Monday, October 10 (all sessions at VU Conference Center)

Session 1 9:00 – 10:55 (Andrej Prša, Villanova University)

9:00 *Welcome*
9:05 Edward Guinan – *The Proxima Centauri Star-Planet System: Planet and Stellar Properties from Time-Series Observations* (keynote)
9:40 Melissa Graham – *LSST overview and status*
10:05 Tony Tyson – *LSST optical transient survey modes* (invited)
10:30 Mark Wells – *Preliminary Results on the Performance of the LSST on the Detection of Eclipsing Binaries* (invited)

Coffee 10:55 – 11:15

Session 2 11:15 – 12:30 (Paula Szkody, University of Washington)

11:15 Lynne Jones – *The Solar System and LSST* (keynote)
11:50 Colin Slater – *Image Differencing in LSST*
12:05 Eric Christensen – *The Enhanced Catalina Sky Survey for Near-Earth Objects*

Lunch 12:30 – 1:30 (on site)

Session 3 1:30 – 3:20 (Eric Christensen, University of Arizona)

1:30 Sarah Greenstreet – *Preparing for LSST with the LCOGT NEO Follow-up Network* (keynote)
2:05 Tim Lister – *The LCOGT NEO Follow-up Network* (invited)
2:30 Ashish Mahabal – *CRTS: Recent Progress and Results*
2:55 Patrick A. Taylor– *Arecibo Radar and Multi-Wavelength Collaborations on Near-Earth Asteroids* (invited)

Coffee 3:20 – 3:50

Session 4 3:50 – 5:15 (Ashish Mahabal, Caltech)

3:50 Gareth Williams – *Implementing Minor Planet Center V2.x* (keynote)
4:25 Joseph Masiero– *NEOWISE: Overview and Recent Results* (invited)
4:50 Larry Denneau – *The Asteroid Terrestrial-impact Last Alert System (ATLAS) Update* (invited)

Breakouts 5:30 – 6:30

5:30 *Near Earth Asteroids* (1 hour)
5:30 *Large Synoptic Survey Telescope* (1 hour)

Reception 7:00 pm (Villanova University Conference Center)

Hot-Wiring the Transient Universe V, Villanova, PA, 10-14 October 2016

Tuesday, October 11

Session 5 9:00 – 10:20 (Larry Denneau, University of Hawaii)

9:00 *Announcements*
9:05 Matthew J. Lehner – *The Transneptunian Automated Occultation Survey (TAOS II)*
9:30 Dan Avner – *FRoST: Flagstaff Robotic Survey Telescope* (invited)
9:55 Brian Burt – *The State of MANOS and asteroid.lowell.edu* (invited)

Coffee 10:20 – 10:50

Session 6 10:50 – 12:30 (Joshua Pepper, Lehigh University)

10:50 Paula Szkody– *Lessons Learned from Past/Ongoing Survey Followups* (invited)
11:15 Eric Bellm – *The Zwicky Transient Facility* (invited)
11:40 R.K. Pawłaszek– *Project Solaris - a global network of robotic telescopes. Current status and prospects*
12:05 M. Litwicki – *Environmental data acquisition system for Project Solaris*

Lunch 12:30 – 1:30 (on site)

Session 7 1:30 – 2:45 (Tara Murphy, University of Sydney)

1:30 Roy Williams – *Skymap Viewer: Evaluating Observation Priority for Gravitational-Wave Follow-up*
1:55 Maohai Huang – *SVOM Science Ground Segment*
2:20 Reed Essick – *Internal vetting and analysis of low-latency GW triggers* (invited)

Coffee 2:45 – 3:15

Session 8 3:15 – 4:55 (Roy Williams, Caltech / LIGO)

3:15 Samaya Nissanke – *EM Follow-up for LIGO* (keynote)
3:50 David A.H. Buckley – *The SAAO-SALT Transient Detection and Followup Program* (invited)
4:15 Gautham Narayan – *ANTARES: Progress towards building a Broker of time-domain alerts*
4:40 *ANTARES Demo* (15 min)

Breakouts 5:30 – 6:30

5:30 *Rapid response follow-up for multi-messenger phenomena* (1 hour)

Dinner (on your own)

Wednesday, October 12

Session 9 9:00 – 10:30 (Rachel Street, LCOGT)

9:00 *Announcements*

9:05 Jessie Christiansen– *Detection and Characterization of Exoplanets in the Era of Space-based Transit Surveys* (keynote)

9:40 Michael B Lund – *Exoplanets as Byproducts of Modern Surveys* (invited)

10:05 Knicole Colón – *Multi-Epoch Surveys with the NASA K2 Mission*

Coffee 10:30 – 11:00

Session 10 11:00 – 12:40 (Eric Jensen, Swarthmore College)

11:00 Tabetha Boyajian – *KIC 8462852: Where's the Flux?* (invited)

11:25 Matthew Penny – *WFIRST: The Wide-Field InfraRed Survey Telescope and what we can learn from its microlensing survey* (invited)

11:50 Jennifer Yee – *The WFIRST Microlensing Survey: 2.8 sq deg of the Bulge at a 15 minute cadence* (invited)

12:15 Keaton J. Bell – *Stellar Pulsations in Sparse Time Series Photometry* (invited)

Lunch 12:40 – 1:30 (on site)

Session 11 1:30 – 3:10 (Joshua Pepper, Lehigh University)

1:30 Scott G. Engle – *Revealing the Secret Lives of Cepheids Through Photometric Surveys and Multi-Wavelength Data*

1:55 Bartlomiej Debski – *Light Curve Mophology of close binary stars: a tool for refined classification in large photometric surveys*

2:20 Jan van Roestel – *Sky2Night*

2:45 Scott W. Fleming – *Project Blacklight: Intra-Visit Variables with gPhoton*

Coffee 3:10 – 3:25

Session 12 3:25 – 4:20 (Gautham Narayan, University of Arizona)

3:30 Tim Staley– *Software sustainability in astronomy* (keynote)

4:00 *Software Demos & Discussions* (20 minutes)

Tour 4:30 (Villanova Astronomy Department)

Banquet 7:00 (Moshula, Penn's Landing)

Hot-Wiring the Transient Universe V, Villanova, PA, 10-14 October 2016

Thursday, October 13

Session 13 9:00 – 10:55 (Tara Murphy, University of Sydney)

9:00 *Announcements*

9:05 Rachel Street – *Optimizing Facilities and Infrastructure for Time Domain Science* (keynote)

9:40 Ira W. Snyder – *LCOGT Server Deployment and Monitoring: An Adventure in Automation* (invited)

10:05 Curtis McCully – *BANZAI: An Open Source Data Reduction Pipeline for Las Cumbres Observatory* (invited)

10:30 Nikolaus Volgenau – *LCO: around-the-world, around-the-clock operations*

UnCoffee 10:55 – 11:15

Session 14 11:15 – 12:30 (Rachel Street, LCOGT)

9:05 *Unconference*

Pending: unabstracts / unagenda

Lunch 12:30 – 1:30 (on site)

Session 15 1:30 – 3:10 (Eric Jensen, Swarthmore College)

1:30 Andrej Prša – *1% accuracy in fundamental stellar parameters? Not without an extensive redesign of eclipsing binary models*

1:55 Darryl Wright – *Supernova Hunters: combining human and machine classifications*

2:20 James Guillochon – *An Open Catalog for Supernova Data*

2:45 Kyle Conroy – *Model-Centric All-Sky EB Catalog: collaborative open-science and optimizing follow-up efforts*

Coffee 3:10 – 3:40

Session 16 3:40 – 4:55 (Melissa Graham, University of Washington)

3:40 Bryan Miller – *Gemini Operations and the Time Domain* (invited)

4:05 Niharika Sravan – *Single versus binary star progenitors of Type IIb supernovae*

4:30 Greg Schwarz – *Mandates and Narrative: Including data in your AAS Journal article*

Dinner (on your own)

Hot-Wiring the Transient Universe V, Villanova, PA, 10-14 October 2016

Friday, October 14

Session 17 9:00 – 10:20 (Andrej Prša, Villanova University)

9:00 *Announcements*
9:05 Vikram Ravi – *The hottest transients in the Universe* (invited)
9:30 Tara Murphy – *The Dynamic Radio Sky: Transient Pipelines for ASKAP and the MWA*
9:55 Howard E. Bond– *The SPIRITS Survey for Extragalactic Infrared Transients*

Coffee 10:20 – 10:50

Session 18 10:50 – 12:00 (Melissa Graham, University of Washington)

10:50 Tina Peters – *Quasars Selected by both Color and Variability* (invited)
11:15 Vishal P. Kasliwal – *Extracting Information from AGN Variability*
11:40 Tara Murphy – *Wrap-up* (20m)

12:00 pm – Symposium adjourns

Program v1.7, 7 October 2016 *http://hotwired5.villanova.edu*

ABSTRACTS

SESSION 1

[KEYNOTE] *The Proxima Centauri Star-Planet System: Planet and Stellar Properties from Time-Series Observations*

Edward Guinan, Scott Engle, Lucas Ignasi Ribas

The physical properties of the red dwarf Proxima Cen and its newly discovered Habitable-Zone, Earth-size planet Proxima b are discussed. Proxima b has an orbital period of 11-d and is ~0.05 au from its host star and has a minimum mass of 1.3 Me and a stellar irradiance of S = 0.39 Se (Anglada-Escude' et al. 2016). The age of Proxima b of 4.8 +/- 0.4 Gyr is know from its association with the alpha Cen AB. We discuss the time series, multi-wavelength X-Ray, UV, Optical observations that yield the radiative, magnetic, flare and rotation properties of the M5.5 V host star. Combining these data with corresponding data from red dwarfs with ages from 0.1 - 10 Gyr from our "Living with a Red Dwarf" program permits the determination of the X-UV radiation received by Proxima b over its lifetime and the assessment of its water inventory and habitability (Ribas et al. 2016). We briefly discuss the possibilities of determining Proxima b's atmospheric properties and composition (e.g. -is there water?) and searches for possible bio-signatures with upcoming space missions such as JWST, WFIRST, New Worlds (Starshade) Mission and very large Earth-based telescopes such the E-ELT, GMT, and TMT.

We acknowledge and are grateful for support by the NSF and NASA through grants NSF/RUI-1009903, HST-GO-13020.001-A and Chandra Award GO2-13020X to Villanova University.

LSST overview and status

Melissa Graham

LSST optical transient survey modes

Tony Tyson

LSST engineering first light is only a few years away. Now is a good time for community discussion of optimal observing cadence(s) and coordination of facilities for transient follow-up. I will outline the various modes of LSST observing which generate useful data on optical transients, and discuss challenges and opportunities for LSST follow-up of gravitational wave events.

Preliminary Results on the Performance of the LSST on the Detection of Eclipsing Binaries

Mark Wells

In this work we attempt to quantify the performance of /LSST/ on the detection of eclipsing binaries. We use /Kepler/ observed binaries to create a large sample of pseudo-/LSST/ binary light curves. From these light curves, we attempt to recover the known binary signal. The success rate of period recovery from the pseudo-/LSST/ light curves is indicative of /LSST/'s expected performance. Using the analysis of variance routine provided by /VARTOOLS/, we successfully recovered 71% of the targets in our sample. We look at how the binary period impacts recovery success and see that after 10 days the chance of successful binary recovery drops below 50%.

SESSION 2

[KEYNOTE] *The Solar System and LSST*

Lynne Jones

Image Differencing in LSST

Colin Slater

LSST is in the construction phase, and many of the core algorithms are already operational and in use on precursor data. I will discuss our exercising of the LSST image differencing pipeline, starting from raw data all the way to preliminary moving object detection. In particular I will highlight the significant algorithmic improvements we have made recently to handle correlated noise in difference images, which reduce false detections by as much as an order of magnitude and results in a significantly cleaner alert stream to the users.

The Enhanced Catalina Sky Survey for Near-Earth Objects

Eric Christensen

The Catalina Sky Survey (CSS) operates three telescopes on Mt. Lemmon, Arizona, in support of NASA's effort to detect and catalog near-Earth objects (NEOs). CSS is undergoing a period of significant enhancement, including the installation of two large-format cameras built around monolithic 10k x 10k detectors, which replace our reliable but aging 4k x 4k cameras at the survey telescopes. These new cameras increase the field of view (FoV) of our 0.7-meter Schmidt telescope by a factor of 2.4 (from 8.1 deg^2 to 19.4 deg^2), and the FoV of our 1.5-meter telescope by a factor of 4 (from 1.2 deg^2 to 5.0 deg^2), enabling significantly more sky to be surveyed every night. A 1.0-m telescope 70% dedicated to NEO follow-up is also being routinely operated. The immediate increase in discovery capability has prompted changes to CSS's model of integrated discovery and follow-up, and lead to improvements in managing follow-up targets. As an intermediate step, the software tools for human-driven selection and scheduling of NEO candidates are being improved, working toward an ultimate goal of fully automated prioritization and queue-enabled observation of follow-up targets.

SESSION 3

[KEYNOTE] *Preparing for LSST with the LCOGT NEO Follow-up Network*

Sarah Greenstreet, Tim Lister, Edward Gomez

The Las Cumbres Observatory Global Telescope Network (LCOGT) provides an ideal platform for follow-up and characterization of Solar System objects (e.g. asteroids, Kuiper Belt objects, comets, near-Earth objects (NEOs)). The LCOGT NEO Follow-up Network uses the LCOGT telescopes along with a web-based system developed to perform prioritized target selection, scheduling, and data reduction to confirm NEO candidates and characterize radar-targeted known NEOs. To determine how to maximize our NEO follow-up efforts, we must first define our goals. This means answering the following questions. Should we focus on the brightest objects or push to our capability limits by observing the faintest objects possible and risk non-detections? Do (and how do) we prioritize objects in the middle of our observable magnitude range? If we push to faint objects, how do we minimize the data in which the SNR is too low for detection? And how do we find a balance between performing follow-up and characterization observations? To help answer these questions, we have developed a LCOGT NEO Follow-up Network simulator that allows us to test our prioritization algorithms for target selection, confirm SNR predictions, and determine ideal block lengths and exposure times for observing NEO candidates. In the era of LSST, developing/utilizing infrastructure, such as our follow-up network and web-based platform, capable of handling the large number of detections expected daily from LSST will be critical to follow-up efforts. We hope our work can act as an example and tool for the community as together we prepare for the age of LSST.

The LCOGT NEO Follow-up Network

Tim Lister, Sarah Greenstreet, Edward Gomez, Eric

The LCOGT NEO Follow-up Network performs confirming follow-up of the large number of NEO candidates and to perform characterization measurements of radar targets to obtain light curves and rotation rates. The NEO candidates come from the NEO surveys such as Catalina, PanSTARRS, ATLAS, NEOWISE and others. In particular, we are targeting objects in the Southern Hemisphere, where the LCOGT NEO Follow-up Network is the largest resource for NEO observations. LCOGT has deployed, installed and commissioned nine 1-meter telescopes at McDonald Observatory (Texas), Cerro Tololo (Chile), SAAO (South Africa) and Siding Spring Observatory (Australia). The telescope network has been fully operational since 2014 May, and observations are being executed remotely and robotically. Future expansion to a site at Ali Observatory, Tibet is planned for 2017-2018. We have developed web-based software called NEOexchange which automatically downloads and aggregates NEO candidates from the Minor Planet Center's NEO Confirmation Page, the Arecibo and Goldstone radar target lists and the NASA ARM list. NEOexchange allows the planning and scheduling of observations on the LCOGT Telescope Network and the tracking of the resulting blocks and generated data. We have recently extended the NEOexchange software to include automated data reduction to re-compute the astrometric solution, determine the photometric zeropoint and find moving objects and present these results to the user via the website. We will present results from the LCOGT NEO Follow-up Network and from the development of the NEOexchange software which is used to schedule, analyze and report observations taken with the LCOGT Network.

CRTS: Recent Progress and Results

Ashish Mahabal on behalf of the CRTS Team

CRTS has been leading the astronomical transients' scene with thousands of publicly available high amplitude discoveries. We have now moved to larger and better CCDs. We also continue to work on the archival data which now span well over a decade. We report here on some of the latest results from our ongoing work on quasar variability, unusual binaries, and various classification directions as we start combining multiple and diverse datasets. We also present co-added images from CRTS to be served soon in addition to the current products viz. catalogs and individual images.

Arecibo Radar and Multi-Wavelength Collaborations on Near-Earth Asteroids

Patrick A. Taylor

Arecibo radar observations of near-Earth asteroids are critical for identifying those objects that may be on a collision course with Earth in addition to providing detailed physical characterization of the objects themselves in terms of size, shape, spin, and surface-property (reflectivity, polarization, geologic features and sometimes composition and density) information. In fact, radar investigations are roughly equivalent, in terms of science content, to a spacecraft flyby, but cost orders of magnitude less and can study orders of magnitude more objects. For objects known well in advance, we publish our target lists on our public website: www.naic.edu/~pradar [1] to facilitate collaboration, most often with optical (lightcurve) and infrared observers. However, roughly half of our targets are not known in advance and are detected by Arecibo on their discovery apparition. These, often small, targets are typically visible to Arecibo for only a few days after discovery when they make a close flyby of Earth. This is due to a combination of their inherent faintness, the fourth power dependence of radar signal on distance, and the limited declination range of the telescope. Thus, rapid communication between the optical survey telescopes that discover these objects, the Minor Planet Center that gives them designations, and the telescopes that must dynamically schedule observations is absolutely necessary. I will discuss recent radar observations of near-Earth asteroids with Arecibo, including examples of multi-wavelength collaborations often on short timescales.

SESSION 4

[KEYNOTE] *Implementing Minor Planet Center V2.x*

Gareth Williams

An overview of the past and current capabilities of the IAU's Minor Planet Center and the plans for implementing the pipeline that will handle the expected two orders of magnitude increase in observational activity.

NEOWISE: Overview and Recent Results

Joseph Masiero (NASA JPL/Caltech), A. Mainzer, J. Bauer, R.

The Near-Earth Object Wide-field Infrared Survey Explorer (NEOWISE) is undertaking an all-sky thermal infrared survey to both discover new near-Earth asteroids and comets, and characterize previously known Solar system objects. NEOWISE performs simultaneous imaging at 3.4 and 4.6 microns, measuring the thermal emission from NEOs allowing their diameters to be computed. We discuss the techniques used for asteroid and comet identification, focusing on the unique concerns for space telescopes, and present an overview of recent results from these data.

The Asteroid Terrestrial-impact Last Alert System (ATLAS) Update

Larry Denneau, Ari Heinze, Andrei Sherstyuk, Brian Stalder, (TBD).

We present construction and commissioning status of the ATLAS telescope system for detecting near-Earth asteroids (NEAs). We will provide an overview of the ATLAS data processing pipeline from image reduction to asteroid detection, and science results from our commissioning period. We will speculate on expansion of the ATLAS system beyond its current two-aperture design, and assess the system's capability to characterize the small-body NEA population.

SESSION 5

The Transneptunian Automated Occultation Survey (TAOS II)

Matthew J. Lehner, Shiang-Yu Wang, Mauricio Reyes-Ruiz,

The Transneptunian Automated Occultation Survey (TAOS II) will aim to detect occultations of stars by small (~1km diameter) objects in the Kuiper Belt and beyond. Such events are very rare (<0.001 events per star per year) and short in duration (200 ms), so many stars must be monitored at a high readout cadence. TAOS II will operate three 1.3 meter telescopes at the Observatorio Astronomico Nacional at San Pedro Martir in Baja California, Mexico. With a 2.3 square degree field of view and high speed cameras comprising CMOS imagers, the survey will monitor 10,000 stars simultaneously with all three telescopes at a readout cadence of 20 Hz. Construction of the site began in the fall of 2013, and the survey will begin in the summer of 2017. In this talk, I will give an overview of the survey goals and techniques, and provide a summary of the progress made on the survey implementation.

FRoST: Flagstaff Robotic Survey Telescope

Dan Avner, David Trilling, and Ted Dunham

The Flagstaff Robotic Survey Telescope (FRoST) is a robotic 0.6m Schmidt telescope that will be used for instant follow-up observations of newly discovered Near Earth Objects (NEOs). Here, we present the progress being made on FRoST as well as the remaining tasks until the telescope is fully operational. With more than one thousand NEOs being found yearly, more telescopes are needed to carry out follow-up observations. Most NEOs are found at their peak brightness, meaning that these observations need to happen quickly before they fade. By using the Catalina Sky Survey Queue Manager, FRoST will be able to accept interruptions during the night and prioritize observations automatically, allowing instant follow-up observations. FRoST will help refine the orbit of these newly discovered objects while providing optical colors. We will ingest information from the NEOCP and JPL's Scout program at five minute intervals and observe newly discovered targets robotically, process the data automatically, and autonomously generate astrometry and colors. We estimate that will we provide essentially 100% recovery of objects brighter than V~20. This work was supported by the NSF MRI program as well as by NAU and Lowell Observatory.

The State of MANOS and asteroid.lowell.edu

Brian Burt, Nicholas Moskovitz, Robert Schottland,

The Mission Accessible Neart-Earth Object Survey (MANOS) is a three year survey aimed at obtaining physical properties for mission accessible Near-Earth Asteroids smaller than 100 meters. We have acquired time on Gemini North, Gemini South, SOAR, Kitt-Peak 4m, and CT-1.3m to obtain vivible and infrared spectra and visible photometry to characterize composition and rotation state. This will produce a database of roughly 500 objects, representing an unexplored size regime over an order of magnitude smaller than previous studies. Additionally, we are overhauling an old database system hosted by Lowell Observatory at asteroid.lowell.edu. We are moving the backend database from a series of flat files to a relational database, updating and converting code, and developing new tools. These tools primarily focus on observational planning. A major component of our overhaul is to introduce a system and portal to allow for rapid distribution and collaboration of asteroid observations and physical properties. I will present the state of MANOS and the improved asteroid.lowell.edu web portal.

SESSION 6

Lessons Learned from Past/Ongoing Survey Followups

Paula Szkody

The Zwicky Transient Facility

Eric C. Bellm, on behalf of the ZTF Collaboration

The Zwicky Transient Facility (ZTF) is a next-generation optical time-domain survey that will survey more than an order of magnitude faster than its predecessor, the Palomar Transient Factory. First light is expected in 2017. I will provide a brief overview of the survey design, science goals, and technical progress to date. Thanks to support from the NSF MSIP program, ZTF will include several public components. I will detail our plans for two major public surveys and the associated transient alerts and data releases. Finally, I will describe our progress developing a novel approach to observation scheduling.

Project Solaris - a global network of robotic telescopes. Current status and prospects

Pawłaszek, R.K., Sybilski, P., Konacki, M., Kozłowski, S.,

Project Solaris is a scientific project aiming at precise characterization of binary stellar systems and search for circumbinary planets through photometric observation analysis. Technologically, the project comprises a network of four robotic 0.5m telescopes in the southern hemisphere. After a series of successful tests one of the telescopes was upgraded with a compact spectrograph, BACHES which allows for simultaneous photometric and spectroscopic observations. The photometric setup has been found highly capable for surveying and tracking satellites, space debris and NEOs and is one of Polish key-assets for such activities in ESA. Moreover, the software system developed and implemented for Project Solaris was selected as a core component for the future BlackGEM project, that will perform photometric follow-up observations of merging neutron stars and black holes after the detection of gravitational waves.

Environmental data acquisition system for Project Solaris

Litwicki, M., Kozłowski, S., Konacki, M., Pawłaszek, R.K.,

We present the idea behind the new, compact, standalone night sky monitoring vision system - 2piSky. This is a fully automated, embedded computer module which evolved with Project Solaris to a multipurpose environmental data acqusition system that among others is going be used in project BlackGEM. Although its main task is to acquire images from an allsky camera, process them, and present valuable weather data through a web interface, its capabilities to connect new environmental sensors and applying sophisticated algorithms plays an important role in autonomous observatories' design. We have developed a system the purpose of which is to calculate all sky real time photometry, analyze it to map sky transparency, detect meteors, acquire additional data from dedicated temperature, humidity and light sensors, weather stations etc. and log it to a local database, upload to remote data server, provide it to the robotic observatory main computer, combine it with your observing data, or present all together on a simple observatory dashboard. We will show that taking care of every detail of environmental data processing and embedding it into a robust, expandable and easy to use design can be a crucial part in capturing the transient universe.

SESSION 7

Skymap Viewer: Evaluating Observation Priority for Gravitational-Wave Follow-up

Roy Williams, Thomas Boch

Presenting Skymap Viewer, an astronomical information system for electromagnetic followup of gravitational-wave events, drawing on the vast resources of the CDS Strasbourg. For binary neutron star detections, several galaxy catalogs are shown (GLADE, Supercosmos-WISE, GWGC, etc), along with observation priority based on blue magnitude. For followup of binary black hole detections, the observation priority is based on mass, and catalogs of galaxy clusters are presented, as well as the 2MASS galaxy density for $z < 0.04$. The image of the probability density from the GW observation is enhanced with sun, moon, local horizon, histograms of declination and galactic latitude. The observation priority can be computed from fully 3D probability density from the GW observation, as well as from conventional 2D skymaps.

SVOM Science Ground Segment

Maohai Huang

I will describe the ground segment of the Space Variable Object Monitor (SVOM) satellite which is a collaboration between China and France. In order to implement SVOM's Core Programme, General Programme, and ToO Programme, SVOM ground segment features a VHF network, dedicated ground follow-up telescopes, Ground Wide-Angle Camera, dedicated Burst Advocate teams, and on-board follow-up mechanism driven by proposals or robotically generated events.

Internal vetting and analysis of low-latency GW triggers

Reed Essick

I present an overview of the types of low latency searches operated by the LIGO-Virgo collaboration, focusing on event validation after candidates have been identified. This includes both automated and manual follow-up to characterize the source localization as well as statements about the data quality surrounding the candidate. Specifically, I will describe the system used within the collaboration and the interactions of various processes. In broad strokes, I'll also describe the internal and external communication mechanism put in place to announce candidates. Time permitting, I will also describe some consequences of observed diurnal cycles governing when the LIGO detectors are likely to record data.

SESSION 8

[KEYNOTE] *EM Follow-up for LIGO*

Samay Nissanke

The SAAO-SALT Transient Detection and Followup Program

David A.H. Buckley

I firstly report on the establishment and specifications of the first comprehensive optical transient detection and followup system at the South African Astronomical Observatory (SAAO), namely MASTER-SAAO, and review the specifications of this system and results since it began operating in late 2014. Many new cataclysmic variable transients have been discovered and observed, complimenting to some extent the existing work done by the CRTS. In addition, a number of flaring blazars, GRBs and other transient objects have been discovered and monitored. A large program of optical transient followup, utilizing the 10-m Southern African Large Telescope (SALT), which began in May 2016, will be described and some initial results of followup observations of transients discovered through various alert systems (e.g. MASTER, ASAS-SN Gaia, OGLE, Fermi, Swift) will be presented, which cover most transient object classes. Finally I describe some new robotic facilities at SAAO, some more coming online soon, which will be dedicated to targets of opportunity and transient followup, including from the newly operational MeerKAT radio telescope facility.

ANTARES: Progress towards building a Broker of time-domain alerts

Gautham Narayan, Zhe Wang, Thomas Matheson, Richard Snodgrass

I'll discuss our work on the Arizona-NOAO Temporal Analysis and Response to Events System (ANTARES). Upcoming large optical surveys will provide us with petabytes of images and an unparalleled window into the time-domain. Our system is designed to process this flood of data, identifying, characterizing, and filtering objects and populations. Our goal is to prioritize the "rarest-of-the-rare" transients in real-time, from multi-messenger data streams, to coordinate detailed follow-up studies spanning the entire electromagnetic spectrum. At the last edition of Hot Wiring a Transient Universe, we demonstrated an early prototype of the ANTARES system. We've come a long way since that early prototype, and we'll demonstrate our current version, operating with vastly more complex and realistic algorithms on more pathological noisy data in a cluster environment. We'll discuss some of the challenges we've faced, describe our API and how you can get access to our annotated alerts, and take your feedback.

SESSION 9

[KEYNOTE] *Detection and Characterization of Exoplanets in the Era of Space-based Transit Surveys*

Jessie Christiansen

In the last 20 years, the number of planets detected orbiting other stars has increased super-linearly. With the launch of the ESA CoRoT mission in 2006, the NASA Kepler mission in 2009, and the upcoming launch of the NASA TESS mission in 2017, the pace at which we can glean planets from the avalanche of data is limited largely by the number of people looking at it. This has created a burgeoning coordinated community effort to analyse the data and provide rapid confirmation of the candidate planet signals. I will introduce the missions and techniques, and detail the emergence of the current astronomy community-driven paradigm.

Exoplanets as Byproducts of Modern Surveys

Michael B Lund

The large majority of exoplanets that have been discovered to date have been discovered through specifically designed exoplanet searches, such as transiting planets discovered by SuperWASP, HAT, KELT, and Kepler. This reflects the challenge of collecting a large number of observations for a single star while also observing a large number of stars in order to have a significant yield of recoverable transiting planets. As astronomy moves into the 'Big data' era, new surveys will be generating large amounts of photometric data that can be suitable for exoplanet detection even when this is outside the intended scope of the survey. The Large Synoptic Survey Telescope (LSST) currently under construction provides one such example. Leveraging improvements in data storage and transfer, LSST will collect 15 TB of data per night observing the Southern sky, resulting in 100 to 1000 photometric observations per year for around 1 billion stars. While exoplanets are not one of the official objectives of LSST, the photometry provided, especially in high cadence regions of the sky, is sufficient for carrying out searches for transiting planets. Further, as LSST will be observing many different stellar populations this also provides an opportunity to explore variations in exoplanet occurance rates for different stellar populations. LSST serves as just one example, and as additional surveys produce large amounts of high quality photometric data (such as Gaia and Euclid), there will be additional opportunities to use these data sets beyond their intended purposes and increase our understanding of exoplanet populations.

Multi-Epoch Surveys with the NASA K2 Mission

Knicole Colon

The K2 mission has been operating for over two years and has provided the astronomical community with a wealth of high-precision time-series photometry. With more than ten fields ("campaigns") observed to date along the ecliptic, there is now some overlap between targets observed in earlier and later campaigns. With this overlap, it is now possible to compare time-series photometry acquired in campaigns separated by ~two years. Such overlap can allow for constraints on the orbital period of seemingly transient events and/or further characterization of variability in stars and other astrophysical objects. In this presentation, I will discuss the characteristics of the targets with data acquired in multiple K2 campaigns. I will also discuss what challenges we face in interpreting data acquired for a single target from multiple campaigns. Lastly, I will provide an overview of the upcoming Campaign 17, which is designed to overlap significantly with Campaign 10 in order to provide further high-precision data for extragalactic studies involving quasar variability and supernovae. Campaign 17 is also unique in that the spacecraft will be oriented so we can observe simultaneously from the Earth and the spacecraft, enhancing the science output. Overcoming challenges in interpreting data from overlap fields will be especially critical for the upcoming all-sky TESS mission.

SESSION 10

KIC 8462852: Where's the Flux?

Tabetha Boyajian

WFIRST: The Wide-Field InfraRed Survey Telescope and what we can learn from its microlensing survey

Matthew Penny

I will describe the WFIRST mission, NASA's next flagship astrophysics mission after JWST. After describing the mission's hardware and scientific goals, I will focus on the mission's microlensing survey. From this survey, we can expect the detection of thousands of cold exoplanets, from orbits similar to Earth's out to far beyond the snowline, with masses ranging from super-Jupiter to below Mars. In addition to this haul of bound planets, WFIRST will also be able to discover and characterize the population of free-floating planets over a similar mass range, which could turn out to be a powerful tracer of the planet formation process.

The WFIRST Microlensing Survey: 2.8 sq deg of the Bulge at a 15 minute cadence

Jennifer Yee

Thirty percent of WFIRST's primary science mission is devoted to a microlensing survey for exoplanets. This survey consists of six campaigns in which 2.8 square degrees of the bulge will be observed at a 15-minute cadence for 72 days. Although this strategy is driven by microlensing, it will produce a rich, time series data set with many broader applications including astroseismology, searches for KBOs, and the detection of transiting planets.

Stellar Pulsations in Sparse Time Series Photometry

Keaton J. Bell

Stellar pulsations arise from the excitation of eigenmodes in stars. These vibrations pass through and are affected by stellar interiors, and measured frequencies of photometric variability can be studied to reveal sub-photospheric conditions. The strategies of most upcoming all-sky surveys are not optimized for classical asteroseismology, but the huge data sets that they produce will advance the less understood areas of pulsational energetics and driving and will build extensive catalogs of pulsating objects. Systematic high-duty-cycle time series photometry of select pulsating variables can help map precision asteroseismic results into this larger context. Rapid-response follow-up to transient events may also be a powerful tool for better understanding the nature of these events. I will share my insights into this area from my experience studying pulsating white dwarf stars, with an emphasis on a new pulsation-related transient phenomenon that was recently discovered in the coolest hydrogen-atmosphere white dwarf pulsators.

SESSION 11

Revealing the Secret Lives of Cepheids Through Photometric Surveys and Multi-Wavelength Data

Scott G. Engle, Edwarf F. Guinan, Joshua Pepper, Michael Toce

Current-generation instruments, both space- and ground-based, have made it possible to efficiently reveal completely new aspects of Cepheid activity and variability. The advent of ground-based, wide-field (or all-sky) photometric surveys (e.g. KELT, ASAS) have now made it possible for the yearly (potentially even monthly) monitoring of Cepheids to be undertaken. This will offer an unprecedented look at pulsation period changes in a large number of Cepheids, giving valuable insights into these stars, including evolutionary status and potential companions. Further, UV and X-ray observations have revealed active and dynamic outer atmospheres around a select number of Cepheids. We report on the current results of the Secret Lives of Cepheids program and what the future might hold for the study.

Light Curve Mophology of close binary stars: a tool for refined classification in large photometric surveys

Bartlomiej Debski

The long-timebase photometry of close binaries allowed to study the continuous evolution of the light curve parameters. Various correlations between light curve extrema can be treated as indicators of the ongoing starspot migration and can be used for pinpointing the primary eclipse. In this work I am presenting the initial results of the analysis of the evolution of such parameters as the O'Connell effect and brightness maxima separation applied to the sample of objects from the Kepler Eclipsing Binary Catalogue. I will show the general refinement of the sample parameters and present a case study of several, presumably contact, binaries.

Sky2Night

Jan van Roestel

Sky2Night is a small project which combines the realtime transient identification by PTF with rapid, large scale spectroscopic classification. PTF observed 407 square degrees for 8 nights at a cadence of 2 hours. During 5 of these nights, the 4 meter WHT was available to classify the transients found by PTF the night before. During the survey we found and classified 7 SNIa, 7 Dwarf Novae, 3 CC-SN, 4 M-flares and 2 AGN-outbursts. With this well defined survey, we determined robust observed rates for the observed types of transients. We use simulations of our survey to determine the dwarf novea space density and the SN1a space density. In addition, we calculate an upper limit to the observed rate of fast optical transients.

Project Blacklight: Intra-Visit Variables with gPhoton

Scott W. Fleming, Chase Million, Bernie Shiao, Michael

gPhoton is a time-tagged database of more than a trillion UV photon events from the GALEX spacecraft covering 77% of the sky, publicly available at the MAST archive. Open-source software allows users to construct calibrated light curves and images at user-defined temporal and spatial scales. For the first time, it is now possible to study UV variability within a GALEX visit (less than 30 minutes) using the entire corpus of GALEX data. In this presentation, I will demonstrate how the software enables these studies using a simplified front-end, and show some of the first science results from our efforts. These include studies of small stellar flares with energies and durations smaller than even Kepler can probe, pulsations of white dwarfs, detections of transients not included in the mission's source catalog, eclipsing binaries, and cataclysmic variables. To find out more about gPhoton, visit https://archive.stsci.edu/prepds/gphoton/ [1]

SESSION 12

[KEYNOTE] *Software sustainability in astronomy*

Tim Staley

This year, the 4 Pi Sky project launched our first public data-service - a remotely queryable database that aims to provide an archive of all publicly available transient alerts ('voeventdb'). I'll briefly cover the functionality we provide, but I'd like to focus primarily on some wider issues - how can we achieve 'software sustainability' and re-use in astronomy? Should we even bother trying? I'll discuss some of technical and social aspects of sustainable development, touching on tools we've found useful, and areas where I think we could probably do better.

SESSION 13

[KEYNOTE] *Optimizing Facilities and Infrastructure for Time Domain Science*

Rachel Street

All aspects of time domain astronomy will continue to develop with the advent of the next generation of surveys, including ZTF, Evryscope and LSST. It is particularly noteworthy that whereas the first time domain surveys focused on specific science goals, future surveys are increasingly planning to address multiple themes, though the surveys themselves will often act as discovery engines, with follow-up observations performed by other facilities serving to characterize the detections. The larger scale of these projects, and developments in technology, raise both challenges and new solutions to the effective conduct of programs aiming to respond to survey alerts: How can we make sure that teams can accurately select targets from the survey alert feeds? (alert dissemination, catalog cross-matching, available data products, real-time alert processing and analysis) How can we ensure targets can be observed at appropriate timescales? (telescope time allocation in queue mode, access to facilities, target-of-opportunity modes, distribution of facilities, interfacing with manual-, remote- or robotic-facilities) What's the best way to handle data? (reduction pipelines, real-time data products, archiving) How to multiple, completing teams achieve their science goals efficiently while minimizing duplicated work and observations? I will present a discussion of both challenges and outline some potential solutions currently under consideration.

Hot-Wiring the Transient Universe V, Villanova, PA, 10-14 October 2016

LCOGT Server Deployment and Monitoring: An Adventure in Automation

Ira W. Snyder

This talk will provide an overview of how Las Cumbres Observatory deploys operating systems and telescope control software to computers around the world in a highly controlled and easy-to-manage way. It will also explore how with limited staff we monitor the network effectively and with minimum human intervention. I will describe the benefits of automation and continuous delivery, and detail our choice of open source tools. I'll detail how we release new features faster and how by using version control, we have the ability to revert to previous operating models within minutes. I'll explain how we have re-worked our new and existing computing infrastructure into manageable, self documenting components and how, over the last 18 months, we have transformed ourselves from a traditionally chaotic computing services operation into an astro-synergistic, super-agile, caffeine-free DevOps shop!

BANZAI: An Open Source Data Reduction Pipeline for Las Cumbres Observatory

Curtis McCully

As we move into the era of time-domain astronomy, the way we think about observational data has to change. We can no longer take observations, visually inspect every image, and have a student work for months to produce final reduced data. Instead, robust, automated data processing pipelines are essential. Las Cumbres Observatory (LCO) is a prototype for future time domain follow-up: we currently operate a network of 18 small aperture telescopes around the world which produce nearly 50,000 images per month. We reduce this data in real time using the BANZAI image reduction pipeline which I present as a case study to illustrate the challenges of running a high volume data reduction service. LCO is committed to being an open source organization: the BANZAI pipeline is therefore an open source project. This encourages transparency, allowing people outside the observatory to help improve the quality of our data. The code is no longer a black box, improving the reproducibility of scientific results and allowing for customizations for specific projects. Data reduction at this scale is not without challenges, e.g. robust deployment, extensibility, performance. Monitoring a data flow of this size is both challenging and critical; to solve this, we have tightly integrated the pipeline into telescope operations and now capture metrics that we use to produce summary reports to monitor the health of the telescope network, both hardware and software. As the astronomical data rate continues to explode, we hope to apply these lessons learned to future facilities.

LCO: around-the-world, around-the-clock operations

Nikolaus Volgenau

Las Cumbres Observatory (LCO) is a global network of telescopes that was developed specifically

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to support time-domain astronomy. LCO currently comprises 18 telescopes distributed over 6 sites and provides continuous coverage of the night sky. Science observations are coordinated by centralized software that dynamically optimizes a schedule for the entire network. The observations support investigations into a wide range of transient and variable phenomena, and several thousand hours per semester are devoted to key projects to study supernovae, AGN variability, and Galactic microlensing events. Monitoring the site conditions, instrument performance, and data quality for an around-the-clock observatory is a challenge. This presentation describes the changes that LCO has made within the past year to improve operations and provide information to its users. LCO also continues to implement new capabilities. In 2016, LCO expanded its set of 0.4-meter telescopes to seven and made three of those telescopes (in Australia, Spain, and Hawaii) available for science observations. Also in 2016, LCO began processing all raw data through a new reduction pipeline and storing data products in a new cloud-based archive. Beginning in 2017, the US astronomical community will gain access to the LCO Network through the NSF's Mid-Scale Innovations Program (MSIP). LCO's open-access program will allow participants to gain real-world experience executing time-domain follow-up projects. The program will favor proposals for follow-up observations of current time-domain surveys, as well as proposals that seek to develop the software infrastructure required to maximize the science return of the LSST.

SESSION 15

1% accuracy in fundamental stellar parameters? Not without an extensive redesign of eclipsing binary models

Andrej Prsa

Eclipsing binary stars can be used to determine the radius and mass of stars by relying on simple geometry and well understood laws of physics. Observations obtained over the last decade have greatly improved in accuracy, so the theoretical models used to interpret these data require substantial revision. This project identifies the aspects of theoretical models in need of revision and proposes a path to update the models. This will enable accurate (within 1%) measurements of stellar masses and radii. Precise determination of fundamental stellar properties is critical to many branches of astrophysics, from studying the life cycles of stars to determining distances throughout the universe. The advances in modelling approaches and classification are applicable to many problems in astronomy, physics, engineering, and applied mathematics. Conducting this program at a primarily undergraduate institution will provide opportunities undergraduate students learn modern research tools and techniques.

Supernova Hunters: combining human and machine classifications

Darryl Wright

Hot-Wiring the Transient Universe V, Villanova, PA, 10-14 October 2016

Efficient identification and follow-up of astronomical transients is hindered by the need to manually select promising candidates from data streams that contain many false positives. With data from Pan-STARRS1 we present the citizen science project, Supernova Hunters created with the Zooniverse project builder. The project allows us to crowdsource classifications of supernova candidates, and test methods to combine human and machine classifications. We show this combination produces a purer and more complete sample of supernovae than either individually.

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An Open Catalog for Supernova Data

James Guillochon, Jerod Parrent, Raffaella Margutti, Luke

I will present the Open Supernova Catalog, an online collection of observations and metadata for presently 30,000+ supernovae and related candidates. The catalog is freely available on the web, with its main interface having been designed to be a user-friendly, rapidly-searchable table accessible on desktop and mobile devices. In addition to the primary catalog table containing supernova metadata, an individual page is generated for each supernova which displays its available metadata, light curves, and spectra spanning X-ray to radio frequencies. The data presented in the catalog is automatically rebuilt on a daily basis and is constructed by parsing several dozen sources, including the data presented in the supernova literature and from secondary sources such as other web-based catalogs. Individual supernova data is stored in the hierarchical, human- and machine-readable JSON format, with the entirety of each supernova's data being contained within a single JSON file bearing its name. The setup I will present, which is based upon open source software maintained via git repositories hosted on GitHub, enables anyone to download the entirety of the supernova dataset to their home computer in minutes, and to make contributions of their own data back to the catalog via git. As the supernova dataset continues to grow, especially in the upcoming era of all-sky synoptic telescopes which will increase the total number of events by orders of magnitude, we hope that the catalog we have designed will be a valuable tool for the community to analyze both historical and contemporary supernovae.

Model-Centric All-Sky EB Catalog: collaborative open-science and optimizing follow-up efforts

Kyle Conroy

With recent missions such as Kepler, and upcoming missions including GAIA, TESS, and LSST in addition to a large network of smaller telescopes on the ground, the scientific opportunities to get large statistical samples should be revolutionizing our science. Unfortunately, especially in the eclipsing binary field, we are failing to keep up with these drastic increases in data. In order to fully benefit from these data, it is essential that we automate as much of this effort as possible, saving man-hours to work on the most interesting individual cases and statistical analysis. Here we present plans and current progress on a model-centric collaborative database in the hope s of automating these tasks and optimizing science output from these surveys.

SESSION 16

Gemini Operations and the Time Domain

Bryan Miller

Gemini Observatory, and Gemini South in particular, will be an important facility for following up time domain discoveries. We will summarize the Gemini operations model and instrumentation suite and describe how this will complement the current and future surveys. Gemini has a variety of modes and time allocation processes in order to accommodate a broad range of project needs. Observations are carried out in queue (service), classical (visitor), and priority visitor (visitors execute the queue) modes. Time is allocated by regular partner TACS, a common large program TAC, and by peer review for "fast-turnaround" proposals. Queue observing allows Gemini to easily execute target-of-opportunity (TOO) observations and this capability will be very important for transient follow-up. The next Gemini instrument is being designed with LSST in mind and the current status will be reviewed. Changes being planned to the planning software to handle the increased volume of TOO triggers will also be presented.

Single versus binary star progenitors of Type IIb supernovae

Niharika Sravan

Stripped-envelope supernovae (SNe) represent a challenge to our understanding of massive star evolution. Wind mass loss and binary interactions are the leading candidates to explain observations. The latter has gained support in the recent years with growing evidence that mass-loss rates due to line-driven winds are, in reality, 2 - 3 times lower. In this talk I will focus on a class of SNe known as Type IIb SNe. These initially exhibit strong Hydrogen spectral lines but they weaken and disappear over time and are thought to arise from progenitors that have retained a small amount of their Hydrogen envelope. They are also the only class of stripped-envelope SNe with identified progenitors. Thus they are powerful tools for testing our understanding of massive stellar evolution. To identify possible evolutionary pathways to Type IIb SNe, we use Modules for Experiments in Stellar Astrophysics (MESA) to model a large population of single and binary star sequences covering a broad parameter space with a wide range of component masses and initial orbital periods and identify those that undergo core-collapse with 0.01 to 0.5 solar masses of residual Hydrogen envelope. We find no single star Type IIb progenitors in the parameter space covered. We find a few binary Type IIb progenitors. These sequences have initial mass ratios greater than 0.6, wide orbital periods and undergo non-conservative mass transfer.

Mandates and Narrative: Including data in your AAS Journal article

Greg Schwarz

Access to the data behind an article is becoming more of a concern for authors due to government mandates. These mandates generally do not specify how much or what type of data should be supplied which gives authors great flexibility to weave their data into the scientific narrative. The AAS Journals has continuously built up our our data product options to provided new functionality that transcend the limitations of the printed, or pdf, page. These data features gives authors unique ways to describe their science. The data will be available to the reader to reproduce the underlying work or do serendipitous science. In this talk I outline all the data features and show how you can use them with your time domain and interdisciplinary data sets in future AAS Journal submissions.

SESSION 17

The hottest transients in the Universe

Vikram Ravi

Fast radio bursts (FRBs) - (sub-)millisecond pulses of GHz radio waves likely originating at distances >100 Mpc - are among the most exciting, yet confounding, astronomical phenomena discussed in the corridors of astronomy departments. While properties of their emission, including polarization, pulse structure and high (>10^35 K) brightness temperature, are reminiscent of (giant) pulses from radio pulsars, drawing parallels between FRBs and the Galactic pulsar population is difficult. Indeed, reconciling the properties of FRBs discovered at different telescopes, such as the repeating Arecibo object and the very bright, non-repeating Parkes events, as well as detection rates at different telescopes, is fraught. Explaining among the most apparently luminous, and certainly the hottest, compact sources of radio emission in the known Universe therefore remains a compelling puzzle. I will discuss issues in searching for and classifying FRBs, with a focus on multi-telescope searches that promise the first meaningful FRB localization. I will also address attempts at stochastic modeling of the FRB population, in particular of the pulse-energy distribution that hints at either a cosmological or a multi-component population.

The Dynamic Radio Sky: Transient Pipelines for ASKAP and the MWA

Tara Murphy, David Kaplan, Keith Bannister

I will give an overview of the transients projects on two SKA pathfinders: The Murchison Widefield Array and the Australian SKA Pathfinder. I will discuss the latest scientific results and computing challenges. In particular I will discuss our current transient detection pipelines, and our future plans.

The SPIRITS Survey for Extragalactic Infrared Transients

Howard E. Bond, Mansi M. Kasliwal, and the SPIRITS Team

Since 2014 our SPIRITS (SPitzer InfraRed Intensive Transients Survey) team has used the warm Spitzer telescope to search for stellar transients and variables in 190 nearby (<20 Mpc) galaxies. We have discovered a large number (>1500) of luminous variables, and dozens of transients. Among the transients are a new class that we have named SPRITEs (eSPecially Red Intermediate-luminosity Transient Events). Their mid-IR (3.6 and 4.5 mu) luminosities at maximum lie between those of novae and SNe, and they are so cool that they lack detectable visual and even near-IR (JH) counterparts during eruption. Their progenitors are likewise inconspicuous in pre-outburst optical HST images. SPRITEs lie predominantly in star-forming spiral arms, indicating that they probably arise from stars of at least intermediate (>8 Msun) masses. They may represent electron-capture SN explosions of heavily dust-obscured extreme AGB stars, binary-merger events that produce very dusty outflows, or other new phenomena.

SESSION 18

Quasars Selected by both Color and Variability

Tina Peters

Using a Bayesian selection algorithm, we determine the optimal combination of color and variability information to identify quasars in current and future multi-epoch optical surveys. The color analysis is based on SDSS photometry, and the variability parameters are calculated from power-law fits to the structure functions. Simultaneous color and variability classification improves classification over either color or variability selection alone, with particular improvement in the selection of quasars with colors similar to stars. This method identifies 22,867 new type 1 quasar candidates in SDSS Stripe 82, which can be combined with the WISE and SDSS photometric quasar candidate catalogs. The redshifts of the candidate quasars were estimated using all available bands, weighting each band by smoothing the PDF. We show how to correct the candidate quasar luminosity function (QLF) for the completeness fraction and systematic errors in redshifts. The corrected QLF is comparable to those determined by spectroscopic investigations, suggesting that LSST and other next-generation surveys will be able to accurately determine the QLF in the absence of spectra.

Extracting Information from AGN Variability

Vishal P. Kasliwal, Michael S. Vogeley, Gordon T. Richards

AGN exhibit rapid, high amplitude stochastic flux variability across the entire elec- tromagnetic spectrum on timescales ranging from hours to years. The cause of this variability is poorly understood. We present a new method for using variability to (1) measure the time-scales on which flux perturbations evolve and (2) characterize the driving flux perturbations. We model the observed light curve of an AGN as a lin- ear differential equation driven by stochastic impulses. Physically, the impulses could be local 'hot-spots' in the accretion disk—the linear differential equation then governs how the hot spots evolve and dissipate. The impulse-response function of the accretion disk material is given by the Green's function of the linear differential equation. The timescales on which the hot-spots radiate energy is characterized by the powerspec- trum of the driving stochastic impulses. We analyze the light curve of the Kepler AGN Zw 229-15 and find that the observed variability behavior can be modeled as a damped harmonic oscillator perturbed by a colored noise process. The model powerspectrum turns over on time-scale 385 d. On shorter time-scales, the log-powerspectrum slope varies between 2 and 4, explaining the behavior noted by previous studies. We re- cover and identify both the 5.6 d and 67 d timescales reported by previous work. These timescales represent the time-scale on which flux perturbations grow, and the time-scale on which flux perturbations decay back to the steady-state flux level respec- tively. We make the software package used to study light curves using our method, Kālī, available to the community.