomi team and the public archive, and produce documentation and user guides. Preparations and procedures for the final software, calibration database (CALDB), and science data release are in the final stages. These efforts include validation of the data, testing the software and CALDB via scientific analysis, and thorough documentation of all the above.

Dr. Hiroya Yamaguchi worked in the Hitomi (formerly Astro-H) Science Data Center, supervised by his GSFC sponsor Dr. Lorella Angelini. Hitomi observed several targets before the mission failure in the end of March. During this quarter, Dr. Yamaguchi contributed to both software/database development and to scientific data analysis. He was assigned to be the lead-corresponding author of a paper regarding the elemental abundance study on the Perseus Cluster, one of the most important results from Hitomi. He presented this result at the Hitomi Science Working Group meeting held in Tokyo, Japan in February, and at the Japanese Astronomical Society meeting held in Fukuoka, Japan in March. He also summarized other Hitomi highlights

at a special session in the 229th AAS meeting in Texas as an invited talk. Dr. Yamaguchi's paper, titled "The origin of the iron-rich knot in Tycho's supernova remnant," was published by The Astrophysical Journal (Yamaguchi et al. 2017, ApJ, 834, 124). This result is highlighted also in Nature Astronomy, 2017, V.1, No.0017 (http://www.nature.com/articles/s41550-016-0017). He submitted two observational proposals to NuSTAR and Chandra during this quarter.

The handful of targets acquired has been analyzed exhaustively and each analysis was summarized in a step-by-step guide. Dr. Ilana Harrus contributed several parts in the wrapping-up of this long and exacting close-out. At the beginning of the year, the testing of all the scripts necessary to reproduce the plots and analysis of the existing data was carried out. As the data are all in unconventional modes, it is more than likely that the astronomical community will use only the results coming from the internal analyses that the Hitomi team have performed since launch rather than redo the analysis of the data themselves. It is nevertheless useful to have scripts ready for post-release check and also for future, hopefully more successful, missions. Dr. Harrus has also compiled a list of all the questions that were sent to the formal Hitomi Helpdesk. These questions by definition all came from internal members of the Hitomi collaboration (because no one else had access to the data!) and dealt for the most part with the ancillary response file (arf) generation and ray-tracing program. A document summarizing the answers to these questions is being compiled separately. As the reprocessing of the Hitomi data wound down, Dr. Harrus was involved in several different endeavors, including management classes (toward a PMP certification).

Dr. Koji Mukai completed his invited review paper for the Publications of the Astronomical Society of the Pacific (PASP) on X-ray emission from accreting white dwarfs. This is an outgrowth of the ASTRO-H White Paper for these objects that Dr. Mukai wrote as the team leader of the white dwarf task force. While the White Paper focused on potential areas where the XRS instrument can make a significant impact, it also contained a short summary of the state of the field and scientific questions that can be addressed using X-ray observations in general. The review paper for PASP greatly expanded on this part of the White Paper and also included introductory materials for non-experts. It was submitted on 2017 January 25 and accepted by PASP on March 16.

Dr. Tahir Yaqoob works with the Software and Calibration Team (SCT) of the Hitomi mission, Dr. Yaqoob is also a member of the Hitomi Science Working Group (SWG), which met regularly to discuss a broad range of topics related to the mission, including the instrumentation it carried, the science observations it performed, the software that is used by astronomers to analyze the data, and the scientific results from the observations. Dr. Yaqoob has been responsible for developing a number of the Hitomi software tools in collaboration with US and Japanese members of the SCT. In the current reporting period, Dr. Yaqoob and other members of the SWG continued to use the software tools and calibration files developed by the SCT to model and interpret inflight data from Hitomi. A particular focus of Dr. Yaqoob's contribution was the telescope ray-tracing package and associated spectral response tools. These require many different calibration files and the accuracy of the calibration information in all of these files has a direct impact on the reliability, accuracy, and systematic uncertainties of scientific results derived from analyzing real inflight Hitomi data.

Dr. Yaqoob completed work with the telescope and instrument teams, along with other members of the SCT, on construction, modeling, and fine-tuning of some of the critical calibration data, based on both prelaunch ground-based data and inflight data. The work was aided by bi-weekly telecom meetings with the two telescope teams in Japan. Dr. Yaqoob completed the documentation pertaining to the relevant calibration files and activities, which included quantitative assessment of the statistical errors on the four sets of combined telescope and detector effective area versus energy functions generated by the spectral response generator tools. The SCT made further releases of all of the processed Hitomi data, along with releases and patches of the software package, during the current reporting period.

Dr. Yaqoob has participated in the post-pipeline analysis, testing, evaluation, trouble-shooting, resolving issues, correcting, and refining of the software tools. This work has included the data reduction and analysis related to critical assessment of some of the calibration data. In addition, Dr. Yaqoob updated the user help files for software tools for which he was primarily responsible. In rotation with other members of the SCT, Dr. Yaqoob has performed duties researching, problem-solving, and answering queries submitted by SWG members to the e-mail "Hitomi Help Desk" service. Some of the issues raised involved correcting software, and some of the issues required either new functionality in the software to be introduced or existing capabilities to be improved. Dr. Yaqoob was primarily responsible for the changes that affected the raytracing suite or spectral response function tools.

With members of the wider Hitomi collaboration, Dr. Yaqoob also participated in scientific studies on the Hitomi data for several of the astrophysical sources observed by Hitomi, contributing to aspects of the data analysis, modeling, and scientific interpretation of the results. There are several Hitomi collaboration scientific papers in progress that will eventually be published in peer-reviewed journals. Dr. Yaqoob also began working on a paper presenting the theory, methodology, and implementation of the ray-tracing suite of software tools for X-ray telescopes of the type deployed by Hitomi. Development and design of the suite was led by Dr. Yaqoob, in collaboration with other members of the SCT and Hitomi telescope teams.

With his UMBC collaborators Prof. T. J. Turner, M. M. Tatum, A. Scholtes, M. Trevor, and S. Aubin, Dr. Yaqoob continued to work on research using X-ray data from the Suzaku, XMM-Newton, NuSTAR, and Swift satellites to study the properties of circumnuclear matter in a very large sample of active galaxies. This research aims to characterize column densities of the global matter distribution in these active galaxies, deriving any constraints on the geometry of the distribution, using self-consistent spectral-fitting models. The impact on the apparent X-ray spectral signatures of matter in the vicinity of the putative central black hole arising from using improved models of the global matter distribution compared to previous work will also be addressed by the study. In addition, with collaborators from UMBC and GSFC, Dr. Yaqoob worked on two Chandra high-resolution X-ray spectroscopy projects on the origin of the Fe K-alpha line and its kinematic signatures, one project involving a sample of X-ray binary systems, the other involving a sample of active galactic nuclei. Work on the X-ray binary project, in collaboration with Dr. P. Tzanavaris (UMBC/GSFC) was completed, and a paper describing the methodology and results was submitted to the Monthly Notices of the Royal Astronomical Society, and is currently being peer-reviewed. The paper, based on a large number of observations, rules out a uniform, solar-abundance, spherical geometry of the circumunclear

matter in the majority of the X-ray binary observations studied. The results also include the most robust constraints on the velocity width of the Fe K-alpha emission line from that material, at the best spectral resolution currently available.

Dr. Yaqoob also worked on a project, as co-author, with collaborators Dr. S. LaMassa (STScI) and R. Kilgard (Wesleyan U.), studying the X-ray spectra of the AGN Mrk 1018. A paper reporting the modeling of the dramatic variability in the X-ray continuum and measurements of the Fe K-alpha line was submitted to the Astrophysical Journal and accepted for publication. The main conclusion was the inference of time lags between the continuum and emission line, and an estimate of the global column density of circumnuclear matter.

Dr. Michael Loewenstein is the lead scientist in charge of HEASIM, an all-purpose X-ray data simulator for application to Hitomi and other future missions, the SKYBACK astrophysical background simulator that interfaces with HEASIM, and the SXSBRANCH tool that computes the distribution over different classes of events in real and simulated SXS event files, and compares these with theoretical expectations. These were all included in the software release, and a manuscript is being prepared as part of a suite of Hitomi hardware and software papers to be submitted this spring. In his role as Hitomi Software and Calibration Team (SCT) Soft X-ray Spectrometer (SXS) instrument scientist, Dr. Loewenstein contributed to all of these SCT efforts. Toward these ends, he continually interacted with SXS instrument team members and other SCT members in the U.S., Japan, and Europe through participation in regular and ad hoc meetings and in telecons.

Dr. Loewenstein focused in particular on writing and testing the Hitomi analysis and step-by-step guides, and checking the end-to-end processing, and post-processing analysis, of the Perseus SXS data -- which is considered of particular importance -- as well as that of G21.5-0.9, IGR J16318-4848, and the Crab Nebula. Results on the spectral analysis of these sources and tests of the data products used in the analysis were presented at the 16th ASTRO-H Science Meeting at Tokyo Metropolitan University in February as part of the SCT session. The results of these analyses contribute to the scientific papers being prepared based on the Hitomi analysis, with Dr. Loewenstein directly involved in papers presenting the implications of the Hitomi-derived elemental abundance pattern in Perseus and on timing studies of the Crab Nebula.

Dr. Loewenstein is part of the team actively analyzing the Hitomi Perseus data to further constrain the purported 3.55 keV emission line. A paper on these results was accepted (ApJ, 837, L15). Dr. Loewenstein is also co-author of "Uniform Contribution of Supernova Explosions to the Chemical Enrichment of Abell 3112 out to R200" (Ezer et al. 2017, ApJ, 836, 110) that aims to measure and interpret global galaxy cluster metal enrichment and was recently accepted by the ApJ. This is also the subject of the Astrophysics Data Analysis Program (ADAP) proposal entitled "Detailed Study of Chemical Enrichment History of Galaxy Clusters out to Virial Radius" for which work has just begin. Dr. Loewenstein reviewed a paper for the Journal of High Energy Astrophysics, worked his regular rotations (two shifts this quarter) for the NASA/GSFC, ‘Ask a High Energy Astronomer’ web-based outreach program, and frequentlly contributed to the on-line Hitomi help desk.

Soft X-ray Instrumentation (662.037)

Dr. Nick Thomas has been working on data analysis for the 2015 flight of DXL, the results from which are forthcoming. He updated the electronics for the DXL sounding rocket in preparation for a January 2018 flight. He continued his work at the 100 meter X-ray beamline where he is characterizing slumped micropore, 'Lobster-Eye' X-ray optics for a future space-based, wide-field of view, X-ray telescope.

X-Ray Optics R&D for Flight Projects (662.038)

Dr. Hideyuki Mori has been setting up a new coating chamber system to address the multi-layer coating onto glass substrates/silicon wafers that will be used for future X-ray optics. Dr. Mori designed a stainless mask with a curved slit. This mask was placed in front of a platinum (Pt) or carbon (C) target to regulate the direction of sputtered particles and to perform the uniform coating onto a ~20 cm sample. For a Pt single layer, the thickness uniformity of +/-1% was achieved. Dr. Mori developed an automation system for the coating, in which a Pt layer can be coated onto the front and the backside surface of the substrates separately. Dr. Mori tried the Pt coating on two glass substrates with a radius of 248 mm. The height and width of the substrate was 8 inch and 4 inch, respectively. The layer thicknesses were 150 and 322 angstrom. Using an optical interferometer, the surface shapes of these substrates were measured (1) before the coating, (2) after the coating on the front side surface, and (3) after the coating on the backside surface. After the coating on the front side surface, the substrates were found to be distorted. A peak-to-valley value of the surface figure profile at the center of the substrate with a thickness of 322 angstrom changed from 0.7 to 1.0 micrometer. This distortion may be caused by internal stress of the Pt single layer. To mitigate the stress, the coating on the backside surface was performed. The shape of the substrate with the Pt layers coated on both sides was quite similar to that of the substrate without the coating. This result demonstrated that the backside coating makes it possible to control the substrate distortion caused with the reflector coating.

NuSTAR (662.039)

The NuSTAR Guest Observer Facility continued to prepare for NuSTAR's Guest Observer Cycle 3 proposal opportunity. The proposal submission deadline was on January 27, 2017, and resulted in 215 proposals, a slightly higher number than in previous cycles. The Proposal Selection Review was prepared, and its date and location were settled (April 4-6, 2017, Hotel Lord Baltimore in Baltimore, Maryland). Drs. Koji Mukai and Katja Pottschmidt assisted Dr. Andrew Ptak (NASA) in assembling and organizing the peer review panels by suggesting and recruiting reviewers, dividing the proposals into six panels, assigning reviewers to these panels, and assigning primary and secondary responsibilities of each proposal to panel members. Because of the increased interest in NuSTAR, it was a major effort leading up to March 9 when instructions for downloading encrypted proposals were sent out to the reviewers

Dr. Katja Pottschmidt attended regular telecons involving participants from NASA HQ, the NuSTAR PI, Operations Manager, Project Manager, Project Scientist, and GOF. She was also responsible for replying to questions to the NASA NuSTAR helpdesk, where she was the primary contact for two weeks out of every four weeks.

In her NuSTAR research endeavors, Dr. Pottschmidt conducted observation planning as well as data analysis and interpretation for observations of X-ray binaries with INTEGRAL, RXTE, Suzaku, NuSTAR, Swift, and Chandra. For NuSTAR this included participating in the analysis of NuSTAR Director's Discretionary Time (DDT) data on accreting pulsars, including A 0535+26 (Ballhausen et al., 2017, A&A, submitted), XTE J1859+083 (Stierhof et al., 2017, A&A, in prep.), projects led by students of the FAU Remeis Observatory, Germany, Swift J2103.5+4545 (Brumback et al., 2017, ApJ, in prep.), a project led by a University of Dartmouth graduate student, and Cepheus X-4, target of two studies, one by a University of Tuebingen, Germany, graduate student (Vybornov et al., 2017, A&A, in press) and one by an Inter-University Centre for Astronomy and Astrophysics, India, graduate student (Bhargava et al, 2017, MNRAS, in prep.). K. Pottschmidt is coordinating the analysis of the accreting pulsar 4U 1626-67 (Cycle 1 observation, PI Pottschmidt) between the lead author (Iwakiri et al., 2017, ApJ, in prep.) and, among other co-authors, another FAU graduate student (S. Falkner), who is modeling pulse profiles. She is/will be involved as a CoI in the analysis of about 10 additional NuSTAR Cycle 1 and about five NuSTAR Cycle 2 observations, as well as further NuSTAR DDT observations, e.g., of the accreting pulsars 4U 0115+63 (PI, 2x 2015/10) and SMC X-3 (PI, 2016/08). She is a co-author of a NuSTAR paper by Dr. Mihoko Yukita (JHU & NASA-GSFC) on an accreting pulsar candidate observed by NuSTAR in the field of M31 (Yukita et al., 2017, ApJ, 838, 47) and of a NuSTAR paper by Dr. Matthias Kuehnel (FAU) on the accreting pulsar GRO J1008-57 (Kuehnel et al., 2017, MNRAS, submitted).

The Suzaku GOF is comprised of Drs. Koji Mukai, Katja Pottschmidt, and Kenji Hamaguchi. The Facility continued working on final document updates. An updated version of the XIS chapter of the "Technical Description" (instrument characteristics, former guide for proposers), provided by Dr. Masahiro Tsujimoto and the XIS team and further iterated between the GOF and the XIS team, was made public on the GOF web pages in January 2017: https://heasarc.gsfc.nasa.gov/docs/suzaku/aehp_data_analysis.html, ftp://legacy.gsfc.nasa.gov/suzaku/nra_info/suzaku_td_xisfinal.pdf. Other GOF web pages were updated as well in order to reflect the post-operations mission status. The GOF also continued to revise the "ABC Guide" (data analysis guide) and among other updates started working on including a new chapter giving an overview of important on-board and calibration events throughout the mission. The GOF members took turns answering occasional Suzaku helpdesk questions with the person primarily responsible changing every two weeks (Mukai 02/01-15 & 03/16-31, Hamaguchi 01/01-15 & 02/16-28, Pottschmidt 01/16-31 & 03/01-15).

In her Suzaku-related research endeavors, Dr. Pottschmidt conducted observation planning as well as data analysis and interpretation for observations of X-ray binaries with INTEGRAL, RXTE, Suzaku, NuSTAR, Swift, and Chandra. For Suzaku, this included supervising Diana Marcu-Cheatham's (UMBC) comparative study of a sample of X-ray pulsars observed with Suzaku which is part of Ms. Marcu-Cheatham's Ph.D. project. Dr. Pottschmidt is also participating in the analysis of Suzaku data from additional accreting pulsars, namely 4U 0115+63 (Hertel et al., 2017, A&A, in preparation, as part of Hertel's diploma project at FAU, Germany) and Cen X-3 (Gottlieb et al., 2017, ApJ, in preparation; results of Gottlieb's 2015 CRESST project and GSFC undergraduate internships).

Dr. Mukai was a co-I on three NuSTAR submitted proposals; furthermore, he submitted one Fermi proposal as the PI on gamma-ray emission from novae.

NICER Background Simulations (662.040)

Dr. Steven Sturner and Dr. John Krizmanic continued an effort to characterize the in-orbit background for the NICER X-ray telescope experiment which is to be flown on the International Space Station (ISS). In this effort, Dr. Sturner's responsibility is to produce a computer mass model of the NICER experiment as well as select other components of the ISS and to run Monte Carlo simulations of various particle spectra incident on the NICER experiment, using the MGEANT simulation package. During this quarter Dr. Sturner performed extensive high-fidelity background simulations for NICER while in its stowed position. These simulations utilized the NICER mass model Dr. Sturner created in the previous quarter. The results of these simulations will be used to inform the decision to un-stow NICER once it is installed on the ISS and powered up.

Drs. John Krizmanic is also working with Dr. Keith Gendreau, Dr. Zaven Arzoumanian, and the NICER team, and they have developed a MGEANT-based simulation model of the NICER experiment to assess the impact of background radiation on the X-ray signal detection and to develop background rejection methodologies. Dr. Sturner is leading the MGEANT-modeling activities while Dr. Krizmanic is leading the development of instrument response function algorithms, quantifying the accuracy of the simulated physics processes, quantifying the background rate as a function of orbit, and developing background rejection methodologies. During the last quarter, Dr. Krizmanic worked with Dr. Sturner to develop a mass model of NICER in its stowed configuration. This was then used to calculate the background rates and spectra for this configuration using all cosmogenic and terrestrial background sources and with high statistics.

Hitomi SEO Science Support (662.042)

Dr. Maurice Leutenegger, together with Dr. Megan Eckart and other coworkers, continued maintenance and development work on various specialized X-ray calibration sources which are being used to calibrate the Astro-H SXS flight spare detector assemblies, as well as to support development work for other calorimeter devices. Dr. Leutenegger and colleagues produced on-orbit calibration files and accompanying documentation for Astro-H; further analysis of pre-flight and on-orbit calibration data is ongoing. Dr. Leutenegger and colleagues participated in analysis of data from Astro-H observations of performance verification targets, which has resulted in the publication of one Nature paper, and is expected to result in several more refereed journal articles.

Dr. Leutenegger remotely supported work by colleagues at LLNL to perform further characterization measurements on a thermal cracking atomic hydrogen source, and to prepare the source for further charge exchange measurements. Dr. Leutenegger also continued work with collaborators at Swarthmore College, University of Delaware, West Chester University, and University of Wisconsin on X-ray radiative transfer in the winds of massive stars. Dr. Leutenegger continued analysis of the Chandra HETGS LP observation of Plaskett's Star,

including new observations obtained in December. The preliminary results on Plaskett's Star were presented at the NZ Stars conference.

Dr. Hamaguchi attended the Hitomi science working group meeting held Feb 13-15 and discussed analysis of the Hitomi data obtained during the performance verification phase. Beside this, Dr. Hamaguchi continuously analyzed XMM-Newton and NuSTAR data of Eta Carinae. He established a method to measure NuSTAR source positions from point-spread-function image fitting and investigated NuSTAR particle and sky background during these observations. He made quick-look analysis of two NuSTAR observations of the Wolf-Rayet binary system, WR140, obtained in January and February. He also analyzed XMM-Newton data of another Wolf-Rayet binary system, gamma2 Velorum, which he obtained last November and December. He submitted two proposals for observing Eta Carinae and WR140 using NuSTAR. He mentored Lucas Tax, a UMD student, who plans to take a college credit though his research project of the Be star, gamma Cassiopeia --- the nature of a multiple absorption event discovered with XMM-Newton. He also mentored a UMD student, Austin Kim, who studies a stable component of gamma Cas. He wrote a proceeding paper for the IAU symposium 329: “The lives and death-throes of massive stars,” held in Auckland, New Zealand 11/28-12/2. He also participated in a ground based observation of WR140 using the CHARA infrared interferometric array at the Mt. Wilson observatory and attended the calibration meeting (IACHEC) at Lake Arrowhead, CA, in late March.

Dr. Francesco Tombesi contributed to the analysis and interpretation of the X-ray calorimeter observation of the Perseus cluster, focusing on the search for the putative dark matter emission line at an energy of E=3.5keV. The paper has been published in ApJ. Dr. Tombesi is also a member of the team working on the study of the Hitomi data of the AGN at the center of the Perseus cluster, namely NGC 1275. Dr. Tombesi contributed to the analysis of the calorimeter data and additional data from NuSTAR, XMM-Newton and Chandra. A publication on these results is being finalized.

Dr. Yang Soong continues to improve the reflector shape of X-ray mirrors, as well as the surface quality by working with the existing ASTRO-H-type hardware. He is fine-tuning the physical parameters in the replication processes, e.g. radius matching, pressing weight during mating of the substrate and the mandrel surface, (which is covered by a piece of thin glass) in order to fabricate this faithfully following the shape of the substrate. The figure error, has a simple second-order polynomial form and the image quality scales as x/4 arc-minute, where x is the figure curvature error measured in microns. Dr. Soong is able to fabricate reflectors which could potentially deliver an image resolution of 0.5 arc-minute with proper modification of alignment scheme than that being carried out when fabricating the ASTRO-H SXTs. The newly fabricated reflectors, in terms of their figure, surface quality and circularity, was tested in the 100-meter X-ray beam in the last quarter. The X-ray tests showed a mixed result when comparing with the ASTRO-H flight spares. The new reflectors showed some desirable characteristics such as better surface quality and flatter surface figure, but features of 1-2 micron in height over a few millimeters in length on the reflectors offset the gain of the above-mentioned characteristics. Further research and development has improved surface quality. X-ray beam tests are scheduled for mid-April in preparation for fabricating two mirrors of the ASTRO-H "recovery" mission, now called XARM.

NICER Science Support (662.043)

Dr. Michael Loewenstein is part of the science team "General Observatory" Working Group tasked with evaluating potential NICER targets outside of the primary target class of Neutron Stars, with a particular emphasis on high redshift galaxy clusters, galaxy cluster outskirts, and intergalactic filaments associated with galaxy clusters. On the subject of filaments, he and Observatory Science Working Group member Dr. Esra Bulbul (Massachusetts Institute of Technology) proposed to observe the dense ends of the Warm-Hot Intergalactic Medium (WHIM) in the Abell 1750 galaxy cluster, based on these simulations. Internal review of prospective Observatory Science proposals was completed, and A1750 was selected to be observed for 100 ksec. Dr. Loewenstein continues work with the NICER team to characterize and evaluate the contribution of the diffuse astrophysical background to NICER spectra, which involves modeling the relevant local, galactic, cosmic, and solar wind charge exchange components; and, on calibration of the response to extended sources.

PCOS Science Support (662.045)

Dr. Antara Basu-Zych continued her research on the X-ray binary populations within low-metallicity star-forming galaxies. This research on a sample of low-redshift, emission line-selected galaxies has been promising because these galaxies appear to be excellent analogs of primitive galaxies in the early Universe and the relationship explored by Dr. Basu-Zych may offer insight into the X-ray emission from first galaxies and those galaxies responsible for heating the intergalactic medium, in early epochs. To further gain understanding into the role of X-ray binaries within "early universe" galaxies, Dr. Basu-Zych plans to collaborate with theorists to find physical explanations for her current and ongoing observations and has proposed for additional data in recent calls for proposals. This past quarter, Dr. Basu-Zych has presented the preliminary results from an ongoing study on the X-ray emission relation with galaxy properties (e.g., star formation rate, metallicity, stellar age) in a low-metallicity, young sample of galaxies at a special meeting titled “Ultraluminous X-ray Sources: from the Local Group to the Very First Galaxies,” at the International Space Science Institute in Bern, Switzerland, where Dr. Basu-Zych participated as a key collaborator. Related to PCOS Science support, Dr. Basu-Zych recently attended the American Physical Society April meeting. Efforts here included preparing brochures, coordinating with executive committee members, and organizing the PCOS mini-symposium and several Science Interest Group symposia. Dr. Basu-Zych is now organizing PCOS presence at both the High Energy Astrophysics Division (HEAD) meeting in Sun Valley, ID. She is also leading content revision for the LISA spacecraft NASA website.

Suzaku Source Catalog (662.046)

Dr. Nikolai Shaposhnikov did not submit a report for this quarter.

Gravitational Astrophysics

Gravitational Relativity (663.002)

In this quarter, Dr. Bernard Kelly worked on finishing a paper draft on the behavior of magnetized plasmas in the environment of a merging black-hole binary, in collaboration with Dr. Zach Etienne (WVU), Dr. Bruno Giacomazzo (U Trento), and Drs. Jeremy Schnittman and John Baker (NASA). He has supplied Dr. Schnittman with regularly sampled 3D simulation data from which Dr. Schnittman can use his Pandurata tool to produce a series of EM spectra reflecting each stage of the black holes' inspiral and merger. Additionally, Dr. Kelly is co-authoring a paper using some of the same technology to understand the EM characteristics of black-hole neutron-star binaries.

LISA Pathfinder & LISA Instrument Characteristics (663.006)

The two main areas of focus for Dr. Jake Slutsky in this quarter were the analysis of existing data from the LISA Pathfinder initial mission, and the planning of the experiments for the remaining extended mission timeline, particularly for the NASA-led portion. He has worked with colleagues at JPL to successfully drill down on systematic factors effecting the calibration of the NASA-supplied Colloidal Micro-Newton Thrusters, and used this information to design complimentary experiments in novel control configurations of the spacecraft to minimize data corruption and artifacts. Dr. Slutsky has also led the development and analysis of joint operations to cross-characterize the different thruster systems, in collaboration with European colleagues. He presented a talk on his work at the "April" meeting of the American Physical Society this January.

Pulsar Pair Cascades (663.007)

Dr. Andrey Timokhin with colleagues at GSFC is working on a global kinetic model of pulsar magnetospheres. He has also been working on developing models for drifting subpulses seen in some pulsars. Dr. Timokhin, together with Dr. Alice Harding, is supervising graduate student Gabriele Brambilla who is working on global kinetic simulations of pulsar magnetosphere. Dr. Timokhin is also supervising an undergraduate student Benjamin Wade from University of Maryland College Park in his work on modeling of pair cascades in pulsars.

Gravitational Wave Technology Support (663.008)

Dr. Shannon Sankar is engaged in an ongoing project to design, prototype, align and test an optical telescope for the LISA mission (an initiative focused on the L3 ESA launch opportunity). This work included several detailed models of telescope performance, quantified by scattered light levels and wavefront uniformity over the field of view. Dr. Sankar has implemented and used a linear perturbative alignment model of the telescope. Dr. Sankar was key to the integration and alignment phase of operations, which involves laser-based measurements of prototype telescope fiducials and took place on Center in a flight-level cleanroom. Dr. Sankar has fully aligned this prototype telescope to meet mission wavefront specifications of approximately 35 nanometers over the full field of view, and is currently testing the prototype for back-scattered light performance. The sensitivity of this test, which was designed and implemented by Dr. Sankar, is currently better than 30 parts per billion and further sensitivity

improvements are expected in the coming months. Additionally, Dr. Sankar has been deeply involved in the development of a future ISO TRL-6 prototype telescope for possible inclusion in an engineering model around 2022. One major advancement in that round of work is expected to be the demonstration of high-dimensional stability in a representative environment. This follow-on telescope is currently in the process of being designed and studied.

Laboratory Support for MAHI (663.009)

In this quarter, Dr. Paul Fulda has investigated the sources of noise that limit the sensitivity of the tabletop Multi-Axis Heterodyne Interferometer (MAHI) system. Working with Michael Aitken, Dr. Fulda demonstrated that temperature fluctuations limit the length sensitivity below 0.1 mHz, and that mechanical vibrations limit the sensitivity above a few Hz. Dr. Fulda has also been able to rule out a limiting contribution of noise from the optical phase-locked loop. Dr. Fulda has worked with Eugenia De Marco, Ryan DeRosa and Michael Aitken to prepare a MAHI system for vacuum operations, where a reduction in noise contributions from temperature fluctuations and air currents is expected. The first in-vacuum noise measurements are expected in the coming week. Dr. Fulda has also continued simulation investigations into the effects of imperfections in a MAHI setup on the recovered length and alignment signals.

Observational Cosmology

CMB Polarization (665.006)

This quarter Mr. Sam Pawlyk, a University of Maryland grad student, continued work on the implementation of a continuous adiabatic demagnetization refrigerator (CADR). Mr. Pawlyk worked to diagnose and resolve a number of issues with the CADR, as well as working on finalizing an operating procedure. Mr. Pawlyk also worked on resolving issues with the momentum dump rotator for the PIPER experiment. Mr. Pawlyk also began developing a Mirror Transport Mechanism (MTM). This is a proof of concept of mobile mirror that will be a component of the Fourier Transform Spectrometer for the PIXIE mission.

Mr. Alexander Walts, a University of Maryland grad student, continued to work on the thermal mitigation techniques needed for successful operation of the PIPER balloon electronics when in flight. The PIPER balloon is scheduled for launch in early June, so all thermal models have been completed, and flight hardware needed for the electronics thermal control is currently being assembled and integrated by Mr. Walts. The thermal models developed by Mr. Walts indicate that with a 1 square meter radiator panel for each of the 30U electronics subrack housings as well as a 5 square meter Earth infrared radiation shield, the payload electronics will operate within their specified thermal limits. Temperature data will be collected for all of the electronics and then analyzed following completion of the early June launch of the payload.

Dr. Fixsen and Dr. Kogut are working on two papers on the beams of PIXIE and Galactic dust from the FIRAS experiment. In addition they are working on a program with UBC to optimize optics for PIXIE and a prototype mirror transport for PIXIE.

Cosmic Evolution of Dust (665.010)

Dr. Richard Arendt assisted E. Dwek (NASA/GSFC) in the analysis and preparation of a paper on the progenitor and pre-SN environment of SN 2010jl, based on published upper limits established using HST and Spitzer data. Dr. Arendt also updated the SN 1987A light curve for the latest Spitzer/IRAC measurements, and provided related review material to P. Bouchet for a JWST GTO presentation. Dr. Arendt provided convolved and aligned mid-IR to radio images of the Galactic center for analysis by Dr. Dwek.

Far-Infrared Interferometry, Instrumentation, and Astrophysics (665.012)

Dr. Todd Veach continued this quarter where he left off the last, with the BETTII mission. During this quarter, he continued collaborating with the WFIRST team to fly one of the H4RG detectors destined for WFIRST on the BETTII payload. The collaborative arrangement is such that the detector will serve as the angle sensor for the BETTII payload while providing an increase in the Technology Readiness Level (TRL) for the WFIRST detectors, which have yet to be flown in an operational-like environment. This collaboration will also allow the WFIRST team to characterize the flight performance of the H4RG, something that was lacking for the H2RG detectors that were used as the focal plane for WFC3. During this quarter, the H4RG flight hardware has been delivered and is being integrated into the BETTII instrument. Dr. Todd Veach has further spent the past quarter developing solutions to ensure a successful flight of the BETTII payload in June of 2017 from Palestine, TX. Since the Fort Sumner launch was scrubbed due to weather, the BETTII team has been afforded the opportunity to upgrade and repair the original payload based on system level tests performed while waiting for launch in Fort Sumner.

Dr. Dale Fixsen reports that the BETTII dewar was disassembled and the source of the leaks were discovered. Several parts were redesigned including the windows, pump out port, and feed-throughs for the new H4RG and the TES detectors. A new CEB was designed and completed. Two of the detectors were retested in a separate dewar, after returning from Ft Sumner. Following that the full complement of detectors was retested in another dewar. The errors and problems from that test have been traced to various places in the cabling. Corrections will be made and tested before shipment to Texas for flight.

Development of Large Format Arrays for Astrophysical Instrumentation (665.014)

During this period, Dr. Cillis analyzed the performance of Sensor Chip Subassembly (SCS) Euclid Flight Detectors: scs_18249_001-4_0008F015, scs_18268_004-5_0014F017, scs_18278_001-5_0010F014, scs_ 18284_008-1_0012F016. The tests performed on this system were derived from the ESA SCS Procurement Specification EUCL-EST-PS-7-001 and reflect the Euclid Level 4 requirements. Each SCS includes the Sensor Chip Assembly (SCA), Sensor Chip Electronics (SCE), and the Cryo-Flex Cable (CFC). The ESA-supplied Euclid Firmware v3.0b was primarily utilized. The SCS results were reported at an operating temperature of 100K, a detector bias of 0.5V, a gain setting of 15dB, and a frame time of 1.4548s. Dark current, CDS noise, maximum Quantum Efficiency (QE) gradient, pixel-to-pixel uniformity, dynamic range, and persistence results were reported for operable pixels only (with an applied operability mask).

Spectroscopy noise, photometry noise, QE, and linearity results were reported for all 2040x2040 pixels as well as operable pixels, because they are inputs to the operability mask in addition to the requirement to report them for operable pixels. The operability mask was not applied for inter-pixel capacitance and channel-to-channel crosstalk. The four detectors fulfilled performance requirements. Each detector is surrounded by a band of reference pixels. These pixels are not light-sensitive and instead are used to correct the remaining 2040x2040 pixels for drift in the amplifiers. During this period, but before the analysis of the performance of the flight detectors, Dr. Cillis carried out an extensive analysis to determine the best way of performing reference pixel correction for SCS flight detectors.

Dr. Archana Devasia continued her work on the fabrication of fine wire metallic magnetic calorimeter devices. Upon probing test structures she identified 2 major problems: (1) shorts between Nb1 ground plane and Nb2 meander coils, (2) removal of Nb1 ground plane during Nb2 etch process. She determined that problem (1) was being driven by two issues: (a) the removal of insulating Nb2O5 between Nb1 and Nb2 during reverse bias clean, and, (b) reduced etch rate of Nb along the sloped edges of Nb1 resulting in a short between Nb1 and Nb2. To resolve (a), she experimentally determined the reverse bias etch rate of Nb2O5 at multiple locations across a wafer and calculated the etch time required to remove native oxide between Nb1 and Nb2 in the shorting locations while at the same time preserving the Nb2O5 in other locations so as to insulate the Nb1 from the Nb2. She resolved issue (b) by developing a model for the Nb etch over open areas and sloped edges, based on empirical results. She found that the Nb etch rate over sloped edges was only 72% of that of Nb on flat surfaces and modified the Nb2 etch time to account for this. In order to prevent the removal of Nb1 during the Nb2 etch process, Dr. Devasia designed and implemented a mask to introduce an additional 40 nm thick Al2O3 insulating layer between the Nb1 and Nb2. Dr. Devasia also worked on re-designing the position of absorber stems on chips in order to prevent shorting between Au absorbers and Nb2 meander coils. In addition, Dr. Devasia completed the fabrication of an interface plate for flip chip bonding to form a hybridized pair of PIXIE chips. The resulting hybridized pair had a gap ranging from 16.5 micrometers to 20 micrometers which is very close to the target of 20 micrometers. Finally, Dr. Devasia started a re-work process designed to replace a MoN meander with indium on a parametric amplifier wafer. She attempted to resolve a single defect on a large parametric amplifier chip by etching a defective MoN meander and patching it with a thin 100 nm indium layer. Upon deposition she determined that the indium was too thin to form a continuous metal sheet and instead resulted in the formation of a cluster of disconnected islands. She is currently working on resolving this issue.

Dr. Kyowon Kim did not submit a report this quarter.

GALEX:UV Luminous Galaxies (665.015)

Dr. Basu-Zych has been working on research related to radio observations of ultraviolet-selected galaxies. The work on this project has been paused during the past few quarters. However, the data analysis has been completed and interpretations are underway. We expect that work will resume in the next quarter to begin writing up this analysis.

Micro-X (665.019)

As a member of the James Webb Space Telescope (JWST) thermal engineering team, Dr. Giuseppe Cataldo successfully completed the validation process of the thermal models required for the upcoming cryogenic vacuum test at NASA's Johnson Space Center. In particular, he carried out a thorough temperature analysis and was able to add the heat flows in the loop, optimizing their values through the model-based systems engineering methodology he previously developed to this end. Substantial improvements were obtained, which led the thermal system to meet the mission requirements with margin. Dr. Cataldo prepared a draft of a journal paper describing all the efforts brought to completion for JWST over the past three years. The draft is currently under review by the paper's co-authors. Finally, he developed a rigorous framework for model-based design under uncertainty and Bayesian-based model validation for spacecraft systems, which will be used to perform analytical studies in support of the JWST Observatory Integrated Modeling and final pre-launch verification-by-analysis of key performance requirements.

Dr. Cataldo also continues his work on the focal plane design and optimization of a medium-resolution Micro-Spec instrument. He led the efforts to identify the causes of some data misbehavior in microwave (HFSS) simulations used to simulate the electric field distribution, return loss and isolation in the spectrometer multimode region as a function of frequency. He worked closely with other team members, requesting the necessary information and data, providing advice and setting up the appropriate meetings. The problem's causes were successfully identified and the team can now move forward with thorough trade-off studies and the final instrument design, which is expected to be completed by the end of 2017. Finally, Dr. Cataldo gave several tours of the JWST facilities at GSFC and participated as a speaker in the 2-day JWST event for employees, family and friends.

Euclid-LIBRAE (665.020)

Dr. Richard Arendt provided text and editing for the CIB fluctuation review article that is in preparation. He provided estimates and description of very large scale structure to be expected in Euclid CIB measurements due to zodiacal light and Galactic foregrounds. Healpix format images of the zodiacal light foreground were provided to collaborator Dr. Dale Fixsen (CRESST/UMCP). Dr. Arendt presented a talk on structure in the zodiacal light foreground at a YCAA seminar at Yale University. Dr. Arendt participated remotely in a thesis committee meeting for Y. Li (U. Hawaii). During this quarter, Dr. Arendt also completed validation of a new data model for the least-squares self-calibration procedure. This data model can simultaneously accommodate multiple detector arrays into the self-calibration. This is a necessary extension of the procedure for use on Euclid data. However the procedure is also very beneficial to CIB analysis carried out with Spitzer/IRAC data.

HIRMES (665.022)

Dr. Kutyrev is working on the development of the new mid-infrared instrument for the SOFIA observatory: HIRMES (HIgh Resolution Mid-infrarEd Spectrometer). The primary activities for this period were further development of the optomechanical design of the instrument and

beginning procurement of the components. Dr. Kutyrev participated in the preparation of the Preliminary Design Review (PDR) and the presentation at the PDR. The lab facility for selected instrument components development and testing is being prepared. The cryogenic rotary stage for the grating positioning and spectral tuning of the instrument has been acquired and is in testing. Based on the results of these tests there were corrections made in the rotary stage design: an absolute encoder was added to provide adequate positioning accuracy. Dr. Kutyrev continued to participate in other aspects of the instrument development, in particular evaluation of the optical, mechanical, spectral performance of the instrument as well as interaction between the partners and contractors.

Dr. Richard Arendt provided slides and presented a segment of the delta-PDR presentation held on March 8th and 9th. This material described additional development of the data analysis pipeline, FITS files formats, and observing strategies that have been worked out by the team since the HIRMES SRR. Dr. Arendt continued to support the work of Dr. A. Kovacs (U. Minnesota) on the adaptation of the CRUSH software for use with HIRMES data. As Dr. Kovacs' contract has been finalized in this quarter, weekly tag-ups have begun between Dr. Kovacs and Dr. Arendt.

WFIRST Science (665.023)

Dr. John Cannizzo continued development work on Monte Carlo simulations of galaxy morphologies in the IR based on the 2MASS catalog as a zero-point test for WL (weak-lensing) measurements that will be part of the WFIRST science. Dr. Cannizzo continued work on formulating an efficient strategy for constraining cosmological parameters based on putative WFIRST SN Ia data.

ExoPlanets & Stellar Astrophysics

Optical/UV Detectors (667.001)

Dr. Timothy Norton, who has been out on extended medical leave, did not submit a report this quarter.

Extrasolar Planetary Studies (667.004)

Ms. Aara’ L Yarber has completed the equivalent width analysis for the simulated WFIRST exoplanet data. The purpose of calculating the equivalent widths of simulated spectra is to determine the minimum signal-to-noise and spectral resolution values necessary to detect planetary absorption lines. This work will help determine under what circumstances the WFIRST integral field spectrograph can obtain useful scientific measurements for unusual or unexpected types of planets. Ms. Yarber is currently drafting a report with her results.

WFIRST Microlensing (667.008)

Dr. David Bennett worked with postdoc Dr. Daisuke Suzuki to complete the analysis of the first low magnification microlensing event with signals from 2 planets, event OGLE-2014-BLG-1722. This analysis is nearly complete. Dr. Bennett also supervised the work of Notre Dame graduate student, Aparna Bhattacharya, on the Hubble Space Telescope follow-up observations of planetary microlensing events MOA-2008-BLG-310 and MOA-2008-BLG-379. The paper on the MOA-2008-BLG-310L planetary system has been submitted to the Astronomical Journal. It showed that the star previously identified as a candidate host star does not host the microlens planet. We hope to have a paper completed on MOA-2008-BLG-379 in the next quarter. With graduate student Naoki Koshimoto, who was visiting until mid-March from Osaka University, Dr. Bennett supervised the completed the analysis of planetary microlensing event MOA-2016-BLG-227. As a part of this analysis, Bennett and Koshimoto have developed a new method for interpreting high angular resolution follow-up observations of microlensing events that attempt to detect the planetary host star and determine the masses of the planet and host star. This will be written up as a separate paper.

Dr. Bennett is also supervising NPP Postdoc Clement Ranc, who showed that, contrary to expectations, there is no planetary signal in microlensing event OGLE-2015-BLG-1737. Drs. Bennett and Ranc have also been working with the K2 microlensing team to analyze the data from K2 Campaign 9. In particular, Drs. Ranc and Bennett have worked with collaboration with NYU student Dun Wang to create a C++ version of Wang's Causal Pixel Method (CPM) photometry algorithm. This method will allow the fitting of binary and planetary microlensing light curves to the K2 data while simultaneously correcting for systematic effects in the data. Dr. Bennett has worked on the analysis of 3 additional planetary microlensing events, MOA-2010-BLG-117, MOA-2011-BLG-291, and OGLE-2015-BLG-0954. MOA-2010-BLG-117L is the first planetary microlens system with two bright binary source stars, which significantly complicated the analysis. MOA-2011-BLG-291L appears to be the first planetary microlens system with a source star in the Galactic disk. OGLE-2015-BLG-0954 was previously published by the KMTNet and OGLE Collaborations, but MOA data indicate a mistake in the analysis that led the authors of the previous paper to mistakenly conclude that the planetary lens system is located only a few hundred parsecs from us. Dr. Bennett and collaborators expect to submit papers on all 3 of these events in the next quarter. As a member of the WFIRST Formulation Science Working Group, Dr. Bennett identified a problem with the slew and settle times for the WFIRST telescope that could do serious damage to the WFIRST exoplanet microlensing and supernova programs. In response to this, the WFIRST Project team has added 2 reaction wheels to the spacecraft and is considering higher torque wheels, as well.

Visible Nulling Coronography (667.009)

Dr. Brian Hicks is continuing laboratory development of the Visible Nulling Coronagraph (VNC) and Segmented Aperture Interferometric Nulling Testbed (SAINT) following commencement of work on a NASA Strategic Astrophysics Technology (SAT) Technology Development for Exoplanet Missions (TDEM) award: "Nulling of an Actively-Controlled Segmented Aperture Telescope." The goal of the effort is to demonstrate broadband high-contrast imaging in the presence of complex diffraction using sequentially controlled active

optical elements. In related work, Dr. Hicks is working on two FY17 internal research and development (IRAD) awards to improve coronagraphic throughput and broadband performance, ultimately to improve future exoplanetary detection and characterization capability. Dr. Hicks will conclude work with an intern in the spring of 2017 to model extrasolar object target accessibility based upon future mission parameters. Dr. Hicks submitted a SAT/TCOR proposal to build a Modular Adaptive Segmented Telescope for meeting future large space telescope technology needs including ultra-stable structures, robust coatings, and high-contrast coronagraphic demonstrations. Work on this proposal, if awarded, would take place in calendar years 2018 and 2019.

HEASARC and Guest Investigator Programs

Fermi/SSC (661.001)

During the reporting period, Dr. Chris Shrader' s primary responsibility was the management of the Fermi Science Support Center (FSSC). This includes conducting weekly staff meetings, presentations to the Fermi Users Group, periodic meetings with the project scientist, the NASA HQ program scientist and frequent informal interactions with the FSSC staff. Staffing issues long term planning, and internal staff issues are also important responsibilities. A significant activity during the quarter involved management of the Fermi Guest Investigator proposal cycle. Proposals were due at the FSSC in late February. Plans for an early May Peer Review meeting were finalized. Proposals were logged in, assessed, sorted into 6 committees. Recruitment of peer panelists was particularly difficult, requiring about 220 solicitation emails to secure 43 commitments for participation in the review. Proposals were sorted, assigned to reviewers, posted and distributed in coordination with the HEASARC utilizing the ARK online proposal support system. Shrader continued to address FSSC staffing and budgetary issues as well as conducting weekly meetings and overseeing day-to-day activities. Also, a significant activity involved communications with Cycle-8 and 9 guest investigators and the Code 660 resource analysts to facilitate the implementation of guest Investigator grants issued just prior to the start of the quarter. The FSSC continues to meet and exceed its obligations in this area. Planning for reduced FSSC staffing levels, beginning as early as the start of calendar year 2017, were undertaken. In addition, the FSSC will begin planning to partner with Stanford on certain instrument-specific mission planning activities as the DOE contribution to the Fermi mission is significantly reduced after FY2018. One long-time key staff member left the group at the end of the quarter. This led to a significant level of planning and reassignment of various day-to-day tasks within the FSSC. Oversight of FSSC activities in the key areas of user support, archive and data operations, mission scheduling and planning support and maintenance and dissemination of the Fermi science analysis tools. FSSC operations over the quarter were nominal, meeting or exceeding expectations.

Dr. Shrader with Drs. Kazanas, Tombesi, Fukumura (James Madison University) and Behar (Currently at UMD) continued exploring the application of a MHD-driven accretion-disk wind model to astrophysical data. High-resolution X-ray spectroscopic data for galactic black-hole X-ray binaries, notably GRO J1655-40 as well as to several Seyfert type-1 AGN have now been modeled. An article describing the GRO J1655-40 results was accepted for publication the journal Nature Astronomy and it appeared in March. An accompanying "Nature News" article

describing the paper and the methodologies applied therein was featured in that same volume. The team's results are unique in that for the first time a single model, which computes the gas density, velocity and ionization structure of the outflowing wind, has been able to successfully reproduce a large number of velocity shifted and broadened atomic absorption features. Dr. Shrader, with Drs. Stecker and Malkan (UCLA) continued exploring a study of the radio galaxy contribution to the diffuse gamma-ray background (DGRB) above 100 MeV. The DGRB, which has been measured with unprecedented accuracy by the Fermi Gamma-Ray Space Telescope, is expected to be comprised of un-resolved point source populations plus some possible truly diffuse component such as dark-matter annihilation emissions. Radio galaxies are known to be weak gamma-ray emitters, but they are great in number compared to other contributing populations. Currently published estimates are inconclusive and in contradiction with one another. Dr. Shrader, with Dr. Macomb (Boise State University) and his student, performed a joint Fermi-Swift analysis to investigate an unanticipated sample of radio loud (>~1.5 Jy at 15 GHz) gamma-ray "quiet" AGN. It is unclear whether this sample appears as a result of selection bias or if they represent physically distinct objects which are, for some unforeseen reason, deficient in terms of their Doppler boosting characteristics, which normally leads to gamma-ray emission. The hard-X-ray band could possibly provide a clue towards resolving this issue. A deep search using all of the available Swift/BAT data failed to yield any significant detections. Preliminary results were presented at the January 2017 AAS meeting.

Dr. Elizabeth Ferrara is the deputy manager of the Fermi Science Support Center. She oversees science outreach, documentation development, and user support, including providing user support directly to the Fermi science community. Over the past quarter, Dr. Ferrara has been focused on preparing for the future ramp-down of funding by the Department of Energy, and transitioning oversight of day-to-day operations of the Large Area Telescope commanding and data processing from SLAC to GSFC. She helped organize a software week meeting at SLAC where FSSC and SLAC software support personnel began the process of transferring knowledge. She also coordinated Fermi's presence at the winter AAS meeting in Fort Worth, Texas, and at the "April" APS meeting in Washington, D.C. With Dr. Corbet, Dr. Ferrara has been working with students at the Maryland Institute College of Art, presenting Fermi science topics for their 2D animation class, and helping the students develop these concepts. As part of the operations team, Dr. Ferrara regularly schedules observations for the Fermi observatory, and is often on-call to address target of opportunity requests. This quarter, she has added regular LAT instrument timeline planning, as part of the SLAC transition. Dr. Ferrara maintains the online analysis methods documentation for the observatory, and leads or participates in four FSSC and mission-level meetings each week.

Dr. Ferrara is a full member of the Fermi-LAT collaboration, and focuses her research on catalog development, and the characterization and classification of LAT unassociated sources. She is involved in providing candidate source lists to be used in upcoming proposals for the Arecibo, GBT, Parkes, and GMRT radio observatories focused on radio pulsar searches using Fermi-LAT positions. She attends five different weekly telecons with the LAT team, balanced between science and mission-level topics. She also provides three input products for the LAT catalog analysis; a list of detected gamma-ray pulsars, a list of new radio pulsars discovered since the last ATNF catalog release, and the archive of extended gamma-ray sources. Dr. Ferrara is also a full member of the NANOGrav collaboration, and is serving as their press officer. She is an

active member of the pulsar timing working group, and takes regular shifts observing pulsars at both Green Bank (GBO) and Arecibo (AO) Observatories. She attends three regular telecons for the timing group, search group, and management team, as well as attending the monthly collaboration-wide meeting. Dr. Ferrara is currently maintaining the list of known millisecond pulsars and their evaluation status for inclusion in the Pulsar Timing Array (PTA). She has been the PI of several projects to evaluate groups of pulsars prior to adding them to the PTA.

Dr. Jerry Bonnell has continued to update operations scripts, perform analysis, test science tools software and respond to assigned help desk queries as a member of the Fermi Science Support Center. During this reporting period, he participated in training for Fermi LAT mission planning. He continued to maintain a bibliographic tool for cataloging Fermi-related publications. Working with the FSSC operations group, Dr. Bonnell regularly scheduled the weekly preliminary and final science time lines. This quarter included the development of re-planned timelines for Fermi ToO observations and the generation of Fermi LAT command files.

Dr. Robin Corbet continued supervision of the operations section of the Fermi Science Support Center (FSSC). The work of the operations section includes delivery of weekly scientific timelines and evaluation and execution of Target of Opportunity (ToO) observations. Fermi science operations continued smoothly. In late 2018, the FSSC will assume several of the roles of the Fermi "ISOC" at Stanford which operates the Fermi LAT. The FSSC operations team will take over routine instrument commanding. Dr. Corbet is supervising the FSSC ops team involvement with this, and the FSSC ops team has starting receiving training from the ISOC, and the FSSC scheduled some weeks of instrument operations. No problems were found and it appears feasible for the FSSC to take over these aspects of the ISOC's responsibilities.

Dr. Corbet also continues analysis of long-term Swift BAT light curves of X-ray binaries in collaboration with Drs. Hans Krimm (formerly code 661) and Joel Coley (code 661). A paper on the properties of five high-mass X-ray binaries from BAT observations led by Dr. Corbet approached completion towards the end of this reporting period. In addition, BAT analysis by Dr. Corbet was included in a paper on the Be/X-ray binary IGR J01217-7257 by C. Boon (Southampton) et al.

Dr. Corbet continues his collaboration with the Maryland Institute College of Art (MICA). During this period another group of MICA animation students started working with Code 600 scientists on producing a set of animations related to Fermi and aspects of high-energy astrophysics. Dr. Corbet is an adjunct professor at MICA and is teaching introductory astronomy to these students in parallel with their animation work. Dr. Corbet and Prof. Laurence Arcadias (MICA) gave public presentations on this art/science collaboration at the Farpoint science fiction convention, and at the Enoch Pratt library facilitated by the "popscope" group.

HEASARC (662.007)

Dr. Steve Sturner continued to maintain the INTEGRAL public data archive at the HEASARC as the INTEGRAL archive scientist. He downloads the approximately twice-monthly public data releases from the ISDC and installs them into the HEASARC archive. In addition, there are data that are public as soon as they enter the ISDC archive from the processing pipeline. Examples of

this are various Galactic bulge and disk monitoring programs where the program PI has deemed that the data become public immediately. Thus Dr. Sturner monitors the ISDC archive for new data and downloads this data as soon as it is available. He also performed updates to the INTEGRAL Guest Observer Facility web page. Dr. Sturner has worked with Drs. Tess Jaffe and Mike Corcoran on a project to verify the compliance of the HEASARC mission archives with the documented OGIP standards. He has worked with Drs. Jaffe and Corcoran to develop testing software and protocols. Among the missions Dr. Sturner is responsible for testing are Suzaku, Asca, SAS-2, OSO-8, Fermi, and INTEGRAL. During this quarter OGIP standards testing for these missions was completed and the preliminary documentation of the results has been added to the SEDWIKI page.

Dr. Keith Arnaud continued his work on XSPEC and related software. In this quarter he participated as one of the lecturers at the two-week long COSPAR Capacity Building Workshop in Viedma, Argentina teaching young Latin American astronomers about X-ray astronomy data analysis. He also took part in the 2017 meeting of the International Astronomical Consortium for High Energy Calibration (IACHEC) which brings together X-ray astronomers from around the world to discuss calibration issues. In his capacity as Treasurer of the High Energy Division of the American Astronomical Society, Dr. Arnaud helped organize HEAD activities at the AAS Winter Meeting as well as planning for the HEAD meeting in August later this year.

Dr. Stephen Drake continued his position as the USRA (Interim) Associate Director for CRESST until this cooperative agreement vehicle expired on March 31st, 2017. As part of this position, he attended the weekly CRESST Management Council Meetings and worked with civil service sponsors and the CRESST scientists to ensure that the extension period of the CRESST cooperative agreement continued to be successful. Given that USRA is not one of the institutions in CRESST-II, the follow-on to CRESST, Dr. Drake worked with his USRA Business Manager and Human Resources Department so as to expedite the transition of the 25 USRA employees as they changed from USRA to one of the CRESST II institutions. In addition, Dr. Drake continued to serve as a CRESST group leader and as the CRESST representative on the ASD Colloquium Committee. He was also appointed as the CRESST representative to the Goddard Scientific Colloquium Committee.

Dr. Drake continued his work supporting the HEASARC in its functions of providing the scientific community with high-energy astrophysics and cosmic microwave background data, together with supporting information in the form of web content, catalogs, software and metadata. He attended the roughly bi-weekly HEASARC meetings led by the HEASARC Director, Dr. Alan Smale. In this period, Dr. Drake added 10 new tables to the HEASARC Browse and Xamin databases, including 3 Chandra tables, 1 XMM-Newton table, and 4 radio source catalogs, and updated 3 other tables. In terms of his work for the HEASARC web site, Dr. Drake wrote 16 new items for the HEASARC rss feed, and helped to maintain and update as needed the HEASARC, NICER and NuSTAR web sites at http://heasarc.gsfc.nasa.gov/, http://heasarc.gsfc.nasa.gov/docs/nicer/ and http://heasarc.gsfc.nasa.gov/docs/nustar/, respectively. Dr. Drake continued to generate the HEASARC data volume and download statistics for normal site-monitoring purposes: these statistics (at http://heasarc.gsfc.nasa.gov/docs/heasarc/stats/2016_stats/) are now complete through the end of CY 2016. In 2016, HEASARC users downloaded 154 terabytes (TB) of high-energy data from

the archive, an amount equivalent to 1.9 times the size of the archive, and 12 TB of web pages. In other activities, Dr. Drake continued to oversee Mr. Douglas van Orsow's (INNOVIM) work updating the bibliography metadata for HEASARC data sets: over 1.6 million links between HEASARC data sets from observations made by its 8 primary X-ray missions on the one hand, and papers indexed in the ADS which have utilized these data on the other, have been created as of the end of this reporting period. In his research activities, Dr. Drake participated as a member of the NICER Observatory Science Working Group in their selection of discretionary targets for this mission. As part of this, he submitted a proposal to monitor the active, nearby RS CVn binary system, HR 1099.

During the second quarter of FY17, Dr. Mike Corcoran continued in his programmatic roles as HEASARC Archive Scientist for Fermi and ROSAT, calibration database manager, NuSTAR associate archive scientist, editor of the High Energy Astrophysics Picture of the Week, as well as providing general web content for the HEASARC website and maintaining the Astro-Update website. He participated in HEASARC staff meetings and consulted with the Fermi Science Support Center and Fermi project on archiving, calibration database and data access issues and participated in weekly FSSC meetings. Dr. Corcoran, with Dr. T. Jaffe and Dr. S. Sturner, developed and implemented methods to validate the compliance of FITS files in the HEASARC archive, one of the HEASARC's Prioritized Archive Objectives from the last Programmatic Review. Dr. Corcoran also maintained and updated the HEASARC CALDB. During this quarter there were 7 updates to the HEASARC Caldb including what is expected to be the final release of calibration data for Hitomi. Dr. Corcoran also participated in meetings of the HEASOFT software group. Dr. Corcoran continues to write and maintain the HEASARC Picture of the Week website, and acts as administrator of the HEAPOW facebook group which currently has over 1800 members from around the world. Dr. Corcoran also maintains the Astro-Update website, used by scientists to keep track of updates to important high-energy astrophysics software packages. During this quarter Dr. Corcoran rewrote and implemented the software which updates the astro-update page, which has reduced latencies from about 1 week (often more) to 1 day or less. During this time Dr. Corcoran was first author on a refereed paper published in the ApJ. Dr. Corcoran organizes and leads weekly skype sessions on monitoring the WR 140 long-period massive binary system through its periastron passage (which occurred December 18, 2016).

Dr. Theresa Jaffe continued the work of verifying the HEASARC archives for compliance with OGIP standards. She finished applying the tools she has developed in the previous quarter to every mission on the HEASARC archive and collecting the data on OGIP compliance in the set of metadata files. Dr. Jaffe then wrote tools to present the results as a set of web pages for each mission and for each requirement. These constitute the first level of results for the archives' OGIP compliance. Dr. Jaffe also documented the tools and results on a SED-internal wiki she set up for the private use of the HEASARC. Then Dr. Jaffe began to adapt these tools to be lighter for verifying the entire contents of the archives (as opposed to samples of each data type) for FITS standards compliance and checksum computation. Dr. Jaffe also wrote a python interface to the publicly available hammurabi tool that she maintains and supports for simulating astrophysical observables related to Galactic magnetic fields. This work will be the basis from which she will develop a hammurabi-based Jupyter notebook on Galactic foregrounds for the LAMBDA site. Dr. Jaffe also contributed to a LAMBDA web page on foreground modeling.

Swift/Science Center (662.020)

Dr. Eleonora Troja regularly updated the Swift proposal pages and other Swift webpages and supported Swift users by answering questions that were received through the Swift helpdesk. She interacted with the NuSTAR and ALMA staffs in order to initiate new joint Guest Investigator opportunities with Swift. Dr. Troja continued her research on GRBs observed with the Swift and Fermi satellites. In the past quarter she worked on two first-author publications. The former is already submitted to the journal and Dr. Troja worked on the response to the referees and the paper's revision. The latter manuscript is still in preparation and expected to be submitted within the next 2 months. Dr. Troja is also working (as co-author) on a paper for Swift observations of a fast radio burst. Dr. Troja served as Burst Advocate (BA) for gamma-ray bursts in regular 24-hour rotations and published GCN circulars on the results of the Swift observations. She continued to co-chair the Athena Mission Working Group panel dedicated to target of opportunity observations.

ASD Education and Public Outreach

ASD Communication (660.004)

Dr. Barbara Mattson continued to lead the activities of the Astrophysics Science Division (ASD) Communications Team with oversight from Dr. Amber Straughn (NASA). Sara Mitchell joined the team on January 1 as the ASD's social media lead. During this performance period, Dr. Mattson finalized a draft of a strategic communications plan, with input from the team. The plan was submitted to NASA HQ and when approved will help the team expand its capabilities. Dr. Mattson also wrote a charter for an ASD communications advisory group. This group will provide a Lab-based perspective on communications to help the ASD Communications team determine messaging and story priorities. Dr. Mattson and Ms. Mitchell gave presentations to two ASD Laboratories on the functions of the communications team and opportunities for individuals to participate in communications. Dr. Mattson updated parts of the Imagine the Universe website, the ASD's website for communicating astronomy topics with the general public. During this quarter, Dr. Mattson worked with J.D. Myers (Syneren Technologies), the Imagine web curator, to publish updated pages on neutron stars and pulsars.

During the performance period, Ms. Sara Mitchell focused on re-launching NASA Blueshift, the ASD’ s social media presence on Wordpress, Twitter, and Facebook. As NASA Blueshift was effectively unfunded for three years, necessary updates were identified and completed for each platform. Ms. Mitchell also met with the Goddard social media lead, as well as social media leads for NICER-SEXTANT, TESS, and WFIRST, to discuss opportunities for collaboration between mission-level, division-level, and center-level social media efforts. In particular, current efforts are focused on NICER-SEXTANT, which is scheduled to launch in the next quarter.

APOD (662.032)

Dr. Jerry Bonnell continues to edit and author 50 percent of the Astronomy Picture of the Day (APOD) daily pages. Dr. Bonnell also maintained the APOD archive. Dr. Bonnell presented

invited APOD talks at the Amateur Astronomers Association of New York Lecture Series: American Museum of Natural History, January, 2017, and the Central European Deep Sky Imaging Conference: Linz, Austria, March 2017. In collaboration with Dr. Robert Nemiroff (MTU), Dr. Bonnell submitted a sole source proposal to NASA HQ for continued support of Astronomy Picture of the Day.

Heliophysics Science

Heliophysics, Astrophysics and Solar System Education (670.009)

Dr. Barbara Mattson, Sara Mitchell, and Sarah Eyermann - the Astrophysics Science Division (ASD) Education Team - continued formal work under this task during this quarter. Through their work on this task, the ASD Education Team will infuse astrophysics content into the proposed work of the Heliophysics Education Consortium (HEC) and will build upon its award-winning programs, Family Science Night and Afterschool Universe, to include cross-divisional space science content. During this performance period, Dr. Mattson found subject matter experts within the ASD to help out 10 requestors with activities ranging from judging a science fair, speaking with a scout group, and participating in a student shadowing experience. Dr. Mattson, Ms. Eyermann, and Mitchell have each participated in one monthly HEC incubator working group SIDE by SIDE meetings, which serve the purpose of allowing HEC members to present a project and get feedback and suggestions for improvement from other HEC members.

Ms. Sarah Eyermann – part of the Astrophysics Science Division (ASD) Education Team - continued formal work under this task during this quarter. Ms. Mitchell and Ms. Eyermann presented a half-day workshop for educators on March 7 at the "Extra Learning Opportunities: Promising Practices - Proven Strategies" conference in Harrisburg, PA. The workshop focused predominantly on the NASA Family Science Night program, introducing participants to resources and activities that they can utilize in their out-of-school time efforts with families and children. Twenty-six educators were in attendance, representing U.S. Department of Education 21st Century Community Learning Center grantees from across the state of Pennsylvania. The Astrophysics Education Team is coordinating with conference organizers to hold follow-up professional development opportunities for interested workshop attendees in the summer or fall.

During the performance period, Ms. Eyermann continued to update the Afterschool Universe curriculum support materials. In particular, she focused on finalizing portions of the galaxy-related expansion and refining a session about solar and lunar eclipses in preparation for the 2017 North American total solar eclipse. Ms. Eyermann presented an eclipse-related activity for an Earth to Sky webinar, with support from Dr. Mattson and Molly Wasser (ADNET Systems). Earth to Sky is a partnership between NASA and the National Park Service, and this webinar focused on the August 21, 2017 eclipse, providing activities and background information to Park Service interpreters. Dr. Mattson, Ms. Eyermann, and Mitchell have each participated in one monthly HEC incubator working group SIDE by SIDE meetings, which serve the purpose of allowing HEC members to present a project and get feedback and suggestions for improvement from other HEC members.

During the performance period, Ms. Sara Mitchell continued to update the NASA Family Science Night curriculum support materials. In particular, she focused on refining the session about solar and lunar eclipses, in preparation for the 2017 North American total solar eclipse. Ms. Mitchell updated session text and images with the assistance of new ASD education part-time team member Molly Wasser (ADNET Systems) and ASD graphics designer Patricia Tyler (Syneren Technologies). Ms. Mitchell participated in a Technical Review Committee site visit on March 16 & 17 for a NASA Minority University Research and Education Project (MUREP) grant awarded to the University of the Virgin Islands. The committee reviewed scientific, educational, and administrative aspects of the grant's first year implementation.

Heliospheric Physics

Solar Probe Plus (672.004)

During this quarter Dr. Jason Link assisted in taking pictures and shipping new detectors to CALTECH collaborators as well as participating on weekly teleconferences. At the end of the quarter he traveled to NASA JPL to assist the Epi-Hi team at Caltech in environmental testing of the detector. Also during this quarter the transition between the CRESST and the CRESST-II contract occurred. The work on this task is no longer in scope of the CRESST contract and will be funded through the GPHI contract.

Solar System Exploration

SPASE Model Development (690.004)

For this quarter, work on the Space Physics Archive Search and Extract (SPASE) project continued mainly on the Simulation Resource. The HAPI subgroup continued to develop their server through separate telecons of the members of the subgroup. Their results were discussed at the regular biweekly teleconference for SPASE Data Model Development. Dr. Thieman coordinates and hosts the main SPASE telecons. Future work on describing National Space Science Data Center Archive (NSSDCA) data sets according to SPASE standards may also be a part of this task.

The CRESST funding for the SPASE Data Model task ends on March 31, 2017. The team that will carry on with CRESST II has finally been decided and the extent of the work under CRESST II has been determined as well. Heliophysics work, such as what is done on the SPASE Data Model, will no longer be done within the CRESST II contract. Consequently, this will probably be the last report about the SPASE work within the CRESST reporting system. Dr. Thieman's work on SPASE will likely be funded through the Goddard Planetary Heliophysics Institute (GPHI) in the future.

Dr. Thieman continued to hold regular Radio Jove teleconferences and participate in other meetings and teleconferences for the coordination of the Radio Jove educational project. The Radio Jove Spectrograph Users Group (SUG) and the regular Radio Jove management staff have teleconferences that occur on alternating Tuesdays. The flow of data is expanding for the

archiving of SUG observers data in the Planetary Data System (PDS) and the Paris Astronomical Data Center (PADC). Single frequency data files are usually of the order of 10 MB or less and are not a problem to archive. A day's worth of spectrograph data can be hundreds of MB and are harder to get into the archive. Archiving is usually done through the shipment of hard drives to PDS. The submitted spectrograph data are now being analyzed for possible new determinations of the extent of the Jupiter radio emissions sources in the Central Meridian Longitude - Io Phase probability of occurrence diagrams.

Work continues on the observation of the Great American Eclipse (August 21, 2017) using Radio Jove telescopes. The coordinated observing teleconferences, in preparation for observations to be made during the eclipse, continue about once per month. There is usually a teleconference before each coordinated observing time period to discuss what is to be accomplished and the problems that the observers are having. Radio Jove continues to advertise for Radio Jove observers both inside and outside the path of totality in order to make observations of the effects of the ionosphere on radio emissions received by the Radio Jove observers before, during, and after the eclipse. Now, more than 40 observers have volunteered to make observations. Equipment calibration instructions and observation standards are difficult to enforce among that number of observers but we hope the practice sessions will enable the data to be gathered according to standards, inter-compared, and analyzed for possible new scientific results.

Astrochemistry

DREAM, LRO, VISIONS science (691.003)

Dr. Jason McLain has been collecting data on the desorption kinetics of water, CO_2 and Ar with the new Laser Induced Thermal Desorption (LITD) UHV apparatus for the Solar System Workings (SSW) project titled, “Understanding the Interactions between Rocky Airless Bodies and their Local Environment with New Laboratory Experiments and Exospheric Models,” which was selected for funding for FY16. The LITD experiments sample holder has been redesigned to include a closed cycle helium cryofinger, and the temperature of the sample is currently <50 K. The UHV surface science chamber at the Radiation Effects Facility at GSFC for the DREAM2 project is complete and experiments are underway. Dr. McLain has optimized the neutral atoms source to be used for calibration of the VISIONS2 MILENA instruments, and the MILENA instrument testing is underway. He coordinated and researched the optimal coating to prevent UV light from interfering with the MILENA detectors with LASER Black from Epner Technologies. He designed and fabricated a custom box to deliver the MILENA toroids to Epner. Dr. McLain has submitted two papers. One to JGR Planets titled, "The Statistical Mechanics of Solar Wind Hydroxylation at the Moon, within Lunar Magnetic Anomalies, and at Phobos," which was accepted. Another paper to Icarus titled, "The Martian Dust Devil Electron Avalanche: Laboratory Measurements of the Remediating Effects of Dust-Electron Absorption," is under review. Dr. McLain submitted a Step 2 proposal to SSW. He has used the new FTIR vacuum apparatus in the SPICE lab to determine the optical constants of HCN, C_2N_2 and HC_3N thin-ice mixtures. Dr. McLain has installed an electrode-less Hg UV lamp. This UV lamp is being used for photochemistry studies relevant to Titan's stratospheric ice clouds and prebiotic

chemistry. He is using the redesigned new synthesis manifold to synthesize and purify several new nitrile compounds for study.

Planetary Systems

Cassini CIRS Support (693.001)

Dr. Robert Samuelson spent the past quarter working on a Cassini CIRS Titan limb tangent spectra at 75S, which primarily aims to investigate a massive cloud system that has developed throughout Titan's mid stratosphere at high southern latitudes during late southern fall. This high-altitude south polar (HASP) cloud system is at least an order of magnitude stronger than a northern winter cloud system at 85N observed 10 years earlier by CIRS. The HASP cloud illustrates the rapidly changing conditions within Titan's south polar region, as Titan heads into southern winter. Such changes are both unexpected and highly contrary to the observed configuration as Titan's northern polar stratosphere transitioned out of winter, revealing a relatively slow decay of the cold polar stratospheric temperatures, the strong polar vortex, and the enhancement in stratospheric organic gases and ices. Although good model fits to the HASP cloud were possible using a spherical shell radiative transfer model, it was found that fits to an associated stratospheric ice cloud lower in altitude, represented by a broad spectral emission feature at 220 cm^{-1} (the Haystack), were very poor. However, adjustments to the spherical shell radiative transfer model, enabling variations with latitude along the line of sight, were then incorporated. Very satisfactory fits to the Haystack then became possible, and demonstrated that the Haystack is confined to latitudes south of 67S at this time of year (late Titan southern Fall), suggesting that the Haystack is confined to the south polar vortex prior to the onset of Titan's southern winter season.

Dr. Richard Achterberg continued his routine analysis of Cassini CIRS thermal-IR observations of the atmospheres of Saturn and Titan, including retrievals of stratospheric temperatures on Titan and Saturn and tropospheric temperatures on Saturn, from mapping observations, for monitoring of seasonal change. Titan limb and nadir mapping observations were processed through the T125 flyby in November 2016. Saturn mapping observations were processes through orbit 242 in September 2016. Dr. Achterberg also worked on determining the helium abundance on Saturn by combining Cassini CIRS spectra with Cassini radio occultation data, obtaining preliminary results from mid-latitude occultations taken in 2007 and 2008. He also implemented a Markov Chain Monte Carlo code for estimating the uncertainties in the retrieved helium abundance. In addition, Dr. Achterberg created Cassini pointing designs for a subset of the CIRS observations of Saturn, and for observations designed for determining the effect of sunlight on the CIRS telescope on the calibration of CIRS spectra. He was also the CIRS representative for the Cassini S99 sequence implementation processes. Dr. Achterberg attended the CIRS team meeting held at GSFC in February 2017 and presented talks on Saturn' s helium abundance, and on the offset of Titan's stratospheric atmospheric rotation axis from the solid body rotation axis.

LRO/LEND Epithermal Neutron Flux Measurements (693.002)

Dr. Timothy A. Livengood is pursuing the next step in the exploration of hydrogen and water on the Moon and other solar system targets. He is the Deputy Principal Investigator of the proposed

instrument Submillimeter Observation of Lunar Volatile EnvironmeNT (SOLVENT) for the NASA contribution to the Korea Pathfinder Lunar Orbiter (KPLO), with PI Dr. Gordon Chin. SOLVENT will be a high-spectral resolution instrument to detect tenuous water vapor above the Moon's surface to characterize its spatial and temporal variability. KPLO instrument selection currently is expected in mid- to late-April. SOLVENT will be able to detect gaseous water in transport above the surface by direct thermal emission at low temperatures, with sensitivity of 10^{12} H_2O/cm^2 in 120 sec, down to as small an uncertainty as 10^9 mol/cm^2 over the full mission. This level of sensitivity will powerfully test Dr. Livengood's proposed processes for transporting water over the lunar surface at the dawn terminator. SOLVENT's capabilities are applicable to other solar system targets. He is working with Dr. Chin to develop a proposal to pursue developing instrumentation to combine the laboratory's current infrared heterodyne capabilities with sub-millimeter and terahertz detection strategies for the exploration throughout the solar system of cold tenuous gases representing critical volatiles in low-temperature environments or outgassing from icy bodies such as Europa, Enceladus, comets, or asteroids. Dr. Livengood has also been involved in discussions that may lead to a PICASSO proposal to develop an advanced low-mass high-sensitivity thermal-neutron detector suitable to be deployed on Cubesats or other planetary spacecraft. He recently submitted a manuscript on results from the Lunar Exploration Neutron Detector for consideration by Planetary and Space Science for their special issue on Lunar Reconnaissance Orbiter results. This manuscript currently is being considered by a third referee. The manuscript is on evaluating neutron populations that contribute to the detected neutron count rate by LEND in three of its detector systems. Dr. Livengood is PI of a proposal for which the first-year component has been accepted to conduct a reanalysis of Cassini CIRS infrared spectroscopy of Jupiter from the flyby in 2000-2001, with contributions from infrared heterodyne spectroscopy conducted at the NASA IRTF by the heterodyne group at Goddard. The proposal has been requested to be resubmitted with budget for Years 2 and 3, due to a book-keeping error in submitting the original proposal that led to confusion over the structure and quantity of the original budget. Dr. Livengood is leading three proposals to Solar System Observations for: infrared heterodyne observations of Jupiter in parallel with the Juno mission; isotopic characterization of carbon dioxide in Venus; and atmospheric conditions in the Hellas Basin on Mars.

Investigation of Exoplanet Atmospheres Using Keck (693.003)

Mr. Patrick Tamburo continued his work on the super Earth 55 Cancri e, along with collaborators Dr. Avi Mandell and Dr. Drake Deming. An analysis of six transit observations of the planet showed agreement with past studies, and revealed stronger evidence for variability in the planet's apparent radius at 4.5 microns from 2011 to 2013. Mr. Tamburo generated models to explain the planet's transit and eclipse variability, and attempted to reconcile those models with possible volcanic activity. His work, which will shortly be submitted to Monthly Notices of the Royal Astronomical Society, concludes that while volcanic activity may explain the observed variability, further observations will be required to constrain the timescale of variability.

Voyager IRIS Data Restoration (693.004)

In the reporting period, Dr. Valeria Cottini prepared a proposal with title "CUVE - Cubesat UV Experiment: Unveil Venus' UV absorber with Cubesat UV Mapping Spectrometer," submitted at

the end of November 2016 to the NASA program NNH16ZDA001N-PSDS3: Planetary Science Deep Space SmallSat Studies. This proposal was selected for award, which includes a Mission Planning and Design Lab study to be completed in six months. Dr. Cottini started to work on the instrument design for the project. She investigated water vapor abundance in Titan's stratosphere using all the available data acquired by the Composite InfraRed Spectrometer on board of the Cassini mission to the Saturnian system. The main goal was to retrieve a water profile using the two usual CIRS limb observations staring at 125 km and 225 km and then adding the custom made and newly acquired observations staring at only one altitude, 175 km. This will add one more point to the water profile, which will be an important constraint to photochemical models of oxygen species on Titan. Both limb and nadir data were selected around the equator and averaged (one on-disk average and three different limbs averages) to have sufficient signal to noise and a homogeneous temperature profile to use in the model to fit the data and retrieve the water abundance. Other two molecules, allene and acetonitrile were also investigated in CIRS spectrum to detect their presence. Results were presented at the CIRS Team meeting, GSFC, February 1-3, 2017, in the talk by Cottini et al. discussing Titan's stratospheric water vapor from Cassini-CIRS data.

Mars Atmosphere Radiative Transfer Modeling (693.008)

Dr. Alain Khayat has completed a ground-based campaign targeting volcanic gases in the atmosphere of Mars. This multi-band search required the development of radiative transfer models in the atmosphere of Mars at infrared, microwave and submillimeter wavelengths. The last paper detailing such campaign was submitted to the journal "Icarus" and is now under review. It is entitled: "A deep search for the release of volcanic gases on Mars using ground-based high-resolution infrared and submillimeter spectroscopy: Sensitive upper limits for OCS and SO2." Dr. Khayat and his colleagues found out that there is no major volcanic outgassing in current Mars, and placed upper limits on sulfur-bearing species that could be released during such outgassing event. Dr. Khayat also presented an abstract at the "Sixth International Workshop on the Mars Atmosphere" in Granada, Spain, entitled "Ground-based high-resolution infrared and submillimeter searches for the release of volcanic gases on Mars." He conducted an analysis with Dr. Michael D. Smith on the inter-annual-variations of atmospheric water vapor on Mars by creating water vapor maps with data returned from the Mars Reconnaissance Orbiter's Compact Reconnaissance Imaging Spectrometer for Mars (CRISM), and a manuscript led by Dr. Smith that Dr. Khayat is co-authoring is in preparation. Dr. Khayat is now leading the analysis of CRISM data over the North polar regions of Mars by developing retrieval algorithms looking for water vapor at several Mars seasons, while taking into account the presence of surface ice on the planet. The main objective of this work is to study the variability of water vapor abundance above the northern polar cap of Mars and provide insights on the water cycle above the cap; the main reservoir of water in the atmosphere of Mars. He is also involved in preparing a manuscript about a concept study for a New-Frontiers class robotic mission to Uranus entitled "OCEANUS: A Focused Mission to the Uranus System." The main objectives of this mission are to explore the origins and evolution of planetary systems by studying Uranus' interior structure, magnetosphere, and atmosphere. Dr. Khayat also co-authored two abstracts related to the study, and they were submitted to the Planetary Science Vision 2050 Workshop 2017 entitled "New Frontiers-Class Missions to the Ice Giants," and to the Lunar and Planetary Science XLVIII

(2017) entitled “OCEANUS: A Uranus orbiter concept study from the 2016 NASA/JPL planetary Science Summer School.”

Titan's Particulate & Thermal Properties (693.010)

Dr. Robert Samuelson spent the past quarter working on a Cassini CIRS Titan limb tangent spectra at 75S, which primarily aims to investigate a massive cloud system that has developed throughout Titan’s mid stratosphere at high southern latitudes during late southern fall. This high-altitude south polar (HASP) cloud system is at least an order of magnitude stronger than a northern winter cloud system at 85N observed 10 years earlier by CIRS. The HASP cloud illustrates the rapidly changing conditions within Titan’s south polar region, as Titan heads into southern winter. Such changes are both unexpected and highly contrary to the observed configuration as Titan’s northern polar stratosphere transitioned out of winter, revealing a relatively slow decay of the cold polar stratospheric temperatures, the strong polar vortex, and the enhancement in stratospheric organic gases and ices. Although good model fits to the HASP cloud were possible using a spherical shell radiative transfer model, it was found that fits to an associated stratospheric ice cloud lower in altitude, represented by a broad spectral emission feature at 220 cm^{-1} (the Haystack), were very poor. However, adjustments to the spherical shell radiative transfer model, enabling variations with latitude along the line of sight, were then incorporated. Very satisfactory fits to the Haystack then became possible, and demonstrated that the Haystack is confined to latitudes south of 67S at this time of year (late Titan southern Fall), suggesting that the Haystack is confined to the south polar vortex prior to the onset of Titan’ s southern winter season.

Dr. Achterberg performed retrievals of stratospheric temperatures on Titan from limb observations taken between May and November 2016.

Planetary Magnetospheres

Analysis of Solar Radio Emissions and Plasma Waves (695.001)

Dr. Thejappa Golla is investigating the in situ wave phenomena observed in the vicinity of interplanetary shocks. The motivation is to understand the collisionless dissipation, upstream wave phenomena and heating of the downstream regions of interplanetary shocks. He was invited to present his results in the 16th Annual International Astrophysics Conference: “Turbulence, Structures, and Particle Acceleration throughout the Heliosphere and Beyond,” March 6 - 10, 2017, in Santa Fe New Mexico. He is writing up these results for publication in the proceedings of the conference.

Science Support for Particle and Soft X-ray Instrumentation (695.002)

VISIONS II is the follow on mission, from the VISIONS sounding rocket mission, for which the GSFC team is contributing two Neutral Atom Imaging instruments. Options were investigated regarding changes that need to be incorporated in the electrostatic analyzer for this particular launch. In particular, this launch will take place during daylight hours, so steps need to be taken

to prevent the detectors from being saturated by UV photons. A company was identified who could coat the internal electrostatic elements with a propriety coating "Laser Black." This has a high absorption coefficient for UV light, so the detectors will not be saturated due to photons reaching them. Dr. Dennis Chornay assembled six microchannel plate detectors that form a complete set for one of the sensors. In order to determine operational voltages and amplifier thresholds, he used an electron source to stimulate them and recorded their response as a function of both parameters.

Dust Scattering in the Lunar Exosphere (695.003)

Dr. David Glenar constructs simulations of light scattering by lunar exospheric dust in support of both ongoing archival searches and new searches by orbiting spacecraft. Optical detection and analysis of a dust exosphere on the Moon provides insight into dusty plasma processes common to all airless bodies. A manuscript, "Absence of a Detectable Lunar Nanodust Exosphere during a Search with LRO's LAMP UV Imaging Spectrograph" (first author, C. Grava), has been peer-reviewed and resubmitted to Geophys. Res. Letters (GRL). Dr. Glenar provided modeling simulations for this study. This work was presented as a poster at the March 2017, Lunar and Planetary Science Conference (LPSC), Woodlands, TX. Two Solar System Workings (SSW) proposals were submitted, with the objectives of simulating optical scattering from the known lunar ejecta dust cloud (C. Grava, PI), and simulating optical hazard and dust plume detection for the much of the technical input for both proposals.

Dr. Yongli Wang did not submit a report this quarter.

Juno and MAVEN Scientific Support (695.005)

Dr. Jacob Gruesbeck works with the Magnetometer team of the MAVEN spacecraft, performing data validation, software development, and research. He continues the independent validation of the magnetic field orientation using estimations from calculated from the solar wind strahl electron population observed by SWEA. Dr. Gruesbeck received referee comments for a manuscript discussing an analysis on the asymmetric nature of the Martian bow shock, and work is being done to respond. Dr. Gruesbeck also continues to work on analyzing the Martian magnetosphere during time periods when Mars is being impacted by interplanetary coronal mass ejections. A large set of events has been compiled and a statistical study is underway to determine the impact on the Martian system by Heliospheric events. Dr. Gruesbeck also submitted a letter for publication discussing an analysis of magnetic field observations obtained by the Juno spacecraft on its journey to Jupiter. Variability in this dataset was compared to similar datasets from previous solar cycles to put the current set of observations in context.

Dr. Gina DiBraccio has continued her research as a member of the MAVEN science team by analyzing in situ magnetic field and plasma data to understand atmospheric loss at Mars. Dr. DiBraccio has published a first-author paper in the "Journal of Geophysical Research - Space Physics" on current sheet dynamics in the Martian magnetotail. Her collaborations have resulted in an additional five publications that have recently been accepted. She has expanded her scientific capabilities by joining the Juno science team in order to investigate magnetospheric dynamics at Jupiter. Dr. DiBraccio submitted a ROSES proposal to NASA's Solar System

Workings on the "Investigation of transient plasma structures at Venus and Mars." She served as the social media facilitator at NASA's Planetary Science Vision 2050 Workshop. Dr. DiBraccio volunteered her time as a Postdoc mentor for the Solar System Exploration Division, a participating in Wakefield High School's Career Day, and as a guest speaker at NASA GSFC's Visitor Center. Finally, aside from her research and outreach, Dr. DiBraccio also advised an undergraduate intern.

Dr. Yasir Soobiah has been performing scientific support duties for the Magnetometer (MAG) instrument on the NASA MAVEN spacecraft. This includes validating MAG data with MAG team members to the MAG data for delivery to the PDS and contributing analysis in collaboration efforts with other members of the MAVEN science team. Dr. Soobiah has been supporting MAG team operations through telecons and has been supporting wider Particle and Fields Package (PFP) and MAVEN team operations through TOHBAN duties selecting periods for burst download. He has been developing new tools for use by the MAG team to help scientific analysis. He has also continued with a research goal to prepare a draft manuscript on the study 'Plasma dynamics in low altitude regions of the crustal magnetic field of Mars.' This has required learning and conducting new analysis using 2-d ion velocity distributions in regions of crustal magnetic field of Mars, and Dr. Soobiah has presented results of this work for a PFP weekly science telecon, as well as prepared a first draft manuscript including this analysis. Dr. Soobiah has also progressed on a further study collaborating with MAVEN colleagues at the Laboratory for Atmospheric and Space Physics, University of Colorado to understand the space plasma processes related to the discrete Martian aurora. He has presented results of the study on a MAVEN team science telecon and will be conducting further work on this study for an oral presentation at the International Conference on Mars Aeronomy in May 2017.

During the last three months, Dr. Stavros Kotsiaros was working on the scientific support to the data calibration and data quality control for Juno. More specifically, he has made significant progress toward the characterization and explanation of perturbations in FGM data caused by induced currents on the spacecraft. A Finite Element Model has been developed characterizing the induced currents and an elaborate data analysis has been performed using Juno FGM periapsis data. The model fits the frequency perturbations seen in the data. Preliminary results have been presented in the dedicated Juno science meetings. Currently and during the following months, the model and the data analysis tools are being refined and are expected to give valuable insights on spacecraft generated currents in the Jovian magnetosphere.

Planetary Geodynamics

Analysis of LOLA, LRO, and GRAIL Data (698.002)

Dr. Sander Goossens analyzes raw tracking data from several planetary missions with the goal of determining high-resolution gravity field models of the planets in order to study their interior structure. He is currently working with data from the GRAIL mission to the Moon, data from MESSENGER to Mercury, and data from Mars orbiters. He also has a grant to re-analyze Magellan data around Venus, and to augment this data set with Venus Express data. Dr. Goossens has been working on determining bulk crustal density values from gravity and topography data by applying a well-chosen constraint in the gravity field determination process.

A manuscript describing results for Mars has been revised and resubmitted. The work in this manuscript shows that significant lateral variations in crustal density exist for Mars. This same constraint has been applied to lunar gravity field models using GRAIL data. These models have a very high resolution (a block-size of 4.5 km × 4.5 km at the equator), and the new constraint allows the determination of density variations at smaller scales than before.

Dr. Goossens was a co-author on a paper on small-scale density variations at the Moon that was recently published online at Icarus. He presented a preliminary gravity field model for Venus at the Lunar and Planetary Science Conference in The Woodlands, Texas (March 20-24, 2017). This presentation shows results from a one-step inversion using only Magellan tracking data, and it outlines how the dense atmosphere of Venus affects gravity field models derived from Venus orbiter tracking data. Finally, Dr. Goossens has started work on using gradiometer measurements of the gravity gradient as a tool to estimate the gravity field of a planet. The initial tests focus on using gradiometry at Mars.

Planetary Ocean Dynamics and Magnetics (698.003)

Dr. Robert Tyler did not submit a report this quarter.

Studies in Planetary Volcanology (698.004)

Dr. Patrick Whelley studies volcanic deposit morphology with topographic data derived from space-borne, airborne and terrestrial laser scanners. He manages the comparative volcanology group with members from Codes 690 and 610. Dr. Whelley submitted proposals to NASA's Solar System Workings Program to fund his research. He is revising a manuscript, after receiving a favorable review titled: "LiDAR-Derived Surface Roughness Signatures of Basaltic Lava Flow Textures at the Muliwai a Pele Lava Channel, Mauna Ulu, Hawaii," to the Bulletin of Volcanology. He resubmitted a manuscript titled: "The Emplacement Dynamics of Pumice Lobes Ascertained from Morphology and Granulometry; Examples from the 1993 Deposits at Lascar Volcano, Chile," after revising the text. He performed a field reconnaissance trip to the Potrillo Volcanic field to prepare for a full field excursion in June. Dr. Whelley presented research at the 2017 Lunar and Planetary Science conference in March.

No report received from Ms. Niki Whelley.

Planetary Environments

MOMA-MS (699.001)

The Mars Organic Molecule Analysis (MOMA) instrument is the part of the ESA 2018 Exomars mission. Dr. Shawn Li is the mass spectrometer scientist supporting the instrument development and sample testing. Dr. Li leads the laser desorption/ionization (LDI) test on the blister package sample to check the cleanness. The LDI result shows the blister package is clean enough to behave as the contamination check material, which is consistent with the GC tests results. As the first author, Dr. Li submitted a draft about the LDI mode of MOMA instrument to the special

issue of International Journal of Mass Spectrometry. The paper has been accepted and will be published soon.

During the past quarter, Dr. Benna continued his support to the MOMA project by advising on the development of the instrument's aperture valve.

Dr. Andrej Grubisic extensively supported the integration and testing (I&T) effort on the MOMA Mass Spectrometer (MS) during this quarter. He led the definition and subsequent testing of the automatic gain control (AGC) algorithm for optimal science return during laser desorption mass spectrometry (LDMS) mode of operation of the MOMA-MS, both as part of the Thermal Vacuum (TVAC) test campaign as well as a separate LDMS test campaign on the engineering test unit (ETU). He continues to be the Science lead on the atmospheric pressure valve (APV) redesign team, where his expertise is utilized to test and advance the design in order for it to meet the critical lifetime, leak rate and signal stability requirements.

Dr. Dennis Chornay continued to work on experiments designed to validate the instrument concepts put forward in the SPace-Environment and Compositional Investigation near the European Surface (SPECIES) proposal. In brief, the proposed instrument employs enrichment cells to collect samples from the upper atmosphere of Europa during a flyby. Once the spacecraft has exited the high radiation environment of Europa, the cells will be heated up to release the adsorbed gases, which are then be mass analyzed using a quadrupole mass analyzer, or pass into a gas chromatography instrument for analysis. The collected gases strike the enrichment cell at 4km/s during the flyby. The purpose of the laboratory experiment is to verify that these molecules are not fragmented due to this impact velocity. Experiments were performed earlier in the year using Phenathrene as the sample of interest. The Phenanthrene was heated in a vial under vacuum, and the resulting vapor is then ionized by electron impact in an ion gun. The resulting ions are accelerated to the desired energy, typically from 15eV to 40eV and presented to a target for collection. Using Laser desorption spectroscopy techniques, the team was unable to detect any of the phenanthrene that may have been collected on the target. The experimental setup was reconfigured to incorporate a Quartz crystal microbalance (QCM). This device can detect the small amounts of sample that may be deposited. Electrostatic lenses were also designed and incorporated in the beam line to concentrate the beam onto a small, 5mm diameter target. This significantly reduced the time required to accumulate sufficient material for the QCM to be able to detect. This past quarter, the team was finally able to run the experiment successfully, and collect the rate of deposition of phenanthrene for a number of energies.

SAM (699.002)

Dr. Dina Bower has been working on the development of new protocols for the analysis of heavy noble gases (Argon, Krypton, Xenon) and their isotopes in geologic materials, with a current focus on the three isotopes of Argon and the nine isotopes of Xenon. She ran a series of calibrations measuring noble gases evolved from geologic samples using step heating methods starting with measurements of Argon in obsidian glass. The calibrations were successful and measurements of Argon-doped samples in a similar lithology will begin in the next couple of months. Following the success of the Argon measurements, Dr. Bower will put these new protocols into practice for the measurements of both Argon and Xenon in terrestrial chert

samples for Mars analog studies. To increase the success of multiple measurements, Dr. Bower has acquired a cold trap that will be integrated with the noble gas prep system, and she will oversee the installation in June of this year. She is also preparing to integrate a laser desorption microscope with the mass spectrometer with the goal of evolving heavy noble gases from fluid inclusions. Dr. Bower has established a good baseline with the furnace and laser desorption microscope. Regularly scheduled measurements of noble gases in geologic samples from Mars relevant lithologies will begin in the next couple of months.

Dr. Bower has also begun collaboration with Dr. Barbara Cohen to merge two noble gas labs at GSFC. Dr. Bower is a co-I on a proposal submitted to NASA Habitable Worlds (PI, Andrew Steele) to characterize meteorite samples and the products of electrochemical organic carbon experiments.

Mr. William Sluder, a student at University of Maryland, is working as a code developer for the VPL team's modeling code: Atmos. His main priority is updating the cross section and quantum yield section of the code. The input format has been redesigned and he continues to implement new methods and functionality. Through this process, Mr. Sluder is also diversifying the usability in terms of analyzing specific reaction rates. The code has been simplified to allow the rest of the VPL to choose which data sets to use for specific species. The final goal is debug and successfully use more up-to-date cross section and quantum yield data on the majority of species and reactions currently being modeled.

Dr. Slavka Carvalho Andrejkovičová is working with Dr. Amy McAdam on projects related to the SAM instrument in support of the MSL mission. Dr. Andrejkovičová has been focusing on development of methods to characterize a variety of Mars analogue samples (Hawaii, Australian acid lakes and Antarctica) including artificial mineral mixtures. She installed and successfully used RockJock XRD software to distinguish different amorphous and crystalline phases in Mars analog samples. She also installed and used FULLPAT XRD software to determine mineralogical composition of Mars analog samples. Fullpat is used by MSL CheMin team to identify the mineralogical composition of Mars samples drilled by the Curiosity rover. Knowledge of the detailed mineralogy of analog samples is crucial to interpretation of SAM data. In addition, Dr. Andrejkovičová developed protocols for the most accurate determination of the bulk chemistry of powdered samples of geological materials using a newly acquired X-ray florescence (XRF) spectrometer. Using XRF, she also analyzed several Mars analog samples to determine their elemental composition. This information will allow more detailed comparisons to analyses by the Curiosity Rover. Dr. Andrejkovičová was trained on the Isotope Ratio Mass Spectrometer for analysis of isotopic composition and hydrogen abundances of Mars analog samples supporting the SAM experiment on the Curiosity Rover. In March 2017, Dr. Andrejkovičová was one of the authors on a poster with the title: “Constraints on the mineralogy of Gale crater mudstones from MSL SAM evolved water,” and one of the authors on a lecture: “Studies of young Hawaiian lava tubes : Linking geophysics, geochemistry, mineralogy and habitability in basaltic subsurface environments on Mars,” which were presented at the Lunar and Planetary Science Conference and Astrobiology Science Conference, in Woodlands, Texas.

Ms. Christine Knudson, a Faculty Specialist with CRESST/UMCP at NASA Goddard Space Flight Center, is working with Dr. Amy McAdam analyzing Mars analog materials that are

directly relevant to interpreting Mars Science Laboratory (MSL) Sample Analysis at Mars (SAM) flight data. Evolved gas analysis (EGA) as well as X-ray diffraction (XRD) of Mars-like mineral mixtures and analogs is ongoing. Ms. Knudson is working to further calibrate a recently acquired Bruker M4 Tornado Spectrometer for X-ray fluorescence (XRF). She is continuing the work on an analog of one of the MSL samples which can be analyzed by multiple instruments, including, XRF, XRD, and EGA in order to replicate the types of analyses performed by MSL on Mars. Ms. Knudson is also continuing with interpretation of H_2 and H_2O EGA data from a variety of phyllosilicate samples run under SAM-like conditions to aid in the interpretation of SAM, EGA, H_2, and H_2O data. In March, Ms. Knudson attended the Lunar and Planetary Science Conference, where she was the coauthor on two abstracts titled, “Constraints on the mineralogy of Gale Crater Mudstones from MSL SAM evolved water,” by McAdam et al. 2017 and “Studies of young Hawaiian lava tubes: Linking geophysics, geochemistry, mineralogy and habitability in basaltic subsurface environments on Mars,” by Bleacher et al. 2017.

During the past quarter, Dr. Benna continued to provide support to the SAM instrument and the MSL mission through the use of the SAM numerical simulator (SAMSIM) for the development and the validation of all the SAM flight sequences.

This past January-February Dr. Williams completed his study of the effects of varying experimental parameters on the reduction of unwanted reaction byproducts in the Sample Analysis on Mars (SAM) wet chemistry experiments. In March, he began the planning and setup of two Martian analog studies focused on samples from the Atacama Desert as well as Cherts. He also completed necessary additional safety training for a third study involving irradiated samples.

MATISSE/LTMS (699.003)

Dr. Shawn Li is working on a MatISSE funded project for developing liner ion trap mass spectrometry (LITMS). Dr. Li and coworkers designed a chamber (so called "Mars box") that can adapt the mass spectrometer and perform the test in the lab. All the needed parts have arrived, and the chamber has been cleaned and will be baked soon. The LITMS based instrument concept, EMILI (Europan Molecular Indicators of Life Investigation) has been granted by the ColdTech project. Dr. Li is leading the LDI tests and cryogenic core handling system development. Dr. Li is also working on a PICASSO funded project for developing LCMS coupled to a time-of-flight mass spectrometer. The instrument will enhance the detection sensitivity of organic molecules. Dr. Li leads the implementation of the deposition module to the prototype mass spectrometer, as well as the analog samples tests. A paper describing the instrument has been presented on IEEE Aerospace 2017 conference and 48th LPSC conference.

Mr. Marco Castillo is a Faculty Specialist with CRESST/UMCP, working in the Planetary Environments Laboratory (PEL), mainly as part of the MOMA instrument development team. MOMA is currently under development for the European Space Agency’s ExoMars 2020 rover. Mr. Castillo provides support for MOMA breadboard, MOMA Engineering Test Unit (ETU), and MOMA Flight Unit operations and testing as part of the MOMA MS science team. Since Fall 2016, Mr. Castillo has been directly involved with the testing of MOMA aperture valve (APV) prototypes providing support with installation, testing, and characterization of MOMA

APVs using a MOMA breadboard instrument as well as data analysis resulting from these tests. He is also a part of the EMILI instrument development team and provides support with the ongoing design and development of an EMILI breadboard instrument. Mr. Castillo is also working with Dr. Ricardo Arevalo, Jr., of the PEL, utilizing a laser ablation inductively-coupled plasma mass spectrometer (LA-ICP-MS) instrument and has been directly involved in coordinating with instrument company technicians to upgrade and repair the instrument and instrument software as well as the day-to-day operations of the instrument. Additionally, Mr. Castillo continues to support the development of the Atmospheric Organic Molecule Analyzer (AtmOMA) instrument. AtmOMA is a low temperature plasma (LTP) source linear ion trap mass spectrometer based on MOMA which will allow analysis of key low-concentration molecular markers in solid samples at ambient pressure.

Dr. Andrej Grubisic continued his involvement in the development of the advanced linear ion trap mass spectrometer (LITMS) in the PEL. He designed and successfully demonstrated the negative ion detection capabilities of the LITMS brass board (BB) instrument. He continues to be closely involved in its performance optimization, final definition of the gas calibration mixture composition and signal stability characterization as the instrument is being readied for an upcoming environmental test campaign at Honeybee. Dr. Grubisic was also closely involved in several other research and development efforts in PEL. For example, he successfully led the definition, design, assembly and initial testing of the test chamber that looks to demonstrate in vacuo deposition of liquid extracts followed by LDMS analysis via a prototype laser desorption ionization time-of-flight MS as part of the MACROS project. He has also led the modeling, evaluation and redesign of the differential pumping system on the advanced resolution organic molecule analyzer that is being matured to TRL 3 as part of the AROMA effort. Finally, he is the Task lead on the EMILI project, where he is responsible for prototype ion trap mass spectrometer redesign and testing in an effort to get MOMA/LITMS-like instruments back up to TRL 6 for a Europan environment.

Mr. Benjamin Farcy has been collecting data on plasma recombination of C and N bearing species following the experimental plan organized based on previous results. The data show that CN bonds are most likely forming from the experiments, which confirms the hypotheses on which these experiments are based. Further experiments that would confirm these results are planned for May, with the use of isotopically-doped N and C compounds to show changes in the mass spectra and inform about the laser plasma recombination process. More engineering of the formamide water impact cell apparatus was done recently, and a new set of sample holders was designed in CAD and is currently being manufactured by a machine shop. This will allow less sample loss and contamination, and provide the most likely environment for new organic molecules to form in response to laser plasmas. Formamide impact/LCMS analysis is tentatively planned for May or June. With these new updates to the experiment, both in terms of results and system updates, hopefully enough results will be gathered by the end of the summer to warrant a publication.

MAVEN/NGIMS Science Support (699.004)

During this period, Dr. Benna continued his support of MAVEN operations in orbit around Mars by leading the NGIMS instrument operations and data processing. He also delivered the first data

set of the new thermospheric winds measurements that were collected between April 2016 and March 2017.

Dr. Meredith Elrod produced the various necessary NGIMS data products for the MAVEN team on time for each PDS delivery. Each PDS delivery is a three month set. With no new revisions, as occurred this last quarter, it is matter of simply re-processing. If they are planning new revisions, like are planned for the April and May delivery, it generally takes a few months of planning and testing. The April/May 2017 delivery did include a new revision on CO, which was planned throughout Quarter 2 of 2017. Over time, there is a new revision of the entire data set re-processed as it is for the April/May delivery. If there is no new revision as was the case for February, then just the previous three months are processed and delivered. PDS was successfully delivered in February for the second quarter.

Dr. Elrod continues to work with a recently graduated student, on the NGIMS data in MSE, in coordination with Dr. Shannon Curry at the UC Berkley, comparing the neutrals and ions with mag fields and ion flux to determine the effects of sputtering on the upper atmosphere. The former student, Ms. Hayley Williamson, presented preliminary findings of this work at LPSC. Continued discussion is required as the results continued to be puzzling and inconclusive. Dr. Elrod has started working on a project to re-examine the methods to compute neutral scale heights in the Martian atmosphere using MAVEN NGIMS and IUVS data. Currently the MAVEN team has over six different methods to compute scale heights from the data, all with different assumptions. These scale heights do not always agree and will cause difficulties with modeling efforts. Additionally, there are no scale heights currently computed for species other than Ar. The project is in early stages right now, and preliminary results are likely to be shown at the International Mars Aeronomy Conference in May 2017. Dr. Elrod continues to support the operational side of the NGIMS and MAVEN teams, as needed. She has been training other team members on data delivery and product creation in order to free up time for science analysis. As a result, not only is she attending all the operational meetings, but she is also helping with script delivery and approvals.

In January 2017, Dr. Elrod began downloading Mars Orbiter Mission (MOM) MENCA data from the ISRO in order to begin a new project researching the comparison between the MENCA and NGIMS data. MOM began its orbit around Mars around the same time that MAVEN did. MENCA is a similar MMS to NGIMS and the comparison of neutral data could be useful. MOM officially released its first year of data around late October 2016. Unfortunately, none of the MENCA spice data has been included with the original download, and Dr. Elrod has continued to be in contact with the ISRO team to correct this. Without spice data, there is no method of determining space craft position or pointing; so, the data are meaningless. Timeline on the updates is still pending. Dr. Elrod also co-authored a paper with Dr. Robert Johnson on the Cassini proximal orbits using previous work done on Cassini CAPS data and analysis done through her thesis work. Additionally Dr. Elrod traveled to San Antonio, TX to work with the CAPS and INMS team to close out ring observation and to determine the submission process of the plasma data into the PDS. She also worked with the INMS team to help with proximal orbit planning and close out details that are needed from Goddard. Finally, Dr. Elrod attended the Planetary Vision 2050 meeting at NASA headquarters to present a future mission concept in a

lightening talk. She also helped to represent the PEL and take notes on the meeting in order to get some ideas for the group related to future mission ideas and proposal planning.

Sellers Exoplanets Environment Center (699.005)

Ms. Amber V. Britt is continuing her work on simulating the presence of methane (and other trace gases) in the present day Martian atmosphere. Simulation results provided insight to the time dependence of methane production, and Ms. Britt presented such results at the 2016 American Geophysical Union (AGU) conference in San Francisco. Ms. Britt also participated in the Postdoc and Early Career Scientist Poster session where she presented her Mars work to fellow scientists in Code 690. Ms. Britt also submitted an abstract to AbsciCon 2017 to present on new simulation results that involve ongoing work. She continues to actively develop the photochemical code with colleagues during weekly hack sessions, and is working toward validating the Mars photochemistry for the next code version release. Upon validation, Ms. Britt plans to gather Mars simulations and results for publication as well.

Dr. Ravi Kopparapu continued work on multiple projects. (1) Dr. Kopparapu, along with his collaborators, updated a 3-D climate model with new water-vapor absorption coefficients that are critical to determine the inner edge of the Habitable Zone (HZ) around M-dwarf stars. A paper with these results is in preparation. (2) Using Kepler mission data, Dr. Kopparapu is leading a project to determine the occurrence of exoplanets around different stars. He presented these results at the November Face-2-Face LUVOIR STDT meeting. These occurrence rates are then used in direct-imaging mission exo-Earth yield calculations. (3) Dr. Kopparapu co-authored two papers, one of which is in review in Astrophysical Journal, and another one in the International Journal of Astrobiology. (4) Dr. Kopparapu started working on a book chapter on "Habitability of Exoplanets," to be published by Springer publishing group. (5) Dr. Kopparapu was involved in three proposals to NASA's Habitable Worlds program, one of them as a PI, with due dates of of January 20, 2017.

Ms. Mahmuda Afrin Badhan, a University of Maryland graduate student, has been working with the VPL team under the supervision of Dr. Shawn Domagal-Goldman and Dr. Ravi Kumar Kopparapu. Ms. Afrin Badhan has been building atmospheric "retrieval" tools to reliably model expected observables from future missions, in particular JWST. She has been exploring observable impacts of photochemistry in hot Jupiter models by extending the terrestrial Atmos photochemical model tool to giant regimes. She has finished building two new hot Jupiter templates and is now fine-tuning them, adding high-temperature chemistry to the software from existing literature and KIDA reactions and updating stellar fluxes, model parameters, Rayleigh scattering and improving the radiation-chemistry coupling. The software was released to the public at the M-dwarf habitability workshop at the beginning of the AAS winter meeting. Ms. Afrin Badhan represented the GSFC Atmos development team, aided in teaching, and spoke with prospective users from workshop about the capabilities of the tools, soliciting feedback on what features should be prioritized in future releases. Ms. Afrin Badhan also gave a separate oral presentation on the new hot Jupiter templates during the regular meeting.

Ms. Afrin Badhan submitted an abstract for the 2017 Astrobiology Conference to do a follow up presentation on her recent work, and has been awarded a student travel grant to present a poster

there in April. She also began working on a mini project, to apply the tools to earth models around M-dwarfs, in collaboration with Dr. Kopparapu. Most recently, she worked with her team to improve the stellar database in the Atmos model, integrating stars from the recent MUSCLES database with improved FUV measurements. Ms. Afrin Badhan was also competitively selected for her university's inaugural Science Communication workshop, which met once a week for 5 weeks. She is in the process of obtaining that certificate and preparing 3-minute elevator speech of her research for a professional videoshoot.

CRESST SPECIAL PROJECTS ACTIVITIES

In addition to the science tasks, the CRESST Special Projects (SP) tasks provide general support for the scientific mission of the Astrophysics Science Division. Special Projects provide support for

- Visits to GSFC by scientists and students
- Scientific meetings involving Code 600 scientists or programs
- Colloquia and seminars
- Programmatic meetings such as user group meetings
- Visits and work by scientific consultants
- Other short-term scientific activities

USRA manages these Special Project activities for CRESST. Visitor Coordinator responsibilities (arranging GSFC badges and travel for short-term visitors, and supporting the weekly ASD Colloquium and GSFC Science Colloquium series) were managed by Ms. Lynette Queen. Ms. Queen also served as meeting coordinator and works with GSFC sponsors to support user group, workshop and training meetings, along with occasional larger science conferences. Ms. Jeanette Gardner provided visa support for new USRA and other hires for the CRESST program at GSFC, and USRA's Houston office provided voucher payment. Mr. Jeff Arens provided support for all consultants hired through CRESST as well as for a number of interns and stipend recipients. In addition to visitor and meeting support, USRA staff also handled financial and business functions for other of USRA's programs at GSFC, including GESTAR. SP activities were supervised by the CRESST Business Manager, Mr. John Tooley, and directed by Dr. Stephen Drake.

Visitors and Consulting

During the second quarter of FY 2017 (January 1 to March 31, 2017), the CRESST Special Projects Team supported 36 visitor-related activities (relative to 44 the previous quarter) in addition to supporting 3 continuing consultants and about a dozen more individuals, e.g., stipend and living expense allowance recipients, non-salaried scientists who received visa and medical insurance support, etc.

Meeting Support

During this quarter, the CRESST Special Projects Team supported 11 Astrophysics Science Division Colloquia and 11 Goddard Scientific Colloquia.

PROPOSALS ACCEPTED AND SUBMITTED

Proposals Accepted

1. "Can D/H Isotope Composition of Polycyclic Aromatic Hydrocarbons be used to Indicate the Origin, Conditions, and Alteration History of Carbonaceous Chondrites?," ROSES Emerging Worlds, PI: Heather Graham, Co-Is: J.E. Cook, J.C. Aponte, S.A. Sandford, J.P. Dworkin; Awarded January, 2017

Proposals Submitted

1. " NNH16ZDA001N-HW HW16_2 BLUE MARBLE SPACE Haqq-Misra, Jacob 01/20/2017 Linked HABITABLE MOIST-GREENHOUSE ATMOSPHERES ON TERRESTRIAL PLANETS NEAR THE INNER EDGE OF THE HABITABLE ZONE AROUND M-DWARFS," Habitable Worlds, PI: Ravi Kopparapu, Co-Is: Eric Wolf, Jacob Haqq-Misra, Giada Arney; Submitted January, 2017
2. "A DEFINITIVE INVESTIGATION OF THE MAGNETIZED ACCRETION FLOW IN THE X-RAY PULSAR HER X-1 WITH NUSTAR AND XMM," NuSTAR AO-3, PI: M. Brumback, Co-Is: Including K. Pottschmidt; Submitted January, 2017
3. "A Multi-Wavelength Campaign to Observe a Bright Black Hole Transient in Transition," INTEGRAL AO-15, PI: T.M. Belloni, Co-Is: Including K. Pottschmidt; Submitted March, 2017
4. "ACCRETION PHYSICS AT LOWLUMINOSITIES OF GRO J1008-57," NuSTAR AO-3, PI: M. Kuehnel, Co-Is: Including K. Pottschmidt; Submitted January, 2017
5. "Broad Band Spectroscopy of GRS1758-258 in its Rare Soft State: TOO Observations," INTEGRAL AO-15, PI: M. Hirsch, Co-Is: M. Hirsch, K. Pottschmidt, J.Wilms, B.G.H. Rodrigues, W. Eikmann, M.KÂ¨uhnel, F. KrauÃŸ, R. Soria, V. Grinberg, D.M. Smith, M. Cadolle Bel, I. Kreykenbohm, J.A. Tomsick, A. Bodaghee, E.Kuulkers, E. Kalemci; Submitted March, 2017
6. "Broad band spectroscopy of GRS1758-258 in its rare soft state: Triggering the TOO Observations," INTEGRAL AO-15, PI: M. Hirsch, Co-Is: 15, including K. Pottschmidt; Submitted March, 2017
7. "Checking for Warped Disks in Black Hole Binaries," NuSTAR AO-3, PI: J.A. Tomick, Co-Is: Including K. Pottschmidt; Submitted January, 2017
8. "Comprehensive 3D Atmosphere Modeling of Proxima b," Habitable Worlds, PI: Eric Wolf, Co-Is: Ravi Kumar Kopparapu, Jacob Haqq-Misra, Giada Arney; Submitted January, 2017
9. "Constraining the Habitable Zone for Binary Star Systems," Habitable Worlds, PI: Jacob Haqq-Misra, Co-Is: Ravi Kopparapu, Eric Wolf, Stephen Kane; Submitted January, 2017
10. "Continued Monitoring of the Polarization of Cygnus X-1," INTEGRAL AO-15, PI: J. Wilms, Co-Is: J. Wilms, J. Rodriguez, P. Laurent, V. Grinberg, M. Cadolle Bel, M. Kadler, T. Beuchert, I. Kreykenbohm, K. Pottschmidt, N. Hell, S. Markoff, M.A. Nowak,

P.O. Petrucci, G.G. Pooley, C. Sanchez-Fernandez, F. Fuerst, A. Bodaghee, J.A. Tomsick; Submitted March, 2017

11. "Continued Observation of the Galactic Center Region with INTEGRAL: Progress Report," INTEGRAL AO-15, PI: J. Wilms, Co-Is: J. Wilms, A. Bodaghee, I. Kreykenbohm, K. Pottschmidt, V. Grinberg, P. Kretschmar, J. Rodriguez, A. Bazzano, L. Natalucci, D. Gotz, A. Paizis, E. Kuulkers, M. Cadolle Bel, M. Falanga, M. Del Santo, M. Hirsch, M. Fiocchi, C. Sanchez-Fernandez, F. Fuerst, M.A. Nowak, R. Ballhausen, E. Egron, M. Bachetti, F. Baganoff; Submitted March, 2017
12. "CYCLOTRON LINES IN TRANSIENT PULSARS I: PROBING THE B-FIELD," NuSTAR AO-3, PI: F. Fuerst, Co-Is: Including K. Pottschmidt; Submitted January, 2017
13. "CYCLOTRON LINES IN TRANSIENT PULSARS II: NEW LINES," NuSTAR AO-3, PI: F. Fuerst, Co-Is: Including K. Pottschmidt; Submitted January, 2017
14. "Elemental Distribution in the Evolved Type Ia SNR G344.7-0.1," Chandra AO19, PI: Hiroya Yamaguchi, Co-Is: Patrick Slane (SAO), Sangwook Park (U of Texas Arlington), Satoru Katsura (Chuo U), Brian Williams (STScI), Robert Petre (NASA/GSFC); Submitted March, 2017
15. "Exploiting HETG Higher-Order Resolution for Superior Constraints on X-ray Reprocessor Kinematics in X-ray Binaries," Cycle 19, PI: Panayiotis Tzanavaris, Co-Is: Tahir Yaqoob; Submitted March, 2017
16. "EXTENDING OUR PULSAR MAGNETIC FIELD CENSUS TO THE SMALL MAGELLANIC CLOUD," NuSTAR AO-3, PI: A. Zezas, Co-Is: Including K. Pottschmidt; Submitted January, 2017
17. "EXTREMELY HARD X-RAY VARIATION OF WR140 AFTER PERIASTRON," AO-3, PI: Kenji Hamaguchi, Co-Is: Michael Corcoran, Andrew Pollock, Yasuharu Sugawara, Anthony Moffat, Yoshitomo Maeda, Christopher Russell, Peredur Williams, Noel Richardson, Julian Pittard; Submitted January, 2017
18. "Fermi TOO Observations of Bright Galactic Novae," NNH16ZDA001N-FERMI (Fermi Cycle 10), PI: Koji Mukai, Co-Is: S. Kafka (AAVSO), L. Chomiuk, K. Li, T. Finzell (Michigan State), J. Linford (George Washington), J. Sokoloski (Columbia), T. Nelson (Pittsburgh), M. Rupen (Dominion Radio Astronomical Obs.), A. Mioduszewski (NRAO), J. Weston (Green Bank Obs.); Submitted February, 2017
19. "High Energy Emission from Galactic Black Hole Transients when the Compact Jet Turns On," INTEGRAL AO-15, PI: E. Kalemci, Co-Is: J. A. Tomsick, K. Pottschmidt, J. Wilms, T. Belloni, T. Dincer; Submitted March, 2017
20. "Investigating the Current State of V1535 Sco," Chandra Cycle 19, PI: Justin Linford, Co-Is: K. Mukai, T. Nelson (Pittsburgh), J. Sokoloski (Columbia), L. CHomiuk, T. Finzell (Michigan State), A. van der Horst (George Washington), M. Rupen (Dominion Radio Astronomical Obs.), A. Mioduszewski (NRAO), J. Weston (Green Bank Obs.); Submitted March, 2017
21. "IS THE CYCLOTRON LINE ENERGY OF 4U 1538-522 INCREASING OVER TIME?," NuSTAR AO-3, PI: P. Hemphill, Co-Is: Including K. Pottschmidt; Submitted January, 2017
22. "Landscape Evolution Associated with the 2014–2015 Holuhraun Flood Lava Eruption in Iceland as an Analog for Mars," SSW: Solar System Workings, PI: Christopher Hamilton, Co-Is: Jacob Richardson, Patrick Whelley, Stephen Scheidt; Submitted February, 2017

23. "Linking Lava Flow Morphology to Eruption Rate and Pre-eruptive Magmatic Conditions," SSW, NASA Solar System Workings, PI: Ben Andrews, Co-Is: Patrick Whelley (UM/ NASA GSFC) Co-I Jacob Richardson (USRA/ NASA GSFC) Co-I ; Submitted February, 2017
24. "Linking Mineralogy and Environmental Conditions in Lakes in Volcanic Terrains on Earth and Ancient Mars," SSW: Solar System Workings, PI: Kelsey Young, Co-Is: Patrick Whelley, Douglas Ming, Briony Horgan, Aileen Yingst; Submitted February, 2017
25. "Measuring the Magnetic Field of OAO 1657-415," NuSTAR AO-3, PI: C. Ferrigno, Co-Is: Including K. Pottschmidt; Submitted January, 2017
26. "Modular Adaptive Segmented Telescope," NNH16ZDA001N-SAT, PI: Brian Hicks, Co-Is: Zimmerman, Knight, del Hoyo, Fleming, Juanola, and Petrone; Submitted March, 2017
27. "MONITORING CYCLOTRON LINE ENERGIES OVER LONG TIME-SCALES," NuSTAR AO-3, PI: F. Fuerst, Co-Is: Including K. Pottschmidt; Submitted January, 2017
28. "Monitoring the Cyclotron Line Energy in Hercules X-1: Follow the Long-Term Variability," NuSTAR AO-3, PI: R. Staubert, Co-Is: Including K. Pottschmidt; Submitted January, 2017
29. "Monitoring the Hard X-ray Behavior of the Exceptional Microquasar Cygnus X-3," INTEGRAL AO-15, PI: V. Grinberg, Co-Is: K. Koljonen, M. McCollough, E. Egron, T. Beuchert, M. Cadolle Bel, S. Corbel, I. Kreykenbohm, E. Kuulkers, A. Loh, S. Martínez Núñez, G.G. Pooley, K. Pottschmidt, J. Rodriguez, S.A. Trushkin, J. Wilms; Submitted March, 2017
30. "MONITORING X-RAY BINARIES IN THE M31 BULGE WITH NUSTAR," NuSTAR AO-3, PI: M. Yukita, Co-Is: Including K. Pottschmidt; Submitted January, 2017
31. "NuSTAR Observations of the Be Binary System X Persei," NuSTAR AO-3, PI: M.T. Wolff, Co-Is: Including K. Pottschmidt; Submitted January, 2017
32. "ON THE PATH OF UNDERSTANDING THE EXTREMELY HARD X-RAY COMPONENT OF ETA CARINAE," AO-3, PI: Kenji Hamaguchi, Co-Is: Michael Corcoran, Hiromitsu Takahashi, Theodore Gull, Anthony Moffat, Christopher Russell, Jose Groh, Thomas Madura, Thomas Madura, Noel Richardson, Julian Pittard, Stanley Owocki, Manabu Ishida; Submitted January, 2017
33. "Peering through Accretion-Ejections Mechanisms with an INTEGRAL/Multi-Wavelength GRS 1915+1015 Monitoring Program," INTEGRAL AO-15, PI: J. Rodriguez, Co-Is: Including K. Pottschmidt; Submitted March, 2017
34. "Preparing for the Next `Nova of the Century'," NNH16ZDA001N-NUSTAR (NuSTAR Cycle 3), PI: Jennifer Sokoloski, Co-Is: G. Luna (IAFE), K. Mukai, T. Nelson (Pittsburgh), N. Nunez (ICATE), A. Lucy (Columbia); Submitted January, 2017
35. "Preserved Lava Textures as a Window into Lava Flow Dynamics on Terrestrial Planets," SSW: Solar System Workings, PI: Patrick Whelley, Co-Is: Jacob Richardson, Brent Garry, Christopher Hamilton, Stephen Scheidt; Submitted February, 2017
36. "PROBING ACCRETION PHYSICS AT LOWEST LUMINOSITIES IN THE NEARBY ACCRETING PULSAR GX304-1," NuSTAR AO-3, PI: D. Klochkov, Co-Is: Including K. Pottschmidt; Submitted January, 2017

37. "Regular and Frequent INTEGRAL Monitoring of the Galactic Bulge Region," INTEGRAL AO-15, PI: E. Kuulkers, Co-Is: Including K. Pottschmidt; Submitted March, 2017
38. "Revealing the Origin of the Thermal and Nonthermal Emission from the Supernova Remnant W49B," NuSTAR AO-3, PI: Hiroya Yamaguchi, Co-Is: Takaaki Tanaka (Kyoto U), Robert Petre (NASA/GSFC), Randall Smith (SAO), Adam Foster (SAO), Aya Bamba (U of Tokyo), Brian Williams (NASA/GSFC), Daniel Castro (NASA/GSFC); Submitted January, 2017
39. "Supporting Astronomy Picture of the Day," Sole Source, by invitation, PI: Robert Nemiroff, Co-Is: Jerry Bonnell; Submitted March, 2017
40. "THE BROAD X-RAY SPECTRAL PROPERTIES OF THE ACCRETING PULSAR 3XMMJ004301.4+413017 IN M31," Chandra AO-19, PI: M. Yukita, Co-Is: Including K. Pottschmidt; Submitted March, 2017
41. "The Broad X-ray Spectral Properties of the Accreting Pulsar 3XMMJ004301.4+413017 in M31," NuSTAR AO-3, PI: M. Yukita, Co-Is: Including K. Pottschmidt; Submitted January, 2017
42. "The Cyclotron Line Energy in Hercules X-1: is there a New Turn-up - Deviating from the 20 Year Long Decay?," INTEGRAL AO-15, PI: R. Staubert, Co-Is: J. Wilms, F. Fuerst, K. Pottschmidt, R. Rothschild, F. Harrison; Submitted March, 2017
43. "The Giant Elliptical Galaxy in our Backyard: The Resolved 1-30 keV X-ray Binary Population of Maffei 1," Chandra Cycle 19, PI: Neven Vulic, Co-Is: Ann Hornschemeier, Pauline Barmby, Francesca Fornasini, Sarah Gallagher, Andrew Ptak, Dan Wik, Mihoko Yukita; Submitted March, 2017
44. "The Giant Elliptical Galaxy Lurking in our Backyard: The Resolved X-ray Binary Population of Maffei 1," NuSTAR GO Program, PI: Neven Vulic, Co-Is: Ann Hornschemeier, Mihoko Yukita, Dan Wik, Francesca Fornasini, Valsamo Antonio, and Joel Coley; Submitted January, 2017
45. "The Next Generation of Self-Consistent Models for a Spherical X-ray Reprocessor in AGNs and X-ray Binaries," Cycle 19, PI: Panayiotis Tzanavaris, Co-Is: Tahir Yaqoob; Submitted March, 2017
46. "The Spin Rates of Black Holes in X-ray Binaries," NuSTAR AO-3, PI: J.A. Tomick, Co-Is: Including K. Pottschmidt; Submitted January, 2017
47. "UNCOVERING THE LUMINOSITY DEPENDENCE OF THE CRSF IN 4U 1907+09," NuSTAR AO-3, PI: P. Hemphill, Co-Is: Including K. Pottschmidt; Submitted January, 2017
48. "Understanding the Gamma-ray Production Mechanism in Nova Shocks," NNH16ZDA001N-NUSTAR (NuSTAR Cycle 3), PI: Thomas Nelson, Co-Is: K. Mukai, J. Sokoloski (Columbia), L. Chomiuk (Michigan State), B. Metzger (Columbia), I. Vurm (Tartu Observatory); Submitted January, 2017
49. "X-ray Luminous Accreting White Dwarfs," NNH16ZDA001N-NUSTAR (NuSTAR Cycle 3), PI: Marina Orio, Co-Is: K. Mukai, P. Zemko (Padova); Submitted January, 2017