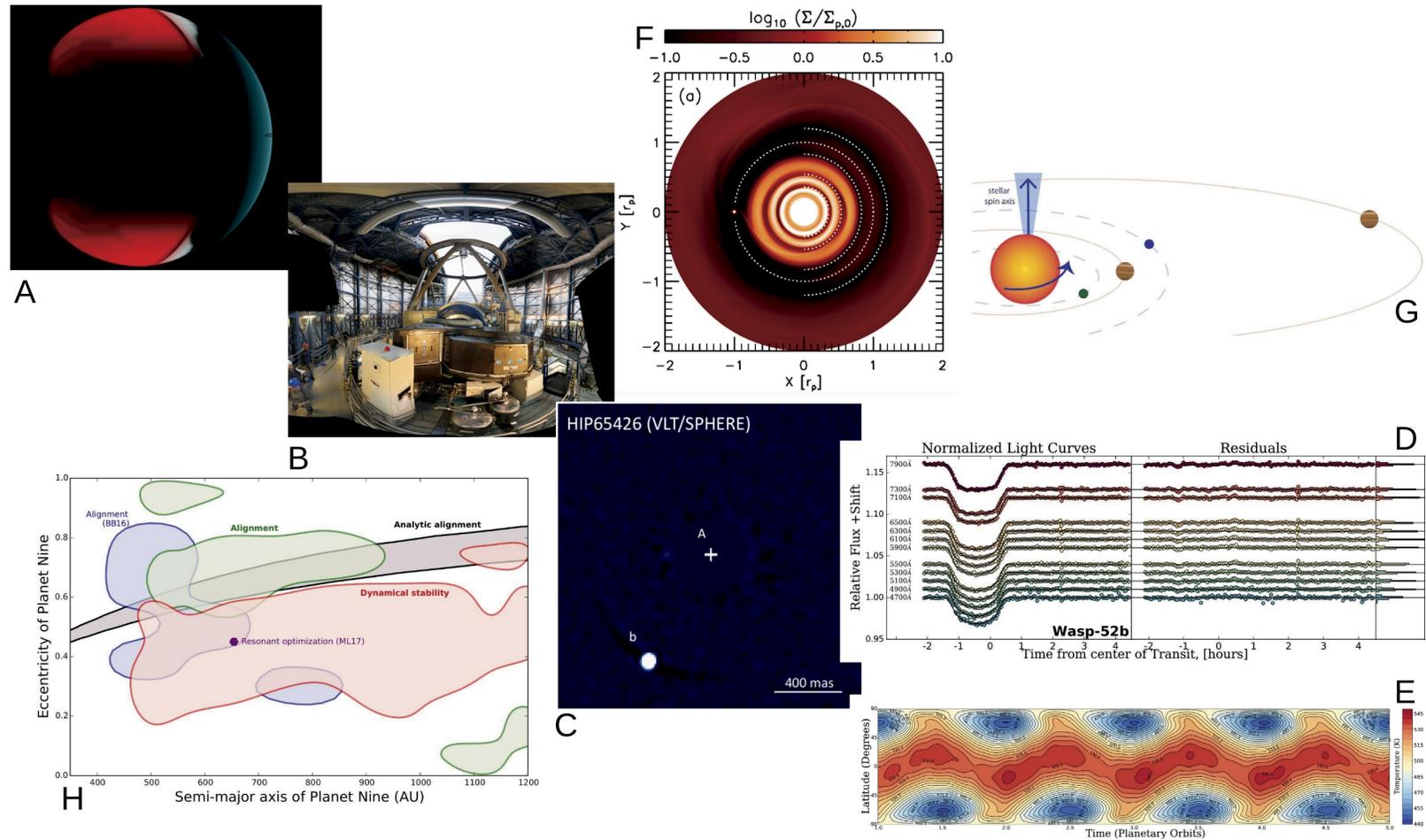


Michigan Astronomy News

FOR ALUMNI & FRIENDS OF THE UNIVERSITY OF MICHIGAN ASTRONOMY DEPARTMENT





Letter From The Chair

through this crowd, with my two children (15 and 9) in tow, I could not help

Dear Friends of Michigan Astronomy.

I want to start off with a big thank you to all our supporters! We are so grateful for your continued support of our department, and our fantastic, wonderful young scientists.

So – thank you.

Looking back over this year, the solar eclipse in August 2017 and our event on the Diag really stands out as a signature moment. As astronomers we knew when and where the eclipse was going to occur; thus, significant planning was made. To be frank, most of this significant planning was for individual faculty members to travel somewhere cool and catch the total solar eclipse (which is stunning). A handful of us, including myself, stayed behind at home and were able to see a partial eclipse in Ann Arbor – which is still fun. The bonus was that we were able to share this event with our University community and our town. So, the department set about to organize an event on the Diag, one where we would set up our telescopes with solar filters – don't look at the Sun! – and provide eclipse glasses to anyone who joined us. As the day of the eclipse approached, the department was fielding random calls asking for eclipse glasses and what type of welder's glass is acceptable (Shade 12 or higher as our executive secretary now knows). Reps for the football team even stopped by with a request for glasses. We did give 50 to the football team – and asked them to share.

Later that day, our event on the Diag itself was amazing – we had several thousand people present, from the steps of the Graduate Library, all the way down to Rackham Graduate School. As I wandered

but be amped up by the excitement from old to young. I received so many questions about the how, the why, and how do we know when. For any scientist, this is like cat nip – we all love to share our understanding of the natural world. How does this work, why is this happening? Nature is pure amazement and we in your Department of Astronomy want to be front and center a place for everyone to come and interact to look at the world with inquisitive eyes. In all, this was a truly special moment for which this Department should be proud.

In terms of news, the Department is more than excited to announce that Dr. Lia Corrales (at right) was awarded a Collegiate Postdoctoral Fellowship from the College of Literature, Science, and the Arts. This new competitive postdoctoral fellowship is associated with a faculty position and Dr. Corrales stood out in a field of over seven hundred college-wide. Thus, you know we have a great scholar on our hands. Dr. Corrales is a leader in studying the interaction of X-rays and solids in interstellar space. These solids are tiny particulate matter, smaller than the width of human hair, and generally composed of silicates: think sand. Astronomers call this material “dust”, but they are simply put – the seeds of terrestrial worlds. We look forward to Dr. Corrales joining us in the coming year and helping us all in our educational and scientific mission.



As always, if you are in town you are more than welcome to visit our department in West Hall. You are welcome anytime. If you do stop by, go ahead and ask someone to explain one of the beautiful astronomical images that grace our walls. Then you can see for yourself the joy of science come to life.

—Ted Bergin

Department of Astronomy Fast-Facts

People

- 25 Tenure-track Faculty (5 are within Physics & History)
- 6 Research Scientist/Professor Faculty
- 3 Emeritus Faculty
- 17 Postdoctoral Fellows/Lecturers
- 29 Graduate Students
- 9 Administrative and Technical Staff
- 60 Undergraduate majors and minors

Computing

- University-wide Flux cluster, with approximately 27,000 cores, InfiniBand network, and 1.5 PB scratch storage.

Observatories

- Magellan Telescopes: 2 x 6.5-m telescopes at the Las Campanas Observatory, Chile
- MDM Observatory: a 1.3 and 2.4-m telescope on Kitt Peak, Arizona
- Curtis-Schmidt telescope at the Cerro Tololo Inter-American Observatory, Chile
- CHARA optical/infrared interferometer on Mount Wilson, California
- Angell Hall student telescopes and planetarium, and Detroit Observatory Fitz telescope, on Main Campus

News From West Hall

Undergraduate News

It's been another great year for undergraduates. Receiving a BS in Astronomy & Astrophysics were Catherine Cerny (honors; starting graduate work at Boston University), Xinyi Chen (honors; who will pursue a PhD in physics at Yale), Catherine Clark (who is moving to Northern Arizona University for her graduate work in astronomy), Brian Cook (whose graduate career will involve numerical relativity at Georgia Tech), Jacob Dennis, Jason Grand (planning a career as a data scientist), Steven Heise, Ryan Keenan (honors; pursuing graduate work at the University of Arizona), Jill Moreau (planning to go to graduate school after a Fall application), Matthew Past (starting graduate work just south of the border at the University of Toledo), Kimberly Sinclair (honors; working as a systems engineer on the Europa Clipper mission at JPL), and Jake Zuckman (working for BlackRock, Inc., the investment management corporation in NYC). Additionally, Elizabeth Chambers and Dennis Walsh (honors; working as a 3D pipeline developer for Mackevision – a market leader in CGI) graduated with a BS in Interdisciplinary Astronomy.

Xinyi Chen was awarded a Virginia Voss Memorial Scholarship in the academic writing category.

In sadder news, **Patrick Dahlin**, a senior Astronomy major, passed away in October, 2016. Patrick worked with Research Scientist Dr. Edmund Hodges-Kluck and Prof. Joel Bregman on measuring the metal content of hot gas in elliptical galaxies, and presented this work at the 15th meeting of the High Energy Astrophysics Division of the American Astronomical Society. On the basis of this work, he was admitted into a competitive Research Experience for Undergraduates summer program at Cornell University, where he worked on instruments that will be deployed in Chile to better measure the cosmic microwave background. Patrick also excelled at classwork, having finished enough courses by the end of his junior year to earn a

posthumous bachelor's degree in Astronomy. Outside of astronomy, Patrick also enjoyed cross-country running, and he worked with a model Mars rover team in the College of Engineering. He is dearly missed.

Graduate Student News

Jaehan Bae (advisor **Prof. Lee Hartmann**) defended “Studies of Star-forming Circumstellar Disks” on March 30th. Jaehan conducted an extensive series of numerical simulations of both star- and planet-forming disks, with the latter work concentrating on planet-disk interactions. In one paper, Jaehan showed that the observed asymmetry of dust emission in a disk around a young star could be explained by a planet producing not only spiral arms but a vortex which concentrates dust, a process that is likely to be important in collecting solids to enhance planet formation. In another paper, he showed that a Jupiter-mass planet could excite turbulence which would have the opposite effect, i.e. stir up dust making growth of larger bodies more difficult. Finally, Jaehan showed that the multiple rings and gaps seen in recent images of planet-forming disks could be caused by a single Neptune-mass planet exciting multiple spiral arms (see page 5). He has received the

Rubin postdoctoral fellowship, named for the astronomer Vera Rubin who made major discoveries pointing to the existence of dark matter, at the Carnegie Institution's Department of Terrestrial Magnetism in Washington DC.

Vivienne Baldassare (advisor **Prof. Elena Gallo**) defended “Active Galactic Nuclei in Dwarf Galaxies” on May 16th. Vivienne's work focused on the properties of actively accreting super-massive black holes at the centers of nearby dwarf galaxies. She made use of high resolution optical spectroscopy, as well as X-ray and UV imaging data. A highlight of her research was the discovery of a record-setting 50,000 solar mass black hole at the center of the dwarf galaxy RGG 118: the smallest yet reported. She has taken up a NASA Einstein Postdoctoral Fellow in the Department of Astronomy at Yale University.



Yet another impressive display of posters by our talented undergraduates at the 2017 Undergraduate Poster Fair in the Michigan League. (Photo Credit: S. Murphy.)

Cover Images: The department's expertise in exoplanets and protoplanetary disks has flourished in the last few years, as illustrated by these images from recent research.

See page 5 for a description of this work. Also, the 21 August eclipse: see page 7.

Newsletter Production: P. Hughes

Brian Devour (advisor **Prof. Eric Bell**) defended “Dust and its Effects on Measures of Galaxy Properties” on July 5th. In his thesis, Brian presented the most comprehensive yet census of dust content and its effects in galaxies. Brian used a combination of long-wavelength datasets and a new technique for quantifying the structure of galaxies to select samples of galaxies that are identical save for their orientation to the line of sight. The face-on members of that sample suffer relatively little from extinction of light from dust; the edge-on members are much more affected. Brian found that dust affects most observed properties of galaxies at the factors of several level, and that many corrections for dust are incomplete. Importantly, the dust content of galaxies is a strong function of a galaxy’s mass, star formation rate and size, in accord with relatively simple physically-motivated scaling relations. He is remaining in Ann Arbor for the time being to continue work with Prof. Bell.

Hui Li (advisor **Prof. Oleg Gnedin**) defended “Star Cluster Formation in Cosmological Simulations” on August 10th. Hui developed a novel algorithm for modeling star formation in galaxy formation simulations, which explicitly models individual star clusters. The growth of a star cluster is terminated by the feedback of its own stars on the interstellar medium. Thus the algorithm calculates cluster mass self-consistently. Comparison of various cluster properties with available observations provides small-scale tests of the implementation of galaxy formation in cosmological simulations. Hui is now a postdoctoral fellow at the Massachusetts Institute of Technology, where he will apply his algorithm to large-scale galaxy simulations.

Meghin Spencer (advisor **Prof. Mario Mateo**) defended “Binary Stars in Dwarf Spheroidal Galaxies” on August 11th. Meghin used three decades of kinematic observations to search for stellar velocity variability caused by binary stars within dwarf galaxies. She generated Monte Carlo simulations of the variability to determine the fraction of stars that are contained in binary systems for seven dwarfs. She also found that the binary populations are different amongst the dwarfs. Her work confirmed that the orbital motions of binaries can mimic the effects of dark matter, and so there could be significantly less dark matter in the faintest types of dwarf galaxies than what is currently reported. Meghin is now going to take a year to travel around the United States to watch and photograph birds.

Marina Kounkel (advisor **Prof. Lee Hartmann**) defended “Distances, Kinematics, and Structure of Nearby Star-Forming Regions” on August 15th. Marina used the Very Long Baseline (Interferometric) Array to measure precise distances to young stars exhibiting non-thermal emission in the Orion molecular clouds. Her work provided the most accurate distance estimates to Orion, which

affects estimates of stellar ages and thus star-formation histories, and resulted in the first indications of the three-dimensional structure of the clouds. Marina also found that a few young stars have been ejected at high velocities from the center of the Orion Nebula Cluster, presumably because of close encounters with the massive stars there. Many of the young stars are binaries, and further studies of their orbits will yield much more accurate masses of the stars, needed to test models of stellar evolution. Marina also conducted an extensive series of optical spectroscopic measurements to help pin down the motions of other stars in Orion to test ideas of star cluster formation. She is currently a postdoctoral fellow at Western Washington University in Bellingham.

Postdoc News

Dr. Sarah Loebman and **Dr. Ke (Coco) Zhang** have won prestigious Hubble Fellowships. Sarah moved to the University of California Davis in the Fall. She was also awarded the University of California Chancellor’s postdoctoral fellowship. Coco remains in Michigan.

Dr. Abdu Zoghbi has won a 2017 Rackham Outstanding Postdoctoral Fellow Award. Ten awards are made annually, across all schools and units in the University. Abdu’s work has launched a sub-field that is driving the performance goals and scientific aims of future X-ray missions, so this is very well deserved.

Faculty News



The Regents of the University have approved the promotion of **Dr. Monica Valluri** to the position of Full Research Professor, and **Dr. Ian Roederer** to the position of Associate Research Scientist. This is great



news and well deserved!



The American Astronomical Society has chosen the AURA HST & Beyond Committee as this year’s recipient of the Carl Sagan Memorial Award. This award is “given to an individual or team who has demonstrated leadership in research or policies advancing exploration of the cosmos”. The committee’s report led directly to the development of the James Webb Space Telescope. Our very own **Prof. Doug Richstone** (who is currently Associate Dean for Natural Sciences) was a committee member and deserves congratulations for this award and our gratitude for his service on our behalf.



Prof. Jon Miller has been awarded the 2017/18 HEAD Mid-Career prize, which recognizes a significant advance or accomplishment

(observational or theoretical) in High Energy Astrophysics. This is fantastic recognition for Jon – congratulations!

Alumni News

Dr. Anne Jaskot, who defended her thesis “HI Gas Cycles and Lyman Continuum Optical Depth in Low-Redshift Starbursts” in 2014, and who is currently a postdoctoral researcher in the Five College Astronomy Department, has been awarded a Hubble Fellowship. She will hold this at the University of Massachusetts at Amherst.

Dr. Zhaohuan Zhu, who defended his thesis in 2011, moved to Princeton as a Hubble Fellow, and then took up a faculty position in the Physics & Astronomy department at the University of Nevada Las Vegas, has received a Sloan

Research Fellowship.

Dr. Ilse Cleeves, who defended her thesis “Molecular Signposts of the Physics and Chemistry of Planet Formation” in 2015, and took a Hubble Fellowship at CfA, has accepted a faculty position at the University of Virginia.

Dr. Rachael Roettenbacher, who defended “Shifting the Starspot Paradigm through Imaging Magnetic Structures and Evolution” in 2016, and who is currently a Postdoctoral Researcher in the Department of Astronomy at Stockholm University, was awarded the 2017 Olivier Chesneau Prize for the best PhD thesis in High Angular Resolution Astronomy. Rachel is the second recipient of this prize, which is based on her impressive study of the magnetically active star, Zeta Andromedae.

The front cover provides a snapshot of recent work on exoplanets and protoplanetary disks, a field in which the department has gone from strength to strength in the last years.



From Prof. Emily Rauscher’s group figure (A) shows a model by postdoctoral researcher **Dr. Mike Roman** for the atmosphere, with clouds made out of the molecule manganese sulfide, of hot Jupiter Kepler 7b. Night-side optical depths are in red, and dominate the image. Images (D) and (E) show work by graduate student **Erin May**: the transit light curves at multiple wavelengths for hot Jupiter Wasp 52b track the stellar flux as it is filtered by the planet’s atmosphere, and constrain the atmospheric composition; evolving seasons on Kepler 47b, a circumbinary planet, are revealed by contours showing the change in temperature with latitude and time over five orbits – no two seasons are exactly alike!

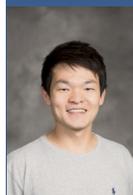


Images (B) and (C) show the SPHERE instrument installed on ESO’s Very Large Telescope in Chile, and the young (10-20 million years old) star system HIP65426 that the SPHERE consortium, including **Prof. Michael Meyer**, discovered. This warm, dusty planet with a mass an order of magnitude larger than that of Jupiter, orbits at 90 AU, and retains significant heat from formation. Discoveries like this can help us understand how massive planets form.



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Graduate student **Jaehan Bae** (see page 3) and **Prof. Lee Hartmann** have shown that one planet can open up multiple gaps in a protoplanetary disk; for the simulation shown in image (F) the full dotted circle indicates the planet’s orbit, whereas the half circles indi-



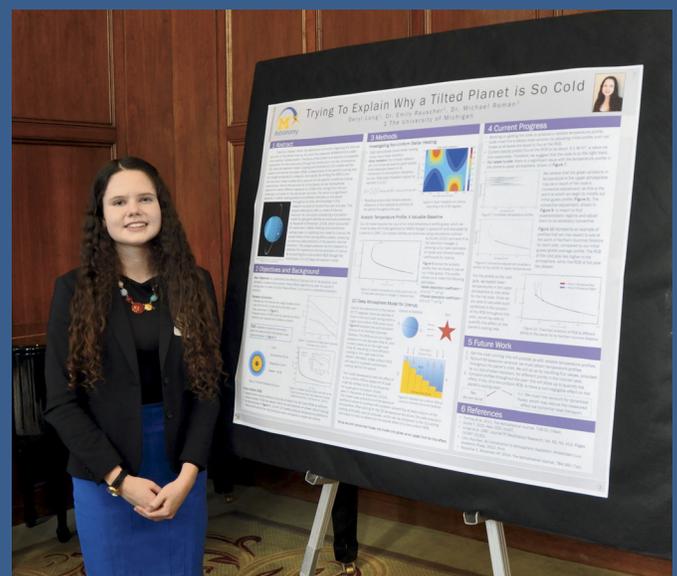
cate the gaps opened by the planet. Beware interpreting the multiple rings in such famous images as the ALMA observation of HL Tau as implying the presence of more than one planet!



Finally, images (G) and (H) show the geometry of the Wasp 47 system, and the preferred regions for Planet Nine’s orbit as studied by graduate student **Juliette Becker** and **Prof. Fred Adams**. The study explores the orbits of trans-Neptunian objects, looking at their survival



probability and alignment, and finds significant overlap for the regions of parameter space allowed by different studies. The optimal orbital elements give this putative planet a high eccentricity (0.4-0.6) and distance of 500-700 AU.



And of course our undergraduates are making their contribution. At this year’s Undergraduate Poster Fair (see page 3) Deryl Long presented her work with Emily Rauscher and Mike Roman on the heating of tilted planets. (Photo Credit: S. Murphy.)



Observations of Space Debris

Research Professor (Emeritus) Patrick Seitzer describes what happens when good satellites go bad.

The space age began in October 1957, with the launch of the first artificial Earth satellite: Sputnik 1. This launch resulted in two objects in orbit: the satellite and the final stage of the launching rocket. This final stage is what today we would consider space debris: an inactive object in orbit that has no useful function.



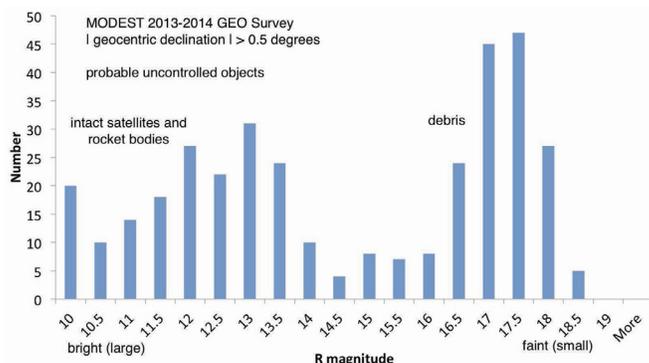
Today over 20,000 objects larger than 10 cm are tracked in Earth orbit. Less than 10% of these objects are active satellites. The remainder is space debris (or orbital debris): dead satellites, rocket bodies, and fragments of other objects. The number of untracked objects smaller than 10 cm is much,

much larger than this. The number of active satellites and amount of space debris is increasing every year, and presents an increasing risk to operational satellites.

Beginning in 2000 with NASA support, University of Michigan telescopes have been used in a project of applied astronomy to quantify and characterize the population of space debris at geosynchronous orbit (GEO). We use all the techniques developed by astronomers to measure natural objects but now in a real-world problem with practical applications. A satellite in this orbit has the same orbital period as the Earth's rotation, and so would appear motionless in the sky. Your small satellite TV antenna is pointing at one of these satellites.

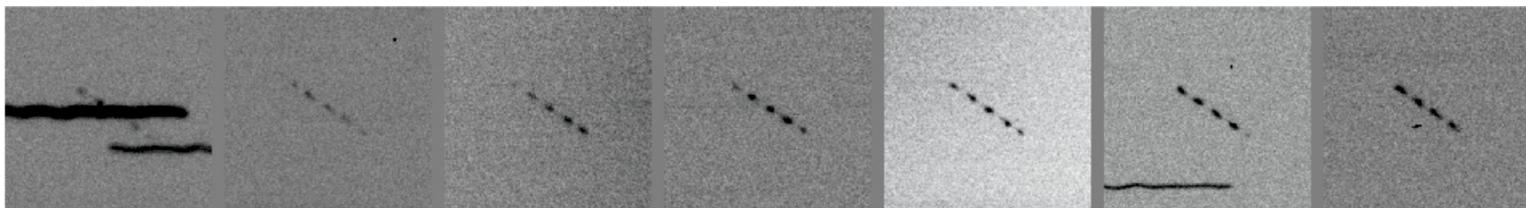
The project began with surveys of the GEO regime

with the Curtis-Schmidt telescope located at Cerro Tololo Inter-American Observatory in Chile (at left). This wide-field 0.6-m telescope was renamed MODEST (for Michigan Orbital DEbris Survey Telescope; and yes, I did submit a MODEST proposal to NASA for funding). Using a scanning CCD it surveyed the region of GEO visible from Chile counting, measuring the brightness of objects, and tabulating their motions. It reached down to sizes of



about 25 cm. Results are shown in the histogram: objects on the left are large, bright, intact spacecraft and rocket bodies (all inactive), while objects on the right are smaller and fainter fragments.

To go fainter, we used the 6.5-m Magellan telescopes for both surveys in small areas of the sky, and spectroscopy of known debris pieces at GEO. Magellan can easily detect objects smaller than 10 cm at GEO – the image sequence below shows a time series of one of these objects. This is a series of 5 second exposures, and shows a tumbling object the size of a small iPhone at GEO (range 40,000 km). The long streaks are background stars: of great interest to astronomers, but contamination and noise in studies of space debris. The number of such faint objects is much larger than seen at brighter limits by MODEST, and indicates that the population of space debris at GEO could be very large indeed. The 6.5-m Magellan is the largest telescope yet used for space debris measurements, and has detected the faintest and presumably smallest pieces of space debris at GEO.



The Detroit Observatory: Telescope Ahoy!



Observatories are, of necessity, open to the sky whenever the telescope is in use. This being Michigan, precipitation often falls from above with little or no notice. Consequently, the Bentley Historical Library recently asked Jonce Fancher (of Fancher's Upholstery in Ypsilanti) to make a waterproof cover that could be quickly draped over the telescope in case of dome leaks, or worse, a shutter stuck open in the rain. Asking someone to make a custom cover for an 1857 telescope is – literally – a tall order, but Jonce's specialty is crafting covers for sailboats and sailboat masts, so he brought a nearly unique skill set and experience to the task of tailoring a three-piece suit for the 17 foot long Fitz refractor.

Detroit Observatory volunteer **Joseph Velez** captured these images of Lab Services Technician **Shannon Murphy**, Postdoctoral Researcher **Michael Roman**, volunteer

Total Solar Eclipse 2017

The map at center on the back cover shows the location of 43 members of the department (individuals: red pins; groups: blue pins) who spread along the path of totality to view the eclipse of 21 August, including a large contingent at the 16th High Energy Astrophysics Division meeting at Sun Valley, ID (green pin).

The montage showing the progression of the eclipse was taken by Postdoctoral Researcher Jiangtao Li, with a 60-300mm Tamron SP Adaptall lens mounted on a Canon 30D camera, at the HEAD meeting.

Ann Arbor was not fortunate enough to see totality (80% coverage), but groups gathered at various downtown locations, including at the District Library, and on the

Stan Shackman, and Detroit Observatory coordinator **Karen Wight** dressing the telescope and its mount with the new cover, in preparation for what they expected would be some relatively minor repairs to the Detroit Observatory dome over the summer of 2017.

Unfortunately, the minor repairs morphed into a major repair and restoration effort. Happily, the new waterproof cover, and a large plywood 'room within a dome' now protect the Fitz telescope and its mount. We are grateful to UM administration and the Board of Regents for their commitment to repairing and preserving this significant monument to the history of the Astronomy Department and the development of UM as a research university. Repairs are well underway, and we hope to reopen in the Spring of 2018.

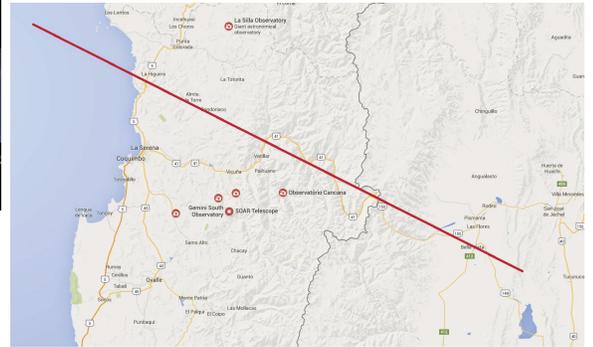
Diag, where over a dozen volunteers from the UM's Museum of Natural History and the Astronomy Department hosted large crowds that spilled along Ingalls Mall. To everyone's delight the clouds held off and a great time was had by all.

For full coverage of the 2017 eclipse see the article by Julie Halpert on the department web page: lsa.umich.edu/astro/.

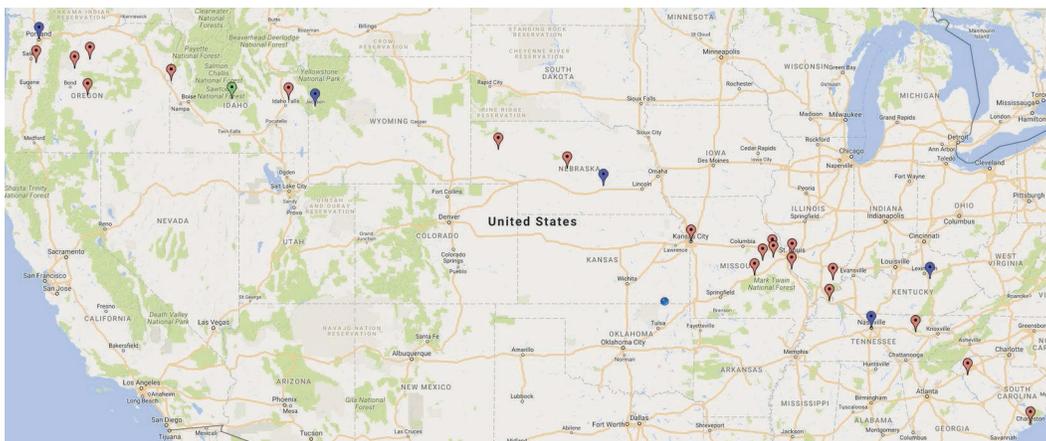
Planning to go observing, or be an observatory tourist, on 2 July, 2019? The next total solar eclipse has a path of totality passing through the Coquimbo Region in Chile, and into Argentina (map on back cover). The path lies just north of La Serena and Gemini South, and south of La Silla.

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Prof. Mario Mateo cycled from Ann Arbor to Missouri for the eclipse, where he met up with former graduate student Hui Li (see page 4). Mario took a break from the design and construction of sophisticated instrumentation for large telescopes, depending on the local foliage to produce “pinhole camera” images. (Photo Credit: H. Li.)



Track of the next total eclipse in 2019.

UM astronomers fanned out along the path of totality for the 21 August eclipse.



(Photo Credit: J.Li)

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