The 34th Annual New Mexico Symposium

09 November 2018

ABSTRACTS

Oral presentations

Session #1, 08:45–09:00

Evidence for Ultra-Diffuse Galaxy 'Formation' Through Galaxy Interactions

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[1] Texas Tech University, [2] University of Arizona, [3] University of Tampa, [4] Royal Military College of Canada, [5] Queen's University

We report the discovery of two ultra-diffuse galaxies (UDGs) that show clear evidence of an association with tidal material and interaction with a larger galaxy, found during a search of the Wide portion of the Canada/France/Hawaii Telescope Legacy Survey. The two new UDGs, NGC 2708-Dw1 and NGC 5631-Dw1, are faint, extended, and have low central surface brightness. These observations provide evidence that the origin of some UDGs connect to galaxy interactions, either by transforming normal dwarf galaxies by expanding them, or because UDGs can collapse out of tidal material (i.e., they are tidal dwarf galaxies).

Session #1, 09:00–09:15

Confused Sources in the ALFAZOA survey

Monica Sanchez-Barrantes (NRAO,UNM, speaker), Patricia Henning (UNM), Emmanuel Momjian (NRAO)

The Arecibo L-band Feed Array Zone of Avoidance (ALFAZOA) Deep Survey is the most sensitive blind HI survey done in the ZOA, and will cover about 100 square degrees of sky in the outer Galaxy ($175 < l < 207$; $-2 < b < 1$). This survey covers a wide angle of the sky, and therefore cuts across a variety of large-scale structures, which makes it ideal for the study of the effects of environment (i.e. overdensities) on hydrogen content in galaxies, as well as mapping out the large-scale structure of the ZOA. The galaxies detected in this survey will be used to measure how the HI mass function (HIMF) changes as a function of environment, but problematic sources appear due to confusion caused by the Arecibo L-band beam size (3.5'). This presents a large problem for the determination of the HIMF because using confused sources will overestimate the mass of the galaxies and undercount the total

number of galaxies, resulting in an inaccurate measurement of the HIMF. Here we show results from the VLA D configuration follow-up of some potentially confused sources from the ALFAZOA survey.

Session #1, 09:15–09:30

The BAaDE survey, possible biases, and SiO masers as tracers of circumstellar shell conditions

M. C. Stroh - UNM (speaker), Y. M. Pihlstrom - UNM, L. O. Sjouwerman - NRAO, M. J. Claussen - NRAO, M. R. Morris - UCLA, R. M. Rich - UCLA

The Bulge Asymmetries and Dynamical Evolution (BAaDE) project aims to explore the complex structure of the inner Galaxy and Galactic Bulge, by using the 43 GHz receivers at the Karl G. Jansky Very Large Array (VLA) and the 86 GHz receivers at the Atacama Large Millimeter/submillimeter Array (ALMA) to observe SiO maser lines in red giant stars. The goal is to construct a sample of stellar point-mass probes that can be used to test models of the gravitational potential, and the final sample is expected to provide at least 20,000 line-of-sight velocities and positions. The SiO maser transitions occur at radio frequencies, where extinction is negligible, thus allowing a dense sampling of line-of-sight velocities in the most crowded regions of the Milky Way.

In the ALMA sample, a 71% detection rate of SiO masers is obtained, which increases to 80% when considering only the likely oxygen-rich stars in our sample. In addition to SiO, emission from carbon-bearing molecular transitions is detected in a small subset of the sample. Based on Galactic locations and kinematical associations, the extent of the emission, and infrared colors, we are able to classify a significant fraction of our carbon-molecule detections as likely young stellar objects. Further, since the primary aim of the BAaDE survey is to use stars as point-mass velocity probes, I will discuss possible biases in our derived line-of-sight velocities, as well as a possible distance-sensitive bias between 43 GHz and 86 GHz detected samples. Finally, I will compare the relative SiO line strengths and their agreement with current pumping models, which suggest the SiO line strengths can trace the changing conditions within the circumstellar envelopes.

Session #1, 09:30–09:45

Distinguishing evolutionary and chemical populations in the BAaDE survey

Megan Lewis (UNM, speaker), Ylva Pihlstrom (UNM), Lorant Sjouwerman (NRAO), Michael Stroh (UNM), and the BAaDE team

The BAaDE (Bulge Asymmetries and Dynamical Evolution) project is the largest ever SiO maser survey of the Galactic Plane. About 19,000 sources have been observed at 43GHz with the VLA, and the production of spectra for these sources is well underway. The name-sake goal of the project is to collect line-of-sight velocities for all the detected masers in the sample to probe Galactic dynamics, and with an expected detection rate of over 60% we should collect over 11,000 velocities. However, the survey is also a large sample of infrared sources with which to explore the different evolved stellar populations within the Milky Way. So far we can discern three distinct groups in the BAaDE sample: the main group containing oxygen-rich, evolved stars with a high SiO maser detection rate, a much smaller population of carbon-rich evolved stars, and finally a group of what likely consists of young stellar objects with no maser emission. These populations can be separated out using 2MASS and MSX (Mid-course Space eXperiment) color-color diagrams, and we find a particularly useful cut between the young and evolved objects using the MSX [14]–[21] micron color. Identification of these populations will help isolate BAaDE's evolved star sample, and will more tightly define the region in the IR color-magnitude diagram where the SiO masers occur. We can further characterize these groups utilizing infrared data, allowing for a more fine-tuned understanding of how the stellar properties change as a function of position and/or kinematical population in the Galaxy.

Session #1, 09:45–10:00

Pulsating Variable Stars in the NASA Kepler 2 Mission

Joyce A. Guzik (Los Alamos National Laboratory, Los Alamos, NM, speaker), Jorge Garcia, Jason Jackiewicz (New Mexico State University, Las Cruces, NM)

The NASA Kepler spacecraft launched nearly 10 years ago has been observing fields along the ecliptic plane for about 90 days each to detect planets and monitor stellar variability. We analyzed the light curves of thousands of main-sequence stars observed as part of the Kepler Guest Observer program. Here we focus on discoveries for delta Scuti variable stars that are twice as massive as the Sun, pulsating in many simultaneous radial and nonradial pulsation modes, with periods of about two hours. We discuss the potential and challenges for these stars for using pulsations to constrain stellar interior properties.

Session #1, 10:00–10:15

Radiative Transfer Analysis of Hyperspectral Image Cubes of Jupiter Acquired During Juno's 13th Perijove Pass

Emma Dahl (NMSU, speaker), Nancy Chanover (NMSU), David Voelz (NMSU), David Kuehn, Robert Hull (NMSU), Paul Strycker (CUW), Kevin H. Baines (NASA-JPL)

As a part of the ground-based observing campaign in support of the Juno mission at Jupiter, we have collected hyperspectral image cubes of Jupiter in the visible wavelength regime during Juno's close perijove passes. Such measurements probe Jupiter's uppermost ammonia cloud deck and are highly complementary to Juno's measurements of infrared and microwave radiation. Using the Non-Linear Optimal Estimator for Multi-variate Spectral Analysis (NEMESIS) radiative transfer package and spectra from Juno's 13th perijove pass on May 24, 2018, we have developed models of representative atmospheric features and retrieved several atmospheric parameters.

Session #2, 10:50–11:00

MRO Interferometer Status Update: First Telescope on the Array and Science Planning

M. J. Creech-Eakman (NMT, speaker), I. Payne (NMT), V. Romero (NMT), C. Haniff (Cambridge), D. Buscher (Cambridge), J. Young (Cambridge) and the MROI Team

The MRO Interferometer (MROI), a 10-telescope optical/near-IR interferometer west of Socorro, has been conceived to be the most ambitious optical interferometric array under construction to date. With baselines ranging from 7.8 to 347 meters, and limiting magnitudes of 14 at H band, it will be able to assess many thousands of astronomical targets on spatial scales of 10's to 0.1's of milli-arcseconds. We present a status update and an exciting astronomical science portfolio including: YSOs and their disks,

Session #2, 11:00–11:15

A resolved protostellar disk around a high-mass star, Orion Source I

Adam Ginsburg (NRAO, speaker)

Disks around low-mass stars are frequently observed and easily resolved. Disks around high-mass stars have been, at best, controversial. I will report observations that resolve the disk around the 15 Msun protostar Orion Source I. We fit a Keplerian rotation curve to the disk to measure the central source mass. I will discuss the extremely weird chemistry observed in this disk and the connection of Source I to the Orion BN/KL outflow, a unique explosive outflow with still uncertain origins.

Session #3, 13:30–13:40

The VLA Sky Survey

J. Marvil (NRAO, speaker) on behalf of the VLASS team

My presentation will provide an overview and update on the VLA Sky Survey (VLASS), a community-driven initiative to observe the entire sky visibile to the VLA in the 2-4 GHz band. To build up the desired sensitivity and enable studies of transient events, VLASS will carry out three independent observing epochs spread over 7 years, for a total of over 5,000 hours on sky. Observations of the first half of the first epoch are now complete (approximately 17,000 square degrees) and reference 'quick look' images have been released. Efforts are currently under way to recalibrate and reimage these data with improved techniques, and preparations for the next observing period (starting February, 2019) are now underway.

Session #3, 13:40–13:55

Early Cataloging of VLASS: Results and Planned Follow-up

Seth Bruzewski, University of New Mexico (speaker)

Using a generalized cataloging method applied to the VLASS Epoch 1.1 quicklook images, we are able to detect and analyze approximately 1.3 million sources in the so-far surveyed half of the sky above -40 degrees in Declination. These sources can then be use to examine the quality of the survey, and thus provide further feedback which may be incorporated into future epoch observations and cataloging efforts. We also compare this data with other large scale surveys in the radio and with the most recent FERMI source catalog in an attempt to locate previously undiscovered targets of interest.

Session #3, 13:55–14:10

Ultraviolet variable stars in the Swift Galactic Bulge Survey (SGBS)

Liliana Rivera, Texas Tech University (speaker), SGBS collaboration

The Swift Galactic Bulge survey (SGBS) is an imaging survey of 16 square degrees of the Galactic Bulge in X-rays and Ultraviolet using the detectors XRT and UVOT onboard Swift. The SGBS has helped to detect a handful of new very faint X-ray transients (VFXTs), as well as several variable stars. I will present results of the analysis of the SGBS UV images. I will describe the spacial distribution and optical properties of these SGBS UV variables.

Session #3, 14:10–14:20

STROBE-X: X-ray Timing & Spectroscopy on Dynamical Timescales from Microseconds to Years

Thomas Joseph Maccarone, Texas Tech University (speaker), on behalf of the STROBE-X collaboration

STROBE-X is a proposed NASA probe mission with three major scientific goals: understanding the spins of black holes in binaries and in active galactic nuclei; understanding the equation of state of neutron stars; and understanding the precursors and electromagnetic counterparts of gravitational wave sources. It has a host of other capabilities and can contribute to nearly any area of astrophysics. I will discuss its three instruments: high collecting area, good spectral resolution detectors in hard and soft X-rays, and an extremely wide field instrument, as well as how its flexible scheduling and fast slewing allow for unique transient source observations.

Session #3, 14:20–14:35

Detection of a Low Frequency Cosmic Radio Transient using Two LWA Stations

S. S. Varghese (1, speaker), K. S. Obenberger (2), J. Dowell (1), and G. B. Taylor (1)
(1) University of New Mexico, Albuquerque, NM, USA; (2) Air Force Research Laboratory, Kirtland AFB, NM, USA

In the past few decades, most of the blind transient searches of the radio sky were focused at frequencies above 300 MHz and the transient sky below 100 MHz remains poorly explored. We monitor the transient sky below 100 MHz using the two stations of Long Wavelength Array, LWA1 and LWA-SV. The first station, LWA1 discovered meteor radio afterglows which is a new form of atmospheric transient. With an average detection of 60 MRAs per year, it is difficult to differentiate between atmospheric and cosmic transients with a single station. The recent commissioning of the new LWA station in the Sevilleta National Wildlife Refuge (LWA-SV) allows application of anti-coincidence detection of cosmic transients. The two stations are separated by 70 km which is sufficient to differentiate the foreground transient events like lightning, MRAs, RFI and near orbit satellites from cosmic events. We report the detection of a potential cosmic transient candidate in the study of 2 year all-sky images from both LWA stations. The transient was detected on 18 October 2017 08:47 UTC near the celestial equator. The detected transient at 34 MHz has a duration of 15 - 20 seconds and a flux density of 842 $\pm$ 116 Jy at LWA1 and 830 $\pm$ Jy at LWA-SV.

Session #3, 14:35–14:50

Searching for Black Widow Pulsar Analogues with the Long Wavelength Array

Christopher DiLullo (UNM, speaker), Kevin Stovall (UNM/NRAO), Greg Taylor (UNM), Jayce Dowell (UNM), Aquib Moin (United Arab Emirates University)

Black widow pulsar systems have been shown to show periodic dispersion measure (DM) variations on timescales near that of the binary period. This effect should not be unique to black widow systems, but should be detectable in any binary system where the pulsar ablates material from its companion star. We have observed four MSPs who have known white dwarf companions in order to search for similar periodic DM variations. These would be a type of black widow analogue. We report changes in DM nearly 3 orders of magnitude smaller than seen in black widow systems, but find no periodic variations.

Session #3, 14:50–15:05

Optimized Radio Follow-up of Binary Neutron-Star Mergers

Dario Carbone (speaker) & Alessandra Corsi, Texas Tech University

Motivated by the discovery of GW170817, we determine the optimal observational setup for detecting and characterizing radio counterparts of nearby BNS mergers. We simulate GW170817-like radio transients, and radio afterglows generated by fast jets, expanding in a low-density ISM, observed from different viewing angles. We determine the optimal timing of GHz observations, assuming a sensitivity comparable to that of the JVLA. The optimization is done so as to ensure that physical properties can be correctly reconstructed with the minimum number of observations. Finally, we discuss how future radio arrays would improve the detectability of radio counterpart of BNS mergers.

Session #3, 15:05–15:20

Predicting the Performance of Future PTAs: An analysis of the millisecond-pulsar population

Tyler Cohen, New Mexico Inst. of Mining and Technology, National Radio Astronomy Observatory (speaker); Paul Demorest, National Radio Astronomy Observatory; Kevin Stovall, National Radio Astronomy Observatory

The fastest rotating and most stable pulsars, millisecond-period pulsars (MSP), are the most precise clocks in the universe. This level of precision makes MSPs ideal for detecting gravitational waves generated by in-spiraling supermassive black hole binaries. The North American Nanohertz Observatory for Gravitational Waves (NANOGrav) searches for inter-pulsar correlations induced by these extra-galactic gravitational waves in the pulse arrival-time data of many MSPs.

Pulsar surveys and MSP-timing observations must be optimized to get the highest timing precision of as many MSPs as possible. Planning such observations requires an understanding of the expected galactic MSP population. Since the full MSP population is not known, I model a galactic population of MSPs. I then calculate the timing precision distribution of the simulated population for a given telescope with variable survey parameters. These results will be used to inform NANOGrav observations with the future generation of timing-capable telescopes such as the Next Generation VLA. Through this analysis I explore optimizing parameters including frequency, bandwidth, integration time per source, and the collecting area of dish arrays. This analysis will also help constrain parameters of the MSP population. Varying population parameters to reproducing results from multiple existing pulsar surveys will help to avoid biases toward a particular type of survey. In contrast, most previous analyses have focused on a single survey. I explore how varying the probability distributions of population parameters including the luminosity, scale height, pulse sharpness, period, spin-down rate, spectral index, and radial distribution changes the overall timing precision distribution. Utilizing existing and future radio telescopes to their full potential will ultimately reduce the time until pulsar timing array experiments detect gravitational waves.

Session #4, 15:55–16:05

Simulations as Numerical Observations: Virtual and Real VLBI Observation

Kevin Lind, Voss Scientific (speaker)

In the mid-1980s, high performance computing was beginning to be applied to astronomy and astrophysics. Coinciding with this, Roger Blandford advised his new first-year graduate student (me) to be involved in observational work in order to properly appreciate theoretical work. By this advice, he planted the seed of numerical observing and its proper integration with instrumental observing. This is an overview of how this developed, and how it relates to modern simulation, observing, assimilation, and machine learning.

Session #4, 16:05–16:20

Constraints on Gamma-ray Burst Engines in a Blandford-Znajek Framework

Nicole Lloyd-Ronning (LANL; UNM-LA, speaker), Chris Torres (UNM-LA), Neelima Prasad (UCSD), Jonah Miller (LANL), Chris Fryer (LANL)

We put constraints on the inner engine of long and short gamma-ray bursts (and their progenitors) in the framework of the Blandford-Znajek process powering the GRB jet.

Session #4, 16:20–16:35

Evidence of Complex B-field Structures in the ICM surrounding Cygnus A

Lerato Sebokolodi (1,2,3, speaker), Rick Perley (1), Chris Carilli (1), and Oleg Smirnov (2, 3)
1. National Radio Astronomy Observatory, 2. South African Radio Astronomy Observatory, 3. Rhodes University

A new high sensitivity polarization study of Cygnus A using 2-18 GHz JVLA data shows significant depolarization below 6 GHz with 0.75" (750 pc) resolution, as well as complicated polarization structures. Our preliminary analysis indicates multi-scale B-fields on scales > 120 kpc and < 300 pc. There is a strong evidence that the dominant rotation measures (thousands rad/m/m) are due to large-scale B-fields in the ambient ICM, but it is still unclear where the small-scales originate and their effect on the observation. We show, however, that the observed polarization structures may result from beam depolarization. We present this ongoing work.

Session #4, 16:35–16:50

Direct Imaging of the Nuclear Torus in Cygnus A

Rick Perley (NRAO, speaker), Chris Carilli (NRAO), Daniel Perley (LJMU), Vivek Dhawan (NRAO)

We present the first direct imaging of what may be the thick torus in the nucleus of the archetype powerful radio galaxy Cygnus A, using the Very Large Array. Such a torus has long been a key component of AGN models, but direct imaging on the relevant physical scales, in particular in sources of extreme (quasar-like) luminosities, are lacking. An elongated structure, perpendicular to the radio jets and centered on the core, is well resolved, of size $\sim$480 $\times$ 260 pc. The radio emission spectrum is consistent with optically thin free-free emission, with a brightness temperature at a radius of 100 pc of about 240 K. The spectrum of the radio core itself shows a sharp cut-off at low frequencies, consistent with free-free absorption by gas in the torus. We present a toy model of a flaring dusty torus, with an ionization cone of half-opening angle $\sim$ 62 d, oriented along the jet axes, roughly in the sky plane. The observations require a clumpy gas distribution, with the free-free emission dominated by clumps with densities of a few thousand per cc.

Session #4, 16:50–17:00

The Curious Radio Streak in Abell 2256

J. Eilek (NMT/NRAO, speaker), F. Owen (NRAO), L. Rudnick (U. Minnesota)

One of the radio galaxies in Abell 2256 – 'Tail C' – is very odd. It is long (900 kpc in projection), skinny (no wider than a few kpc anywhere), straight (bending no more than a few degrees along its length), and apparently one-sided. Earlier studies suggested Tail C is a standard narrow-angle tail, but our new data show this is not the case; the source remains straight and single down to a few hundred pc from the core. Our new results raise many other questions. Is Source C a passive galactic wake, or an active flow? If the latter, why is it so asymmetric? What explains the small, apparently random, patches of high Faraday rotation along the source? How are the radio-loud electrons reaccelerated in the outer part of the source, and is the needed energy provided by fluid flow or Poynting flux? Can Tail C be understood in terms of standard radio-source models, or is it a new class of radio galaxy?

Session #4, 17:00–17:15

Identifying Reionization Sources from 21cm Maps using Convolutional Neural Networks

Sultan Hassan (1,2, speaker), Adrian Liu(3,4), Saul Kohn(5), Paul La Plante(5)
1 University of the Western Cape, Bellville, Cape Town, 7535, South Africa
2 New Mexico State University, Las Cruces, NM 88003, United States
3 Department of Astronomy and Radio Astronomy Laboratory, University of California Berkeley, Berkeley, CA 94720, United States
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5 Department of Physics and Astronomy, University of Pennsylvania, Philadelphia, PA 19104, United States

Active Galactic Nuclei (AGN) and star-forming galaxies are leading candidates for being the luminous sources that reionized our Universe. Next-generation 21cm surveys are promising to break degeneracies between a broad range of reionization models, hence revealing the nature of the source population. While many current efforts are focused on a measurement of the 21cm power spectrum, some surveys will also image the 21cm field during reionization. This provides further information with which to determine the nature of reionizing sources. We create a Convolutional Neural Network (CNN) that is efficiently able to distinguish between 21cm maps that are produced by AGN versus

galaxies scenarios with an accuracy of 92-100%, depending on redshift and neutral fraction range. When adding thermal noise from typical 21cm experiments, the classification accuracy depends strongly on the effectiveness of foreground removal. Our results show that if foregrounds can be removed reasonably well, both SKA and HERA should be able to discriminate between source models with greater accuracy than using the power spectrum alone.

Session #4, 17:15–17:30

Nonthermal production of dark matter from primordial black holes

Jacek Osinski - UNM (speaker); Rouzbeh Allahverdi - UNM; James Dent - Sam Houston State University

We present a scenario for nonthermal production of dark matter from evaporation of primordial black holes. A period of very early matter domination leads to formation of black holes with a maximum mass of $\sim 2 \times 10^8$ g, whose subsequent evaporation prior to big bang nucleosynthesis can produce all of the dark matter in the Universe. We show that the correct relic abundance can be obtained in this way for thermally underproduced dark matter in the 100 GeV $-$ 10 TeV mass range. To achieve this, the scalar power spectrum at small scales relevant for black hole formation should be enhanced by a factor of $O(10^5)$ relative to the scales accessible by the cosmic microwave background experiments.

Special talks

Colloquium, NRAO, DSOC Auditorium, Session #2, 11:15–12:00

The First Stars, Galaxies and Black Holes

Volker Bromm, UT Austin (speaker)

I will review our current understanding of how star and galaxy formation transformed the conditions in the early universe, in terms of initiating the long cosmic reionization and metal enrichment history. It is timely to take stock of our emerging theoretical framework of the first stars, galaxies and black holes, just ahead of the JWST launch. I will discuss the exciting insights on early star formation, and possibly the particle physics nature of dark matter, from the recent EDGES detection of a global 21cm absorption feature at cosmic dawn.

Jansky Lecture, NMT Workman 101, 19:30–21:00

The Radio Harvest

Roger Blandford, KIPAC, Stanford University (speaker)

Radio astronomy germinated in the early 1930s in the fertile imagination (and expertise) of Karl Jansky. Since then it has been cultivated through the skillful application of advances in engineering, electronics and computing to the construction of mighty telescopes and their use in the study of the Universe beyond the narrow filter of visible light. Radio astronomers were central to most of the great discoveries of the past century, including black holes, neutron stars and the cosmic microwave background as well as the quest for life in the Universe, and they continue to reap bountiful, scientific harvests from them. In this talk, I will illustrate the remarkable history and international development of radio astronomy, paying special attention to pulsars, massive black holes, cosmology, and using one of the most fascinating recent discoveries, fast radio bursts.

Posters

P1. ngVLA Calibration Plan

Chris Hales, NRAO

The Next Generation Very Large Array (ngVLA) is a project of the National Radio Astronomy Observatory (NRAO) to design and build a radio telescope operating from 1.2 GHz to 116 GHz. The facility will comprise approximately 244 reflector antennas centered at the existing VLA site in the Southwest US with antennas extending to maximum baselines of approximately 1000 km. The ngVLA is being designed to provide the next major leap forward in our understanding of planets, galaxies, black holes, and the dynamic sky. To observe astronomical targets with the ngVLA, the unavoidable imprints of various instrumental and atmospheric effects will need to be accounted for through the process of calibration. This poster summarizes the key effects that will need to be calibrated and presents a preliminary plan for how this will be accomplished.

P2. Current Efforts for the Preservation of Historical Solar Observations

Alexander Pevtsov, NSO; Luca Bertello, NSO; Alexei Pevtsov, NSO; Ilpo Virtanen, University of Oulu (Finland)

In our quest for understanding the Universe, there is a constant desire for the latest and greatest data, as the astronomical community pushed hard for developing new observational capabilities on the verge of unprecedented quality. This often leaves older (historical) data to be ignored and in some cases to be forgotten. However, historical observations are invaluable in time-domain astronomy, allowing us to learn about long-term changes in astronomical objects. Here, we discuss three current projects in our effort to process, preserve and make accessible historical data from 20th century solar observations taken at Mt. Wilson Observatory and Sunspot Solar Observatory.

P3. Solving the Neutrino Mass Hierarchy Problem, Despite Nuclear Structure

Daine L. Danielson (1 and 2), A. C. Hayes (1), G. T. Garvey (3)
(1) Los Alamos National Laboratory, (2) University of California at Davis, (3) University of Washington)

The Coulomb enhancement of low energy electrons in nuclear beta decay generates sharp cutoffs in the accompanying antineutrino spectrum at the beta decay endpoint energies. It has been conjectured that these features will interfere with measuring the effect of a neutrino mass hierarchy on an oscillated nuclear reactor antineutrino spectrum. These sawtooth-like features will appear in detailed reactor antineutrino spectra, with characteristic energy scales similar to the oscillation period critical to neutrino mass hierarchy determination near a 53 km baseline. However, these sawtooth-like distortions are found to contribute at a magnitude of only a few percent relative to the mass hierarchy-dependent oscillation pattern, both in energy space and in Fourier space. In the Fourier cosine and sine transforms, the features that encode a neutrino mass hierarchy dominate by over sixteen (twenty-five) times in prominence to the maximal contribution of the sawtooth-like distortions from the detailed energy spectrum, given $3.5\%/\sqrt{E_{\mathrm{vis.}}/\mathrm{MeV}}$ (perfect) detector energy resolution. The effect of these distortions is shown to be negligible even when the uncertainties on the reactor spectrum, oscillation parameters, and counting statistics are considered. This result is also shown to hold even when the opposite hierarchy oscillation patterns are nearly degenerate in energy space, if energy response nonlinearities are controlled to below 0.5%. Therefore with accurate knowledge of detector energy response, the sawtooth-like features in reactor antineutrino spectra will not significantly impede neutrino mass hierarchy measurements using reactor antineutrinos.

P4. Data Acquisition System in High-Speed Rotating Frame for New Mexico Alpha-Omega Liquid Sodium Dynamo Experiment

Jiahe Si, Art Colgate, Richard Sonnenfeld (NMT)

NM dynamo Experiment requires data being gathered from sensors spinning with the apparatus. A DAQ system has been designed collect, transmit and store the data. It consists of an embedded computing unit with a multiplexing daughter board to collect data from up to 78 channels with 16-bit resolution, an inter-connection board from sensors, a wifi unit to transmit data, and a power unit to provide stable voltage supply. With a software written in National Instruments Labview, the overall sampling rate can reach up to 200k Samples/sec, and data can be stored in a PC and SD card simultaneously.

P5. Investigating stratification of lunar regolith through modeling of the ground based detection of the LCROSS debris plume light curve

Kristen Luchsinger (New Mexico State University), Nancy Chanover (New Mexico State University), Paul Strycker (Concordia University Wisconsin), Charles Miller (New Mexico State University)

The 2009 Lunar CRater Observation and Sensing Satellite (LCROSS) impact mission confirmed an existing hypothesis regarding the existence of water ice in permanently shadowed craters at the lunar south pole. Ground-based observations in support of the mission were able to further constrain the concentration and mass of the water ice ejected during the impact. Further modeling work provides additional constraints on the initial conditions required to best fit the ground-based observations. We fit the data with models which vary the distribution of dirty ice, lunar regolith, and bedrock as a function of depth.

P6. Assessing the Crystallinity of Water Ice on Europa's Leading Hemisphere

Jodi Berdis[1], Dr. Nancy Chanover[1], Dr. Murthy Gudipati[2], Dr. Jim Murphy[1]
1. Astronomy Department, New Mexico State University, Las Cruces, NM, USA
2. Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA, USA

Europa's ice is likely < 100 Myr old due to resurfacing from its ocean. This surface should be composed of water ice mostly in its crystalline form; however, radiation from Jupiter and vapor-deposited plumes increase the amorphous content.

We acquire disk-averaged NIR spectra of Europa's leading hemisphere using TripleSpec on the 3.5m at Apache Point Observatory, and calculate the leading hemisphere's crystallinity. We produce 1-D model temperatures, incorporate radiation effects and the thermal transformation of amorphous, and calculate the leading hemisphere's crystallinity assuming no geophysical processes. Finally, we assess the extent to which uncertainties and geophysical processes may influence the crystallinity.

P7. Searching for Exomoons in the Radio Using the Giant Metrewave Radio Telescope (GMRT)

Marialis Rosario-Franco (NRAO & The University of Texas at Arlington), Jitendra Kodilkar (Giant Metrewave Radio Telescope), Suman Satyal (The University of Texas at Arlington), Zdzislaw Musielak (The University of Texas at Arlington), Amy Kimball (National Radio Astronomy Observatory), Bryan Butler (National Radio Astronomy Observatory)

Exoplanetary research has undergone a great deal of development and growth. Achievements in theoretical studies and detection techniques have led to the discovery of over 3,700 exoplanets in $\sim$2,800 planetary systems to date. Despite this great success, the confirmation of the first exomoon is yet to be accomplished. Motivated by this, we have applied a novel radio-detection method, proposed by Noyola et.al (2014, 2016). The technique is based on a planet-moon interaction observed in the Jupiter-Io system, where Io-controlled decametric radio emissions were used to determine how the presence of exomoons around giant planets might be revealed by the same modulation mechanism. We performed 325MHz observations of three targets through the Giant Metrewave Radio Telescope (GMRT); located in Pune, India. Preliminary results of our data analysis are presented and discussed.

P8. Investigating the Possible Mechanisms Powering the Radio Pulsations in AR Scorpii

Kelly Sanderson – New Mexico State University, Tony Beasley – National Radio Astronomy Observatory

The radio pulsations emitted from the binary system AR Scorpii(ARSCO), previously observed by the VLA, were interesting to many scientists because of the unusual nature of the compact source believed to be powering the variable emission from the system. This emission reveals three periodicities describing the orbital and rotational motion of ARSCO. Using VLBA observations of this system to determine a model that best described it was proven difficult because of the sensitivity of the instrument and the low declination of our target. However, the VLBA was able to confirm two of the three periodic signals detected by the VLA.

P9. Radio Bright High Proper Motion Stars

Montana Niccole Williams (Texas Tech University), Thomas Maccarone (Texas Tech University), Amy Kimball (National Radio Astronomy Observatory)

A collection of candidate radio stars was found through matching of two all-sky radio catalogs, (NVSS and FIRST) and an optical catalog of high proper motion stars (LSPM). High proper motion was required because late-type stars are the most likely to have the observable radio emission, which would have to be nearby and have high proper motions (>.15"/yr). Two radio catalogs were used to increase the chances of a real match. From the combination of all three catalogs, 13 candidate radio stars were found. We investigated these sources, focusing on the three with the highest flux density. These three had a flux density greater than 35mJy/beam in FIRST. We will discuss these sources to determine if they were in fact radio stars.

P10. Identification of Variable Stars in K2 Mission

Jorge A. Garcia, Jason Jackiewicz (New Mexico State University, Las Cruces, NM); Joyce A. Guzik (Los Alamos National Lab, Los Alamos, NM)

Throughout 12 different campaigns of NASAs K2 mission, which spanned for almost two years, over 15,000 stars were requested to be observed by the spacecraft in order to discover and identify pulsating variable stars. We present the tools developed and methods used to streamline the analysis and classification of targets according to their observed characteristics, with supporting data from the Ecliptic Plane Input Catalog. Current work being done for the identification of delta Scuti stars and binary systems is used as a practical example of these computational resources.

P11. Analyzing Light Curves of M-Dwarf Stars

Stephanie Flynn (Senior at The Masters Program, Santa Fe NM); Mark Flynn, Joyce A. Guzik (Los Alamos National Laboratory, Los Alamos, NM); Jason Jackiewicz (New Mexico State University, Las Cruces, NM)

Using light-curve data collected by the NASA Kepler Space Telescope, it is possible to create an algorithm to count the number of flares from M-dwarf stars. Kepler was launched almost ten years ago with the purpose of discovering exoplanets including those orbiting M-dwarf stars. M-dwarf stars are low mass main sequence stars with a surface temperature of about 3,500 K and have frequent flares. We have analyzed the light-curves to search for correlations between number of flares, rotation period, and other properties such as temperature. We have found correlations between a number of the properties.

P12. Evolution of Low-Mass AGB Stars: An Analytical Approach to Mass-loss Formulas

Henry Prager (New Mexico Tech), Lee Anne Willson (Iowa State Univ.), Michelle Creech-Eakman (New Mexico Tech), Massimo Marengo (Iowa State Univ.)

We have examined a model for the late-stage evolution of Asymptotic Giant Branch (AGB) stars between 0.7 and 2.0 solar masses. This model uses a parameterized value for the evolution of the mass-loss rate, which can be found exactly in power laws and can be found numerically for other formulations. By combining the model with the initial mass function and a star formation rate, we can determine rate of mass loss in AGB stars by distributions of observed stars. This work supports a rapid increase of the mass-loss rate at the end of the AGB and minimal mass loss pre-AGB.

P14. Finding Goldreich-Julian: Determining Plasma Configurations of Pulsar Magnetospheres via Test Particle Energy Minimization

Keith McElroy & Paul Arendt, PhD (New Mexico Institute of Mining and Technology)

In 1969, Peter Goldreich and William Julian wrote the seminal paper on pulsar magnetospheres that showed that they must contain plasma and gave a formula for their charge density. Since then, this result has been the standard on which pulsar magnetosphere models have been built. In an effort to investigate global magnetosphere conditions, a first step towards greater understanding of where active emission regions must lie, we use a simple power law basis and an energy distribution model to try to find the Goldreich-Julian plasma density numerically, with the intent to find more general distributions afterward.

P15. Scattering study using Pulsars below 100 MHz

Karishma Bansal (UNM), Greg Taylor (UNM), Kevin Stovall (NRAO) & Jayce Dowell (UNM)

The interstellar medium (ISM) consists of ionized plasma, which affects radiation as it traverses the medium. Observable ISM effects include dispersion, scattering, angular broadening, and interstellar scintillation. Pulsars are compact and emit short pulses thus making them good candidates to study and understand all the above effects. In the case of scattering, the pulsar profiles grow asymmetrically broader at lower frequencies. Different ISM models predict different frequency dependencies for the scattering time-scale depending on the distribution of inhomogeneity. We explore this frequency dependency for a sample of seven pulsars using the LWA1 data at frequencies below 100 MHz.

P16. Bicoherence of Quasi Periodic Oscillations from GX 339-4

Kavitha Arur, Thomas Maccarone (TTU)

The bicoherence, a measure of coupling between the phases of different Fourier frequencies, can be used to differentiate between models that produce very similar features in their power spectra. I will present the analysis of several observations of RXTE/PCA archival data of the black hole binary GX 339-4 which show QPOs. We find that these QPOs show different patterns in their bicoherence plots, suggesting that they are produced by different physical processes. We also compare these with the results of bicoherence using the model of a Duffing oscillator.

P17. Predicting the next local supernova

John Middleditch, LANL

It has been over 31 years since Supernova 1987A, and we have learned many things from the neutrinos, light curve, evolving spectrum including the "Bochum Event" at day 19.2, the associated "Mystery Spot", the mixing, rings, X- and gamma-rays, polarization, and the 467.5 Hz pulsation and its associated ∼1,000 s precession. Finally, our understanding of this event has progressed to the point where we have a time interval of a few months during which we can predict which supergiant star in our local neighborhood out to 5 Megaparsecs will be the next to die in a supernova explosion.

P18. Probing gas inflow with GBT/ALMA mapping towards starless clump candidates

Brian Svoboda (National Radio Astronomy Observatory)

Understanding the mass accretion history of high-mass stars and star clusters is a key unresolved topic in the field of star formation. Blue-skewed line profiles of optically thick molecular transitions coincident with centrally peaked optically thin transitions provide a powerful observational diagnostic to measure gas inflow velocities, and thus, mass accretion. To this end we present maps of HCO+, H13CO+, HCN, and NH2D from the GBT and ALMA towards six starless molecular cloud clumps (M $\sim$ 200-1500 solar masses) with blue-skewed line profiles. The subset of GBT Argus observations achieve the highest angular resolution at 3 mm of any telescope without spatial filtering (0.18 pc at 4.4 kpc). The higher resolution observations reveal blending of velocity components from dense cores and filaments in addition to protostellar outflows that complicate the interpretation of global gravitational collapse. Existing Galactic single-dish surveys investigating clump inflow velocities and mass accretion rates at $>$ 30" resolution are likely to be similarly affected by complex density structure, varied excitation conditions, and outflows from low-luminosity protostars. However, preliminary results show systematic blueward velocity offsets between the peak HCO+ and H13CO+ velocities in spatially resolved sub-structures. These may be caused by localized collapse and inflow at speeds slower than the ∼1-2 km/s supersonic speeds typically inferred from the globally averaged line-profiles.

P19. SWAG: Distribution and Kinematics of an Obscured AGB Population toward the Galactic Center

Juergen Ott (NRAO), David S. Meier, Adam Ginsburg, Farhad Yusef-Zadeh, & Nico Krieger

Outflows from AGB stars enrich the Galactic environment with metals and inject mechanical energy into the ISM. Radio spectroscopy can recover both properties through observations of molecular lines. We present results from SWAG: "Survey of Water and Ammonia in the Galactic Center". The survey covers the entire Central Molecular Zone (CMZ), the inner 3.35degx0.9deg ($\sim$480$\times$130pc) of the Milky Way that contains ∼5e7 Mo of molecular gas. Although our survey primarily targets the CMZ, we observe across the entire sightline through the Milky Way, covering the full radial profile of the Galaxy's AGB population. AGB stars are revealed by their signature of double peaked 22GHz water maser lines. They are distinguished by their spectral signatures and their luminosities, which reach up to 1e-7 Lo. Higher luminosities are usually associated with Young Stellar Objects located in CMZ star forming regions. We detect a population of ∼600 new water masers that can likely be associated with AGB outflows. That corresponds to a density of $\sim$200/deg^2, with a Galactic Latitude and Longitude density gradient. Our survey will allow us to study the distribution and energetics of the AGB population as well as correlations with additional ∼42 thermal molecular lines that we observe in SWAG.

P20. Variability of Ten Silhouette Disks in the Orion Nebula Cluster in Ten Years

Mackenzie James (University of Arizona), Jinyoung Serena Kim (University of Arizona), John Bally (University of Colorado)

The Orion Nebula Cluster is thought to resemble the birthplace of our solar system. High UV radiation from young massive stars affects the protoplanetary disks around neighboring low mass stars. We used HST data in two epochs and various filters to study variability of ten silhouette disks. There is no significant variation of physical sizes or morphology except for one large dust disk, 114-426. Silhouette disk 114-426 was of special interest, due to its much larger size and visible change in the morphology and size of the disk between the two epochs.

P21. Chemistry of the dense gas within the Central Molecular Zone

Daniel Callanan, Centre for Astronomy, Harvard University; Qizhou Zhang, Centre for Astronomy, Harvard University Eric Keto, Centre for Astronomy, Harvard University; Steve Longmore, Liverpool John Moores University; Xing Lu, School of Astronomy and Space Science, Nanjing; Dan Walker, ALMA Observatory; Ash Barnes, Institut fr Theoretische Astrophysik, Universitt Heidelberg; Perry Hatchfield, University of Connecticut; Jens Kauffman, Haystack Observatory, Massachusetts Institute of Technology; Thushara Pillai; Betsy Mills, Boston University; Adam Ginsburg, NRAO; Jonny Henshaw, Institut fr Theoretische Astrophysik, Universitt Heidelberg

The inner few hundred parsecs of the Milky Way, the Central Molecular Zone (CMZ), contains a large reservoir of molecular gas clouds with densities and temperatures much larger than typically observed in nearby galaxies and within the disk of our own galaxy. By studying the gas properties and chemistry of these clouds one can begin to get an idea of the complex chemistry associated with such protostellar cores and begin to determine important physical properties of these clouds (such as temperature and mass). This data is high-resolution SMA data of all dense gas within the region.

P22. Prevalent CH2DOH in Taurus Starless Cores

Hannah Ambrose, Dr. Yancy Shirley, Samantha Scibelli
University of Arizona Steward 0bservatory

Recent observations have indicated that complex organic molecules are prevalent toward prestellar cores. Deuteration of complex organic molecules have not been well studied, especially in the prestellar phase. Thus far, singly deuterated methanol has only been observed in the starless core L1544. As the formation of the methanol is believed to occur from the chemical desorption of precursor radicals, observations of CH2DOH may be a useful in determining the deuterium fraction in the ice mantles of dust grains. Initial observations toward the B10 region of the Taurus molecular cloud have shown CH2DOH detected in six of the seven cores observed.

P23. Zeeman Effect Observations in 44 GHz Class I Methanol Masers

E. Momjian (NRAO) and A. P. Sarma (DePaul University)

We report the detection of the Zeeman effect in the 44 GHz Class I methanol maser line toward the star forming region DR21W. The 44 GHz methanol masers in this source occur in a $\sim 3''$ linear structure that runs from northwest to southeast, with the two dominant components at each end, and several weaker maser components in between. Toward a 93 Jy maser in the dominant northwestern component, we find a significant Zeeman detection of -23.4 ± 3.2 Hz. If we use the recently published result of Lankhaar et al. (2018) that the $F = 5 - 4$ hyperfine transition is responsible for the 44 GHz methanol maser line, then their value of $z = -0.92\,\mathrm{Hz\,mG^{-1}}$ yields a line-of-sight magnetic field of $B_{\rm los} = 25.4 \pm 3.5\,\mathrm{mG}$. If Class I methanol masers are pumped in high density regions with $n \sim 10^{7-8}\,\mathrm{cm^{-3}}$, then magnetic fields in these maser regions should be a few to several tens of mG. Therefore, our result in DR21W is certainly consistent with the expected values.

Using the above noted splitting factor in past Zeeman effect detections in Class I methanol masers reported by

Sarma & Momjian (2011) and Momjian & Sarma (2017) in the star forming regions OMC-2 and DR21(OH) result in $B_{\rm los}$ values of $20.0 \pm 1.2\,$mG and $58.2 \pm 2.9\,$mG, respectively. These are also consistent with the expected values.

P24. Tracing the properties of the Sagittarius stream across the sky with LAMOST spectra

Madison Walder[1], Jeffrey L. Carlin[2]
University of Arizona

The Sagittarius dwarf galaxy is a satellite that is currently being consumed by the Milky Way's gravity. Its disruption has created the most prominent and widely studied tidal stream in our halo which wraps around our Galaxy with its leading arm in the northern Galactic hemisphere and its trailing arm in the southern hemisphere. We utilized the Large Sky Area Multi-Object Fiber Spectroscopic Telescope (LAMOST) survey to select stars that belong to the tidal stream based on defining characteristics such as distance, velocities, and various other stellar parameters. Additionally, we conducted a graphical analysis of the candidate data, allowing us to use statistics to obtain a subset of stars with little contamination from the disk. As a result, we measured the median metallicity of groups of stars along the stream and found a significant trend between the metallicity of the stream as a function of its position.

P25. Intermediate-Mass Black Holes in Globular Cluster Systems

J. M. Wrobel (NRAO), J. C. A. Miller-Jones (Curtin U), K. E. Nyland (NRAO), T. J. Maccarone (TTU)

P26. Optimizing the Search for Gamma-Ray Counterparts to Gravitational Wave Events

Collin Lewin, University of Arizona ; Colleen Wilson-Hodge, NASA Marshall Space Flight Center; Adam Goldstein, Science and Technology Institute (USRA)

The Fermi Gamma-ray Burst Monitor has been a leading instrument in detecting counterparts to gravitational-wave (GW) events since discovering the first gamma-ray counterpart to a GW signal in 2017. While events above a detection threshold 'trigger' the flight software upon observation, copious non-triggering short gamma-ray bursts are uncovered through a search that analyzes data in a time window for potential events. Several changes are applied to this targeted search, such as adding a blackbody spectral template and adjusting the instrument's energy channels included in the search, and tested on real events and background noise. Investigating which configuration maximizes the detection statistic for real events and minimizes it for background noise will contribute to more effective and confident future detections of gamma-ray counterparts in LIGO/Virgo collaborations.

P27. Distribution of OVI in the Circumgalactic Medium

Rachel Marra (NMSU), Chris Churchill (NMSU), Glenn Kacprzak (Swinburne University of Technology), Nikki Nielsen (Swinburne University of Technology), Jacob Vander Vliet (NASA Ames), James Lewis (NMSU), Daniel Ceverino (Institut fr Theoretische Astrophysik, Universitt Heidelberg)

With ART cosmological simulations we studied the distribution of OVI in the circumgalactic medium of eight simulated Milky-Way type galaxies using synthetic quasar sight lines. I used the Mockspec code (created by Dr. Jacob Vander-Vliet) to create 1000 lines of sight (LOS) through each simulated galaxy and studied the absorption features seen in the synthetic spectra. We found the covering fraction of the simulated galaxy sample and compared it to the covering fraction of the 53 observed galaxies in the Multiphase Galaxy Halos Survey. In addition we looked at the overall distribution of OVI in one of the simulated galaxies.

P28. The black hole-host galaxy connection: Kinematics of a nearby AGN host

Emily Walla (University of Arizona) , Leah Fulmer (University of Washington), Susan Ridgway (National Optical Astronomy Observatory), Stephanie Juneau (National Optical Astronomy Observatory)

nalysis of spatially-resolved spectra is important to understand the dynamics of stars and gas around active galactic nuclei (AGN), galactic nuclei powered by supermassive black holes, to better understand relationships between an AGN and the large-scale structure and evolution of its host galaxy. Spatially-resolved spectroscopy collected by the Multi Unit Spectroscopic Explorer (MUSE) on the Very Large Telescope provides insight into motion and composition within a galaxy. We present results from the analysis of a MUSE data cube of a nearby AGN host galaxy with a large substructure that affects the central AGN engine by redirecting outflows from the nucleus.

P29. Nature vs nurture: what shapes the hybrid morphology of radio galaxies?

Anna D. Kapinska (NRAO), & the Radio Galazy Zoo science team

Hybrid morphology radio sources (HyMoRS) are a rare type of radio galaxy that display distinct Fanaroff-Riley classes on opposite sides of their nuclei. To increase number statistic in the analyses of hybrid morphology radio sources, we embarked on a large-scale search of these sources within the international citizen science project, the Radio Galaxy Zoo. In the first stage of this study we find 25 new candidate hybrid morphology radio galaxies, at redshifts $0.07 < z < 1.0$. For the first time, we investigate the hosts of HyMoRS: for a third of the candidates spectroscopic observations reveal a variety of hosts including quasars, green bean galaxies, and high- and low-excitation galaxies. Although the origin of the hybrid morphology radio galaxies is still unclear, this type of radio source starts depicting itself as a rather diverse class. Further, we present preliminary results from our VLA follow-up program of the candidates. We discuss hybrid radio morphology formation in terms of the radio source environment (nurture) and intrinsically occurring phenomena (nature; activity cessation and amplification), showing that these peculiar radio galaxies can be formed by both mechanisms.