The 35th Annual New Mexico Symposium

21 February 2020

ABSTRACTS

Oral presentations

Session #1, 08:35–08:50

Molecular Gas Accretion in the Galactic Center

Juergen Ott[1] (speaker), David S. Meier[2,1] & the SWAG team
[1] National Radio Astronomy Observatory, [2] New Mexico Institute of Mining and Technology

Molecular gas flows feed the Central Molecular Zone (CMZ) of our Galaxy. Dynamic models show that the clouds are on trajectories that follow x1 and x2 orbits in the central bar potential. The x2 orbits are fed by gas on the x1 orbits and may accrete in pretty dramatic fashion - e.g. the massive star formation region Sgr B2 is thought to be close to the eastern accretion point. Our 'Survey of Water and Ammonia in the Galactic center' (SWAG) provides a unique view of the CMZ, due to its parsec resolution over the full CMZ in ~ 40 diagnostic molecular lines. Our large project produces maps of signature lines that trace shocks and PDRs, temperatures, densities, and ionization grades. The SWAG data (together with single dish observations at 3mm) show a sequence of shocks as the gas approaches the x1-x2 accretion point. Although, in theory, the clouds are stable against gravitational collapse into stars, the dense material shows filamentary structures that are typical for star forming regions in the disk of the Galaxy. The SWAG data also reveal molecular features that are perpendicular to the disk and could be signatures of vertical outflows.

Session #1, 08:50–09:05

The Virial State of Starless Cores

Yancy L. Shirley[1] (speaker)
[1] University of Arizona

Starless cores and gravitationally bound prestellar cores are the initial stage of star formation within molecular clouds. Several different metrics have been traditionally used to determine if cores are prestellar and therefore likely to go on to form a protostar, but they usually only consider a limited subset of energy terms (i.e. kinetic energy and gravitational potential energy). In this talk, I shall discuss the Virial state of the starless cores by considering the constraints we have on all of the terms in the Virial Theorem including boundary pressure, magnetic fields, and the possibility of mass flowing across the "boundary" of the core. I shall use existing and new continuum and molecular line observations of a population of 31 starless core in the central Taurus molecular cloud to analyze each term in the Virial Theorem. Finally, I shall compare the Virial state of the cores with another metric of their evolutionary state, the chemical evolution measured by the deuteration of ammonia (NH2D).

Session #1, 09:05–09:20

Detecting Complex Organic Molecules in Starless and Prestellar Cores in the Taurus Molecular Cloud

Samantha Scibelli[1] (speaker), Yancy Shirley[1]
[1] University of Arizona

Before stars like our Sun are born, they are conceived inside dense clumps of gas and dust known as starless and gravitationally bound prestellar cores. Because prestellar cores are at one of the earliest stages of star formation, we can learn a lot about initial chemical conditions. The detection of complex organic molecules (COMs) toward these cores has sparked interest in the fields of astrochemistry and astrobiology, yet detection rates and degrees of complexity within a larger sample of cores (i.e., more than a few) have not been fully explored. With the Arizona Radio Observatory's 12M telescope, we looked for COMs in 31 starless and prestellar cores, spanning a wide range of dynamical and chemical evolutionary stages, all within the localized L1495-B218 Taurus Star Forming Region. Regions with similar environmental conditions, such as within Taurus, allow for robust comparisons to be made between cores. We found a prevalence of COMs, detecting methanol (CH3OH) in 100% of the cores targeted and acetaldehyde (CH3CHO) in 68%. A deep survey in the young prestellar core L1521E exposed additional complexity, with detections of even larger molecules including dimethyl ether (CH3OCH3) and vinyl cyanide (CH2CHCN). We find organics are being formed early and often along the filaments and within starless and prestellar cores in the Taurus Molecular Cloud and that these organics are abundant in the raw material hundred of thousands of years before protostars and planets form.

Session #1, 09:20–09:35

Protoplanetary Disks in the Orion Nebula Cluster: Gas Disk Morphologies and Kinematics as seen with ALMA

Ryan Boyden[1] (speaker), Josh Eisner[1]
[1] University of Arizona Steward Observatory

We present ALMA CO(3-2) and HCO+(4-3) observations that cover the central $1.5' \times 1.5'$ region of the Orion Nebula Cluster (ONC). The high sensitivity (~ 0.1 mJy) and angular resolution (~ 0.08" $=\sim 40$ AU) of these line observations enable us to search for gas-disk detections towards the known positions of submillimeter-detected dust disks in this region. We detect 23 disks in gas: 17 in CO, 17 in HCO+, and 11 in both tracers. Depending on where the sources are located in the ONC, the line detections are seen in emission, in absorption against the warm background, or in both emission and absorption. We measure the distribution of gas-disk sizes, finding typical radii of $\sim 50 - 200$ AU. Our sample of gas disks are universally larger than the submillimeter-imaged dust disks.

However, the gas and dust sizes do not appear correlated. We derive a positive correlation between the gas size and distance from the massive star Theta1 Ori C, indicating that disks in the ONC are influenced by photoionizing radiation. Finally, we study the kinematics of the detected gas lines, which are broadly consistent with Keplerian rotation. We adopt a simple Keplerian model to infer the masses of the central pre-main-sequence stars, and find that the dynamically-derived stellar masses are discrepant from the spectroscopically-derived masses found in the literature.

Session #1, 09:35–09:50

Understanding dust growth and sub-structures in protoplanetary disks

Yaping Li[1] (speaker), Hui Li[1], Shengtai Li[1]
[1] Los Alamos National Laboratory

There is now strong observational evidence for the existence of substructures (e.g., rings, gaps, crescents, spirals, etc.) in protoplanetary disks (PPDs) from high-resolution observations with the Atacama Large Millimeter Array (ALMA). These structures may play essential roles in the early stage of planet formation due to their effectiveness in dust trapping and size growth. We first carried out a large family of 1D two-fluid (gas+dust) hydrodynamical simulations by evolving the gas and dust motion self-consistently while allowing dust size to evolve via coagulation and fragmentation. We investigate the joint effects of ringed structures and dust size growth on the overall sub-millimeter and millimeter (mm) flux and spectral index of PPDs. Ringed structures slow down the dust radial drift and speed up the dust growth. In particular, we find that the unresolved faint disks with ringed structures can have mm spectral indices as low as about 2.0. With extending our coagulation model to 2D global disks, we investigate the dust growth within a planet-induced vortex and its feedback effect on the long term evolution of the vortex. Both the vortex lifetime and synthetic dust continuum images for the coagulation model are quite different for those single species models commonly adopted in previous works. We further propose that the circularization process of a highly eccentric super-Earth can produce rings/gaps in the outer region of disks. This gap/ring opening process depends on the planet circularization, which could be used to infer the dynamics of the unseen planet.

Session #1, 09:50–10:05

Europa's Observed Surface Water Ice Crystallinity Inconsistent with Thermophysical and Particle Flux Modeling

Jodi R. Berdis[1] (speaker), Murthy S. Gudipati[2], James R. Murphy[1], Nancy J. Chanover[1]
[1] New Mexico State University, [2] Caltech Jet Propulsion Laboratory

Physical processing of Europan surface water ice by thermal relaxation, charged particle bombardment, and cryovolcanic activity can alter the percentage of the crystalline form of water ice compared to the combined content of amorphous and crystalline water ice (the 'crystallinity') on Europa's surface. The timescales over which amorphous water ice is thermally transformed to crystalline water ice at Europan surface temperatures suggests that the water ice there should be primarily in the crystalline form, however, surface bombardment by charged particles induced by Jupiter's magnetic field, and vapor deposition of water ice from Europan plumes, can produce amorphous water ice surface deposits.

We seek to determine whether the Europan surface water ice crystallinity derived from ground-based spectroscopic measurements is in agreement with the crystallinity expected based upon temperature and radiation modeling. Using a 1D thermophysical model of Europa's surface, we calculate a full-disk crystallinity of Europa's leading hemisphere by incorporating thermal relaxation and degradation by particle flux. Concurrently, we derive the full-disk crystallinity of Europa's leading hemisphere using a comparison of near-infrared ground-based spectral observations from Grundy et al. (1999), Busarev et al. (2018), and the Apache Point Observatory in Sunspot, NM, with laboratory spectra from Mastrapa et al. (2008) and the Ice Spectroscopy Lab at the Jet Propulsion Laboratory. We calculate a modeled crystallinity significantly higher than crystallinities derived from ground-based observations and laboratory spectra. This discrepancy may be a result of geophysical processes or it may arise from assumptions and uncertainties in the crystallinity calculations.

Session #1, 10:05–10:20

Studying Meteor Radio Afterglows with the Long Wavelength Array and the Widefield Persistent Train camera

Savin Shynu Varghese[1] (speaker), Kenneth Steven Obenberger[1], Jayce Dowell[1], Gregory B. Taylor[1], J. M. Holmes
[1] University of New Mexico

Meteoroid particles from the solar system enter the Earth's atmosphere at high velocities and ablate due to friction producing meteors and an associated turbulent plasma trail. Some of these bright plasma trails produce radio emission between 20–60 MHz known as meteor radio afterglows (MRAs). These were first detected in 2014 using the LWA1 station. The observed emission is non-thermal, broadband, and have characteristic light curve patterns with a fast rise of a few tens of seconds and a slow decay which can be up to few minutes. Follow-up observations with LWA1 and the recently commissioned LWA-SV station revealed that the emission is isotropic. Even though different mechanisms have been proposed, the emission mechanism is still a mystery.

Currently a new broadband imager is running continuously at LWA-SV which can image the sky every 5 seconds with a bandwidth of 20 MHz. In the first part of the talk, I will discuss on how the broadband imager is used to collect the spectrum of meteor radio afterglows and study their spectral properties. Like MRAs, bright meteors also occasionally produce long lasting emission (minutes to hours) in optical and Infrared known as persistent trains (PT). The PTs are thought to be powered by an exothermic chemical reaction between ablated meteoric material and atmospheric oxygen. In the second part of the talk, I will describe an optical camera, the Widefield Persistent Train camera deployed at LWA-SV to study the association between MRAs and PTs and some new insights into the emission mechanism that are emerging.

Session #2, 11:00–11:15

Chasing the Galactic structure using VLBI and Gaia

Luis Henry Quiroga-Nunez[1,2] (speaker), Huib van Langevelde[3,4], Mark Reid[5], Lorant Sjouwerman[1], Ylva Pihlstrom[2], Megan Lewis[1,2], Anthony Brown[3], Keith Tirimba[6], BeSSeL & BAaDE collaborations
[1] National Radio Astronomy Observatory, [2] University of New Mexico, [3] Leiden University, [4] Joint Institute for VLBI in Europe, [5] Harvard-Smithsonian Center for Astrophysics, [6] University of Florida

The Bar and Spiral Structure Legacy (BeSSeL) survey and the Bulge Asymmetries and Dynamical Evolution (BAaDE) project target maser stellar emission from young massive stars and evolved stars, respectively. Follow-up radio-astrometric measurements are complementary to Gaia results since the inner plane of the Galaxy is obscured at optical wavelengths. We are constructing a cross- match sample between Gaia sources and BAaDE targets. This resulting sample provides important clues on the intrinsic properties and population distribution of evolved stars in the Galactic plane, but especially at the Galactic Bulge. For the BeSSeL targets, which are heavily obscured, we are investigating whether they can be associated with clusters of massive young stars detectable at optical wavelengths, and how such can contribute to improving the accuracy of the fundamental Galactic parameters and the Galactic spiral structure distribution.

Session #2, 11:15–11:30

Predicting the performance of future pulsar timing arrays using population synthesis

Tyler Cohen[1] (speaker), Paul Demorest[2]
[1] New Mexico Institute of Mining and Technology, [2] National Radio Astronomy Observatory

Pulsar surveys and timing observations of millisecond-period pulsars (MSP) 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 pulsar timing array observations with the future generation of timing-capable telescopes such as the Next Generation VLA, Square Kilometer Array, and Deep Synoptic Array. 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 #2, 11:30–11:45

JAGWAR follow up for Gravitational Wave Counterparts

Deven Bhakta[1] (speaker)
[1] Texas Tech University

The era of gravitational-wave (GW) multi-messenger astronomy began with the discovery of the binary neutron star merger GW170817 and its electromagnetic (EM) counterpart. In the ongoing, third, observing run (O3) of LIGO-Virgo, 9 NS-NS/NS-black hole merger candidates have already been announced, suggesting an exterimental NS detection rate of about 1 per month. The JAGWAR collaboration has been organized to maximize the VLA's potential for the discovery of radio counterparts. Additionally, we have partnered with the PIs of leading EM-GW efforts at the world's major radio facilities in order to use the best capabilities of each of these, and to optimize the use of observing time. Here we will present a summary of the events that have occurred so far during O3, and a summary of the JAGWAR responses and results.

Session #2, 11:45–12:00

Probing Unassociated Gamma-Ray Sources in the 4FGL Catalog

Seth Bruzewski[1] (speaker), Frank Schinzel[2]
[1] University of New Mexico, [2] National Radio Astronomy Observatory

Following the release of the Fourth Fermi Gamma-Ray LAT (4FGL) catalog, we present our efforts to probe the large fraction of sources for which there appears to be no known counterpart in any other electromagnetic regime. Probing these unassociated sources has so far lead to the identification of novel and exotic systems, as well as raised questions about new types of gamma-ray sources in the fields without any possibly associations.

Session #2, 12:00–12:15

Modeling Pulsations of Cepheid Variables using the Open-Source MESA Code

Joyce A. Guzik[1] (speaker), Ebraheem Farag[2], Jakub Ostrowski[3], Nancy Evans[4], Hilding Neilson[5], Sofia Moschou[4], Jeremy Drake[4]
[1] Los Alamos National Laboratory, [2] Arizona State University, [3] Pedagogical University of Cracow, [4] Harvard-Smithsonian Center for Astrophysics, [5] University of Toronto

Cepheid variable stars are core helium-burning stars of around 4 to 15 solar masses that show radial pulsations with typical periods of a few days to a few weeks, and magnitude variations of a few tenths to up to 2 magnitudes per pulsation cycle. Cepheids show a period-luminosity relation, discovered by Henrietta Leavitt in 1908, that has been used to determine distances within the Galaxy and to galaxies beyond the Milky Way. Cepheids are also a laboratory to test stellar interior physics, such as nuclear reaction rates for helium burning, turbulence models, and opacities, under conditions not easily accessible in laboratories on Earth. Current problems in Cepheid research include the discrepancy between the Hubble constant derived from the Cepheid period-luminosity relation, and that derived from cosmic microwave background observations; and 2) the discrepancy between Cepheid masses derived from pulsation periods or binary dynamics and that derived using stellar evolution models.

We will show results using the new radial stellar pulsation (RSP) capability in the open-source MESA (Paxton et al. 2019) code for models of Cepheid envelopes. We will compare models with observations for three Galactic Cepheids, the prototype delta Cep, the North Star Polaris, and the binary V1334 Cyg.

Session #2, 12:15–12:30

MRO Interferometer: Prelude to First Fringes

M. J. Creech-Eakman[1,2] (speaker), V. Romero[1], I. Payne[1,2], C. A. Haniff[3], D. F. Buscher[3], J. S. Young[3],E. R. Ligon[1,2], A. Olivares[1,2], A. Farris[1,2] & MRO Interferometer team[1,3]
[1] New Mexico Institute of Mining and Technology, [2] Magdalena Ridge Observatory Interferometer (MROI), [3] University of Cambridge

The Magdalena Ridge Observatory Interferometer (MROI) is an ambitious plan to deploy a 10-telescope optical/near-infrared imaging interferometer capable of producing high-resolution, complex images on statistical samples of galactic and extra-galactic objects, having sub-milliarcsecond resolution and sensitivities several magnitudes deeper than is feasible today with similar facilities. We have made much recent progress – in late 2019 first-light through the beam train and into the inner beam combining facility was achieved using the first telescope, fast tip-tilt system, delay line and a back-end Shack Hartmann beam stabilization system. In 2020, we are preparing to receive the second telescope/enclosure and complete installation of the second delay line, optical tables in the facility, and deploy the fringe-tracker at the summit. This will allow us to realize the milestone of first-fringes planned to begin in late 2020. While we have a Key Science Mission designed to exploit the capabilities of the completed facility, in the earliest stages of MROI's operations new science will still be possible with two and three telescopes owing to our greater sensitivity, first-light spectrometer and reconfigurable array design. In addition to plans for 2020, we will present a few exciting initial science ideas for the early-days science with the facility. We wish to acknowledge our funding through Cooperative Agreement (FA9453-15-2-0086) between AFRL and NMT for risk reduction studies to support imaging of geosynchronous satellites.

Session #3, 14:00–14:20

Calibrating Polarization with Linear Polarized Feeds

Barry Clark[1] (speaker)
[1] National Radio Astronomy Observatory

For an interferometer with linearly polarized feeds polarization calibration can be greatly simplified compared to the case of circularly polarized feeds. By orienting the linearly polarized feeds at different angles, the complete polarization parameters may be solved for by a single observation of a point source without circular polarization.

Session #3, 14:20–14:35

Jets from paramagnetic electrons in superstrong fields

Paul Arendt[1] (speaker)
[1] New Mexico Institute of Mining and Technology

The anomalous magnetic moment of the electron makes it weakly paramagnetic. Schwinger predicted that in fields above 1e13 G, this behavior reverses and the electron becomes diamagnetic, but this prediction has recently been challenged. An alternate scenario has been proposed in which the electron's paramagnetism continues to increase as the field strength increases, which causes a loss of the electron's effective mass and a divergence of its magnetic moment at 3.8e16 G. In this talk, we show that the vacuum then becomes unstable at this field strength, and the expected nature of its expected decay shares many properties with those of astrophysical jet sources, including a strong gamma-ray burst at formation. This gives a natural and attractive alternative model to the Blandford-Znajek and Blandford-Payne family of models for the central engine powering active galactic nuclei and other double-lobed sources, and can be distinguished observationally from them by its simpler magnetic field configuration.

Session #3, 14:35–14:50

Sub-kpc Magnetic Field Fluctuations around Cygnus A

L. Sebokolodi[1,2,3] (speaker), R. Perley[3], C. Carilli[3], J. Eilek[3,4], O. Smirnov[1,2]
[1] Rhodes University, [2] South African Radio Astronomical Observatory, [3] National Radio Astronomy Observatory,
[4] New Mexico Institute of Mining and Technology

Large Faraday rotation measures (LFRMs) are observed across the lobes of Cygnus A, with typical values of ±2000 rad/m/m with a few regions having values as high as ±6400 rad/m/m. The spatial distribution of these LFRMs shows ordering on scales 5–20 kpc. It is currently believed that these FRMs are caused by magnetized, ionized gas external to the source; either from the overall ICM in which the source is embedded, or shocked gas surrounding the lobes. We present the results of our JVLA wideband (1–17 GHz) polarization study of Cygnus A. The data reveal very interesting features such as significant depolarizations, and deviations from λ^2-law. Such behavior suggests the presence of unresolved fluctuations in the structure of the fields, and/or a region of mixed polarized and thermal gas in or around the lobes. We find that the depolarization is independent of the LFRMs implying that these LFRMs are most likely external to the radio lobes – consistent with previous claims. Moreover, we find that the majority of the depolarizations at 0.75 kpc-scale can be accounted for by unresolved structures, implying magnetic field fluctuation scales smaller than 0.75 kpc. The exact location of these fields still remains uncertain, but there is an indication that they may be local to the source.

Session #3, 14:50–15:05

Early science from the POSSUM survey: Shocks, turbulence, and a massive extended reservoir of baryons in the Fornax cluster

Craig Anderson[1] (speaker), George Heald[2], Chris Riseley[3] & the POSSUM ASKAP survey science team
[1] National Radio Astronomy Observatory, [2] Commonwealth Scientific and Industrial Research Organisation (CSIRO),
[3] University of Bologna

The new ASKAP radio telescope is poised to survey the entire sky south of declination +50° in full polarisation to $\sim 20\mu$Jy/bm sensitivity per Stokes parameter at 10" spatial resolution. As part of this, the POSSUM (POlarisation Sky Survey of the Universe's Magnetism) will generate an all-sky Faraday rotation measure grid capable of back-illuminating the magnetoionic structure of numerous degree-scale (and above) foreground objects. Using commissioning data for this survey, we have performed the first ever Faraday RM grid study of an individual low-mass cluster — the Fornax cluster — which also happens to be undergoing a complex series of mergers. The RM data back-illuminates previously unobserved shocks, turbulence, and a massive extended reservoir of baryons in the

cluster. We will highlight these results, and discuss the implications for cluster astrophysics, the origin of cosmic magnetic fields, and the so-called 'missing baryon problem'.

Session #4, 15:45–16:00

Mapping the Kinematics of the Cosmic Web at z 3.2

Kelly N. Sanderson[1] (speaker), Moire K.M. Prescott[1], Lise Christensen[2], Palle Moeller[3], Johan Fynbo[2]
[1] New Mexico State University, [2] Niels Bohr Institute, [3] European Organisation for Astronomical Research in the Southern Hemisphere (ESO)

The Nilsson et al. (2006) Lyman-alpha nebula (LAN) at $z \sim 3.157$ has often been offered as the best example of a LAN powered by the gravitational cooling of infalling gas because of its surface brightness profile and apparent lack of associated galaxies. Recently, Prescott et al. (2015) brought together more extensive ultraviolet, optical, and infrared data to re-evaluate the status of this object and determined that there is likely to be obscured AGN in the vicinity of the nebula. In order to revisit the question of the powering mechanism for this source, we proposed for deep VLT MUSE integral field spectrograph observations to better characterize the kinematics of the emitting gas and search for the presence of AGN emission lines. In this paper, we report the initial results of these observations. We find the kinematics and spatial distribution of the nebula to be tentatively consistent with the presence of an AGN, although the peak surface brightness is lower than typically seen for AGN powered nebulae at this redshift.

Session #4, 16:00–16:15

Using Artificial Intelligence to Understand Fundamental CGM and IGM Physics

Bryson Stemock[1] (speaker), Christopher Churchill[1], Sultan Hassan[1], Caitlin Doughty[1], Alexander Stone-Martinez[1], Farhan Hasan[1], Rogelio Ochoa[1]
[1] Astronomy Department, New Mexico State University

The Circumgalactic Medium (CGM) is the interface between galaxies, directly impacting galaxy evolution, star formation, and more, and the large scale structure of the universe, directly affecting its cosmology. The CGM is studied by analyzing absorption lines in the spectra of distant quasars, which are direct imprints of the invisible gas halos that surround galaxies (the CGM), lying between ourselves and these quasars. The consensus of the astronomical community is that the 2020s are poised to be 'the decade of detailed physics' and absorption line analysis holds the keys for unlocking the fundamental physics of cosmology, the evolution of chemical abundances, the physics and evolution of the Intergalactic Medium (IGM), galaxy formation and evolution, and more. Over the last decade, the community could muster the physical properties of only a few hundred absorption line systems. I am currently developing a machine learning convolutional neural network (CNN) that rapidly and routinely processes thousands of quasar absorption line profiles and determines the physical quantities of the CGM and IGM with minimal human intervention. After mere hours of design and training, the current model of the CNN spent 2 seconds to return the fundamental physical parameters of one thousand absorption line systems, which would require 2-3 years of human effort. This work will exploit supervised CNNs to bypass the human-intensive analysis that is bottlenecking a breakout of IGM/CGM studies.

Session #4, 16:15–16:30

Measuring Cosmic Microwave Background Polarization with POLARBEAR

Kayla Mitchell[1] (speaker), Darcy Barron[1] & the POLARBEAR Collaboration
[1] University of New Mexico

POLARBEAR is a dedicated cosmic microwave background (CMB) polarization experiment located in the Atacama desert in Chile. Studying this remnant of the Big Bang allows us to learn about the early universe and how it expanded to what we see today. Observing the CMB polarization shows certain patterns on the sky, called E-modes and B-modes. E-modes arise naturally from Thomson scattering in a heterogeneous plasma. B-modes, however, can only be created from gravitational lensing or gravitational waves arising from cosmic inflation. The POLARBEAR project was designed to search for this weak B-mode signal from cosmic inflation. Measuring this signal would provide direct evidence of inflation and a better understanding of the mechanism and energy scale of inflation. Upgrades are currently ongoing to increase sensitivity and frequency coverage. These upgrades will result in three telescopes, forming the POLARBEAR-2/Simons Array. The Simons Array will cover 95 GHz, 150 GHz, 220 GHz, and 280 GHz frequency bands, allowing greater control of foregrounds. In this talk, I will focus on the design of POLARBEAR including its cryogenic receivers, detectors, and readout system. I will also discuss the status of the commissioning of the first upgraded POLARBEAR receiver, POLARBEAR-2a.

Session #4, 16:30–16:45

Hunt for the 21cm signature of Cosmic Dawn and the Epoch of Reionization: a decade in review

Daniel Jacobs[1] (speaker)
[1] Arizona State University

The redshifted 21 cm hydrogen line is a unique probe of the early universe from recombination to the end of reionization. In the theory landscape first stars and black holes competed with exotic physics for primacy in a dense universe; a time which is nearly impossible to observe with any other method. On the basis of this compelling motivation, 21cm observations were given very high priority in the 2010 decadal survey, however little was known about the experimental challenges. In the intervening decade much has been learned from a set of first generation instruments and 2nd gen instruments are now under construction. Challenges include human generated interference, calibration of instrument chromaticity, and foregrounds which are 10000x brighter than the background. Meanwhile, a claimed detection by the EDGES experiment of a global cosmic signature of the cosmic dawn at redshift 17 either challenges the standard cosmological model or the instrumental precision. The unique challenges of making high dynamic range spectroscopic measurements at low frequencies has built into a new branch of radio instrumentation and analysis. In recent years clarity over array design, calibration, and the invention of new tools and practices have continued to improve the quality of results. Meanwhile the iterative experimental process continues with HERA, EDGES3, OV-LWA upgrade, MWA Phase III and others which push boundaries and contribute new data.

Session #4, 16:45–17:00

Using the Long Wavelength Array to Search for Cosmic Dawn

Christopher DiLullo[1] (speaker), Greg Taylor[1], Jayce Dowell[1]
[1] University of New Mexico

The search for the spectral signature of hydrogen from the formation of the first stars, known as Cosmic Dawn or First Light, is an ongoing effort around the world. The signature should present itself as a decrease in the temperature of the 21-cm transition relative to that of the Cosmic Microwave Background and is believed to reside somewhere below 100 MHz. A potential detection was published by the Experiment to Detect the Global EoR Signal (EDGES) collaboration with a profile centered around 78 MHz of both unexpected depth and width (Bowman et al. 2018). If validated, this detection will have profound impacts on the current paradigm of structure formation within

ΛCDM cosmology. We present an attempt to detect the spectral signature reported by the EDGES collaboration with the Long Wavelength Array station located on the Sevilleta National Wildlife Refuge in New Mexico, USA (LWA-SV). LWA-SV differs from other instruments in that it is a 256 element antenna array and offers beamforming capabilities that should help with calibration and detection. We report first limits from LWA-SV and look toward future plans to improve these limits.

Session #4, 17:00–17:15

Evolution of neutral oxygen during the Epoch of Reionization

Caitlin Doughty[1] (speaker), Kristian Finlator[1]
[1] New Mexico State University

We use synthetic sightlines drawn through snapshots of the Technicolor Dawn simulations to explore how the statistics of neutral oxygen (O I) absorbers respond to hydrogen reionization. The ionization state of the circumgalactic medium (CGM) initially roughly tracks that of the intergalactic medium, but beginning at $z = 8$ the CGM grows systematically more neutral owing to self-shielding. Weak absorbers trace diffuse gas that lies farther from halos, hence they are ionized first, whereas stronger systems are less sensitive to reionization. While the declining covering fraction is partially offset by continued formation of new halos, the ionization of the diffuse gas causes the predicted line-of-sight incidence rate of O I absorbers to decline abruptly at the overlap epoch, in qualitative agreement with observations. In comparison to the observed equivalent width (EW) distribution at $z \approx 6$, the simulations underproduce systems with EW > 0.1 Angstroms, although they reproduce weaker systems with EW > 0.05 Angstroms. By $z \approx 5$, the incidence of EW < 0.1 Angstrom systems are overproduced, consistent with previous indications that the simulated ionizing background is too weak at $z < 6$. The summed column densities of Si II and Si IV trace the total oxygen column, and hence the ratio of the O I and Si II+ Si IV comoving mass densities traces the progress of reionization. This probe may prove particularly useful in the regime where xHI > 10 percent.

Special talks

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

Expanding Horizons with Millimeter/Submillimeter Astronomy

Anneila Sargent[1] (speaker)
[1] California Institute of Technology

Only a few decades ago, millimeter-wave astronomical images were limited by the sizes of single telescopes. Today's images from the Atacama Large Millimeter/submillimeter Array (ALMA) are dramatically more detailed, thanks to its extended horizons. For example, observations of the disks of gas and dust that surround many very young stars are providing unexpected insights into the way planetary systems form. Dr. Sargent will discuss some of the implications of these results and expectations for the future. She will also explore the path from those single telescopes to larger arrays, touching on how her personal journey has been influenced.

Posters

P1. New Mexico $\alpha\omega$ Liquid Sodium Dynamo Experiment: An Experiment to understand the magnetohydrodynamic amplification of magnetic field in the Accretion Disk

Jiahe Si[1], Art Colgate[1], Stirling Colgate[2], Richard Sonnenfeld[1]
[1] New Mexico Institute of Mining and Technology, [2] Los Alamos National Laboratory

It's generally believed that the magnetic fields are amplified from very weak seed fields by the interaction of electrically conducting fluid motion, the so-called dynamo mechanism. We are attempting an experiment to demonstrate an $\alpha\omega$ -dynamo in New Mexico Institute of Mining and Technology with liquid sodium. The ω-effect had been produced by a stable Taylor-Couette flow between two co-rotating cylinders 60cm and 30cm in diameter, and with speeds up to 70 and 17.5 revolution/sec, with ω-gain up to x8. The α-effect will be produced by helicity generated by driven plumes analogous to star-disk collisions. A DAQ system spinning with the apparatus 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.

P2. Detecting the Particle Acceleration Mechanism in Relativistic Reconnection

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Due to the low density in astrophysical settings the energy in the magnetic fieldcan be much larger than even the equivalent energy density of the rest mass of particles.Under these conditions reconnection is the leading source of free energy that can be converted to heating and particle acceleration if kinetic, non-ideal processes are able to rearrange the topology of magnetic field lines. The resulting particle spectra can be very hard (spectral indices up to -1, harder than shock acceleration) and extend to high Lorentz factors. Our analysis of large VPIC simulations shows that acceleration by the ideal u×B electric field dominates at high particle energies and is not spatially limited to the region directly around the X point. This has implication for systems of astrophysical extents that are much larger than the microphysical lengths that can be directly simulated by fully kinetic simulations

P3. Experimental Gamma-Ray Astronomy at Los Alamos National Laboratory

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Los Alamos National Laboratory (LANL) has a long history of discovery in gamma-ray astronomy, from the first detection of gamma-ray bursts by the Vela satellites to extensive involvement in NASA's highly successful Swift and Fermi missions. Looking to the future, several exciting new opportunities are being pursued, leveraging LANL's unique expertise in space-based gamma-ray detector development and data analysis. We describe current experimental efforts at LANL, including: 1) a concept for a CubeSat mission, MAMBO, to measure the cosmic diffuse gamma-ray background in the MeV band; 2) development of an advanced Compton telescope based on diamond detectors and fast scintillators; 3) a high-altitude ballooning program to test advanced detector technologies in a near-space environment; and 4) contributions to AMEGO, a concept for NASA's next large-scale gamma-ray astronomy mission.

P4. Los Alamos National Laboratory's Contributions to the LOX Mission Concept

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An array of astronomy research is being conducted at Los Alamos National Lab (LANL), from space instrumentation to supernovae to gamma ray astrophysics. LANL is a member of the Lunar Occultation eXplorer (LOX) collaboration. LOX will use the Moon as a platform to probe the cosmos at MeV energies. In particular, LOX is well-suited for all-sky monitoring and time-domain astronomy pertinent to supernova investigations. Our work at LANL encompasses modifying existing modeling and analysis tools in C++ for spectral analysis, time variability, and cross-correlation with observations at different energies as well as creating predictive sky maps extrapolating from pre-existing source catalogs to assess the expected MeV sensitivity.

Complementarily, individuals at LANL are analyzing a data cube of supernovae simulations to parametrize supernovae light curves, working backwards from the data to the physics to find observational signatures across UVOIR and gamma ray energy bands which will be useful to future missions such as LOX. Additionally, this analysis encompasses searching for correlations in the theoretical data to see if they are sensitive to observational folding. Supernovae are a fundamental player in what has been deemed the contemporary 'crisis in cosmology' regarding the Hubble parameter measurement discrepancy at early and late times in the universe. Further constraining the width-luminosity relationship at wavelengths other than UVOIR is essential to how definitively we can address this crisis.

P5. EMU: The Evolutionary Map of the Universe survey

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EMU is a new-generation wide-field radio continuum sky survey being delivered by the Australian Square Kilometre Array (ASKAP) telescope. The EMU survey will image the entire Southern Sky, extending to $+30^\circ$ North, with the aim of reaching 15μJy/bm noise and $\sim$10 arcsec resolution at 1 GHz. EMU is expected to detect 70 million radio sources, including normal star-forming galaxies and radio-quiet AGN to $z = 1$, starburst galaxies to high redshifts, AGN across the cosmic time back to the epoch of reionisation, map the cosmic web and determine cosmological parameters, along detailed observations of Galactic Plane and Local Universe. EMU Pilot Survey observations have been delivered and processed in second half of 2019. Here, we present the survey parameters, and results already being delivered with the early science EMU data.

P6. Convective Blueshift and Systematic Errors in Solar Meridional Flow

Aleczander Herczeg[1], Jason Jackiewicz[1]
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Time-distance helioseismology has been extensively used to study the meridional flow on the sun, from the near surface to the base of the convection zone. However, measurements of the solar meridional flow have been plagued by a systematic error that results in a spurious flow which, to first order, appears to be moving radially outward from disk center. This systematic error is present in the measurements whether the initial data was collected in space or on the ground, regardless of the instrument used. This implies the source of the systematic error is the sun, and the center-to-limb variations that appear in the spurious flow point toward this being a surface effect. Currently, the method for removing this spurious flow from the final model is unsatisfactory. Convective blueshift, the apparent average blueshift due to convection at the solar surface, qualitatively matches the center-to-limb systematic error: both effects vary with the spectral line used to measure it and with the resolution of the instrument, and both effects first increase upon moving from the disk center before decreasing to a minimum near the limb. Using HMI data, time-distance methods are used to compare inverted meridional flow results with and without correcting for convective blueshift before processing the raw data. If the systematic errors are caused - either in full or in part - by neglecting to account for this convective blueshift, this treatment of the data can lead to increased accuracy of all future meridional flow measurements made using the time-distance method.

P7. Flare-induced 3-minute oscillatory power in the chromosphere

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[1] New Mexico State University

Flare-induced 3-minute oscillations in the chromosphere are attributed to both slow magnetoacoustic waves propagating from the photosphere, and to oscillations generated within the chromosphere itself at its natural frequency as a response to a disturbance. Here we present an investigation of the spatial and temporal behavior of the chromospheric 3-minute oscillations before, during, and after the SOL2011-02-15T01:56 X2.2 flare. Observations in ultraviolet emission centered on 1600 and 1700 Angstroms obtained at 24-second cadence from the Atmospheric Imaging Assembly on board the Solar Dynamics Observatory are used to create power maps as functions of both space and time. We detect an increase in the 3-minute power, which we determine to be caused by the X-class flare. The enhancement is not global, instead it is concentrated in small areas around the active region, which is attributed to the localized injection of energy by nonthermal particles.

P8. Auroral Emission in the Venusian Atmosphere During Solar Minimum

Sarah Kovac[1], Candace Gray[1], Nancy Chanover[1], James McAteer[1]
[1] New Mexico State University

The solar wind is known to interact with the ionospheres and upper atmospheres of terrestrial planets, thus contributing to their atmospheric evolution. An essential component of this evolution is atmospheric stripping, the process of ionizing particles such that they escape the atmosphere. One feature of the solar wind is a stream interaction region (SIR), which is created when multiple solar wind streams are compressed to create regions with higher densities, stronger magnetic fields, and steeper velocity profiles. The effects of high energy solar events, like coronal mass ejections and flares, have been shown to contribute to atmospheric stripping, but lower energy events, such as SIRs, have not been studied in detail. These lower energy events are far more common and present throughout the entire solar cycle. Thus, while less intense, SIRs provide an equally important, but poorly understood, source of planetary atmospheric erosion. Venus is an ideal target for studying atmospheric erosion via SIRs due to its lack of an intrinsic magnetic field and known auroral emission. Ground based observations of large solar events have shown auroral emission in Venus's atmosphere, but the energy trigger for this emission is unknown. This study looked for auroral emission during solar minimum in the Venusian night side atmosphere. Over a roughly three-week observing campaign, emission was not detected via the quiet solar wind, but one observation taken as a SIR approached Venus showed emission. This result shows promise for future work looking into the minimum particle energy needed to induce Venusian aurora.

P9. Exploration of Jupiter Brightness Temperature Anomalies

Harrison Bradley[1], Yancy L. Shirley[1]
[1] University of Arizona

From calibration measurements of Jupiter with the ARO 12 Meter Telescope we determined the main beam efficiency from the Fall of 2016 through Fall of 2018. Jupiter's main beam efficiencies were lower than those determined from Mars and Venus. On further investigation we determined that the issue must be with the model of brightness temperature we had been using over the frequency range of observations (85–116 GHz). We determined that a scaled brightness temperature model of 1.0562 times the model used by the ALMA best fits the Jupiter brightness temperatures that we found in the literature.

P10. Searching for Exomoons in Low Frequencies Using the Long Wavelength Array

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The Solar System's planets, including dwarf planets, are known to be orbited by 182 natural satellites. Our knowledge about their commonality in our system and satellite formation theories, encourages the expectation that extrasolar moons (exomoons) should be present around some confirmed exoplanets. Great achievements in theoretical studies and detection techniques have led to the discovery of 4,000+ exoplanets in ∼3,000 planetary systems to date. However, though candidates have been proposed, the confirmation of the first exomoon is yet to be accomplished. A novel radio-detection method for exomoons, based on a planet-moon interaction observed between the Jupiter-Io system, has been recently proposed (Noyola et al. 2014). As an extension of previous 325MHz searches carried out with the GMRT (Rosario-Franco et al. in prep.), which reflects the first application of this method, we perform follow up observations of a nearby (∼3.56pc) stellar binary system Groombridge 34 at lower frequencies (47–67 MHz). We aim to analyze 380 beam-hours of observations with the Long Wavelength Array (LWA), located in New Mexico, utilizing Io-controlled decametric radio emissions to determine how the presence of exomoons might be revealed by the same modulation mechanism. Details of our ongoing observations are presented and the significance of detection outcomes is discussed.

P11. Line Dancing of CO2 in Mira Atmospheres

Dana K. Baylis-Aguirre[1], Michelle J. Creech-Eakman[1], Tina Güth
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We present analysis of mid-infrared spectra of oxygen-rich (M-type) Mira variables. Each star has multiple spectra obtained over a one-year period (2008–09) using the Spitzer Infrared Spectrograph (IRS) in the high resolution mode (R 600). Due to the brightness of this sample, it is straightforward to monitor changes with phase in the infrared spectral features of these regular pulsators. We have identified several ro-vibrational Q-branch bandheads of CO2 that are not observable with ground based instruments because telluric features dominate at these wavelengths. Additionally, there is a narrow bright feature at 17.6μm that is present which we have identified as Fe fluorescence. The CO2 lines exhibit unique, fluctuating behavior possibly tied to the pulsational phase of the star; for example the fundamental band at 15μm is seen in both emission and absorption. We built a file of ro-vibrational data that we used to model the CO2 lines with the radiative transfer code RADEX. We present results from these CO2 models that describe the physical characteristics of the gas such as temperature and density. Using RADEX results from several M-type stars will give us a better understanding of how the CO2 gas behaves in oxygen rich Mira atmospheres.

P12. A highly collimated flow from a high-mass protostar

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ISOSS J23053+5953 SMM2 is a rare example of a high-mass protostar in the phase of rapid mass accretion, but still before the formation of a prominent hot core region. Located at a distance of ∼3.5 kpc, in a molecular core of mass 26 $M_\odot$ within 8000 AU, it shows clear signs of mass infall at a rate of 2×10^{-3} $M_\odot$/yr, and its age is estimated to be ∼5000 yrs. A prominent NH_3 velocity gradient across the core suggests that this object formed by the convergence of two molecular filaments. We have recently used the SMA to perform CO(2-1) observations toward ISOSS J23053+5953 SMM2 and detected a highly collimated outflow (see Figure below). Our JVLA continuum data reveal the presence of compact ionized gas at the center of the core, likely arising from a thermal jet from the high-mass protostar. In this presentation, we will discuss the nature of the jet-outflow system in this extremely young high-mass protostar, and its implications for high-mass star formation theories.

P13. A systematic VLA+GBT survey of the most massive 70μm dark clumps within 5 kpc

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Measurements of the initial physical conditions of entire cluster forming regions are essential to placing robust constraints on models of high-mass star formation. To this end, we report initial results of a combined interferometer and single dish telescope survey of the NH3 (1,1) through (4,4) inversion transitions towards 12 high-mass 70μm dark clumps. The survey targeted the most high-mass, starless clump candidates within 5 kpc (500–3000 solar masses) from the 1.1mm wavelength Bolocam Galactic Plane Survey. Observations from the Jansky Very Large Array (VLA) and the Green Bank Telescope (GBT) were jointly imaged to produce maps with 3.5 arcsec resolution (0.07 pc at 4 kpc) and 0.16 km/s spectral resolution. We model the NH3 lines to derive maps and distributions of velocity dispersion, gas kinetic temperature, and NH3 column density. We report a preliminary analysis of the velocity gradients in filaments and sub-structures to estimate rotational angular momentum and/or longitudinal gas flows. We also present a new Bayesian model estimation algorithm for multiple component fitting of NH3 spectra based on Nested Sampling (github.com/autocorr/nestfit). This VLA survey aims to connect single dish telescope surveys of the most nearby low- and high-mass star forming regions (e.g., GBT GAS and KEYSTONE) to the Galactic population through observations of a blindly selected sample of very young, 70μm dark protoclusters.

P14. Characterizing Physical Properties of Hierarchical Structure in Star-Forming Regions

James Lilly[1], Yancy Shirley[1]
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We present a comparison of the physical properties of several high-confidence starless cores in the Taurus molecular cloud measured using the Astrodendro and CSAR hierarchical structure analysis routines. We directly compare the physical properties of sources identified in NH3 (1,1) integrated intensity maps from the Green Bank Ammonia Survey and H2 column density maps derived from SED-fitting of dust continuum from the Herschel Gould Belt Survey. We find that CSAR and Astrodendro source parameters agree well for the same dataset, but that there can be substantial differences in source parameters when comparing NH3 intensity and dust-derived H2 column density (e.g. in some cases, individual cores detected with NH3 are not distinguishable in H2).

P15. The Role of Hydrogen Cyanide in Probing Densities in the Taurus Star Forming Region

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Pre-stellar cores are gravitationally-bound, dense starless regions, which are sites of future star formation. By studying these dense, starless regions we can better understand the initial conditions of star formation. We have carried out a survey to observe hydrogen cyanide (HCN 1-0) in the regions B7 through B213 of the Taurus Molecular Cloud using the Arizona Radio Observatory 12-m telescope at the Kitt Peak National Observatory. Hydrogen cyanide is commonly used as a dense gas tracer and has been mapped in areas of active star formation in nearby clouds. However, Taurus is a much more quiescent region dominated by pre-stellar cores. The primary goal of this survey was to constrain the density of gas traced by HCN in more quiescent regions by comparing the visual extinction to our HCN 1-0 intensity. Our survey has determined that HCN emission is dominated by intermediate density gas, and that the calculation of the ratio of mass of dense gas ($A\nu > 8$ mag) to HCN 1-0 luminosity indicate much higher values than typically assumed in extragalactic studies.

P16. Study of Deuterated Ammonia in the Cepheus Star-Forming Region L1251

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Understanding the chemical processes during starless core and prestellar core evolution is an important step in understanding the initial stages of star formation. Deuterium fractionation of several orders of magnitude above the standard ISM ratio is expected to occur in molecules such as NH3 in the dense, cold centers of prestellar cores. There is a lack of studies that focus on the entire starless core population within a single cloud. This project is a study of deuterated ammonia, o-NH2D, in the nearby (300 pc) star-forming region Cepheus L1251. We observed 22 dense cores identified by the Herschel Space Observatory with the 12m ARO telescope on Kitt Peak. Deuterated ammonia was detected in 13 of the cores (59%). We compared these observations to an ammonia (NH3) survey of the same region by Keown et al (2017). Comparisons of physical parameters such as mass, radii, average volume density, gas kinetic temperature, peak H2 column density, and virial parameter show evidence of separation between sources with NH2D detection and those without NH2D detection. Our results also demonstrate differences between the physical properties of optically thin (61% of detections) and optically thick sources. These results indicate that the deuteration of ammonia provides an additional evolutionary indicator during the starless and prestellar core phases.

P17. Discovery of the Zeeman Effect in the 25 GHz Class I Methanol Maser Line

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We report the first detection of the Zeeman effect in the 25 GHz Class I methanol maser line toward the high mass star forming region OMC-1. The characteristic spectral feature for the Zeeman effect in Stokes V in OMC-1 is detected in two observations with different angular resolutions taken eight years apart. In our 2009 Very Large Array (VLA) D-configuration observations we measure a value of $zB_{los} = 152 \pm 12$ Hz, where z is the Zeeman splitting factor and B_{los} is the line-of-sight magnetic field. In our 2017 VLA C-configuration observations we measure a value of $zB_{los} = 149 \pm 19$ Hz. Depending on which hyperfine transition is responsible for the maser line, these measurements correspond to B_{los} in the range 171–214 mG. While these magnetic field values are high, they are not implausible. If the magnetic field increases in proportion to the molecular hydrogen density in shocked regions, then our detected fields predict values for the pre-shock magnetic field that are in agreement with mm-dust polarimetry results. With such magnetic field values, the magnetic energy in the post-shocked regions where these 25 GHz Class I methanol masers occur would dominate over the kinetic energy density and be at least of the order of the pressure in the shock, implying that the magnetic field would exert significant influence over the dynamics of these regions. In general, the ability to detect the Zeeman effect in 25 GHz methanol masers opens a new window for magnetic field measurements in star forming regions.

P18. Extended Hot Gas in the Galactic Center

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The inner 300–500 pc of the Milky Way, the Central Molecular Zone (CMZ), is one of the most extreme environments for molecular gas in our Galaxy. Physical properties of the CMZ, including temperature, density, thermal pressure, and turbulent pressure, are key factors for characterizing gas energetics, kinematics, and evolution. In order to better understand the extreme environments in the CMZ, we must better understand the physical conditions of the molecular gas across the entire CMZ. Many of these physical conditions can be derived from observation of ammonia (NH3). We observe NH3 J,K=(1,1)-(6,6) inversion transitions, up to 408K above the ground state, from SWAG (Survey of Water and Ammonia in the Galactic Center) using the Australia Telescope Compact Array (ATCA). We generate maps of the gas kinetic temperature, density, and kinematics covering the entire CMZ. These maps quantitatively agree with previous studies of selected regions at lower resolution which have indicated the presence of multiple temperature components. Rotational temperatures average ∼60K across the CMZ, though several regions,

excluding Sgr B2 and Sgr A, exhibit temperatures of 150-200K and higher. Additionally, we observe higher NH3 transitions of J,K=(8,8)-(13,13) (E_{up}=1690 K) in a sample of clouds using the 100m Robert C. Byrd Green Bank Telescope (GBT) toward selected regions across the CMZ. These higher transitions probe higher temperatures, and we find rotational temperatures greater than 400K for CMZ clouds out to a radius of 400 pc. We identify some of the most extreme molecular gas temperatures detected in the Galactic center thus far. However, with this sample, we do not find a correlation between the hot temperature component and galactocentric radius, nor do we find a relationship between these high temperatures and actively star-forming clouds.

P19. BAaDE: the Bulge Asymmetries and Dynamical Evolution survey

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P20. A Statistical Approach to Distance Calculations for BAaDE Sources

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The Bulge Asymmetries and Dynamical Evolution (BAaDE) survey is the largest ever SiO maser survey of 28,062 infrared-selected selected evolved stars throughout the Galactic plane. We have generated an IR catalogue from 0.79 microns to 70 microns by cross-matching the BAaDE sources with nine different surveys. With this, spectral energy distributions (SEDs) can be formed for our objects. Using this IR catalog and the resulting SEDs, we are attempting to estimate distances to the sources as well as infer properties of the stellar objects and their circumstellar envelopes. The method used to extract these properties is by modeling SEDs of the sources. By generating SED templates, which we can match to sources of known distances, we can subsequently estimate distances to the full set of BAaDE sources. To effectively use this method, an in-depth study of interstellar extinction in the Galactic plane is necessary and we are attempting to map the extinction. Moreover, we will correlate properties of the VLA and ALMA maser data of the BAaDE sources with the IR colors and magnitudes.

P21. Carbon and Oxygen-rich stars in the BAaDE survey

Megan Lewis[1,2], Ylva Pihstrom[1], Lorant Sjouwerman[2] & the BAaDE collaboration
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The Bulge Asymmetries and Dynamical Evolution (BAaDE) survey is the largest ever SiO maser survey of infrared-selected Asymptotic Giant Branch (AGB) stars in the Galactic Plane covering 28000 stars. The name-sake goal of the survey is to measure the line-of-sight velocity of thousands of point-mass probes of the Galactic gravitational potential, but the survey also provides a huge statistical sample with which to study the characteristics of AGB stars. We find SiO masers can be used to trace the oxygen-rich AGB population within our sample, and that with the addition of infrared data, 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.

P22. Searching for Hidden Black Holes in APOGEE-2

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The Milky Way is believed to contain thousands of stellar mass black hole X-ray binaries, but only about 50 candidates are known. I discuss an examination of the APOGEE-2 data for X-ray sources in the Swift Galactic Bulge Survey region. The object HD 158902 stood out as warranting further investigation, because it showed a radial velocity discrepancy between archival data and APOGEE-2. I discuss my work in determining whether this is due to binary motions or other causes.

P23. Limits on Intermediate-Mass Black Holes in 19 Massive Globular Clusters

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The NSF's Karl G. Jansky Very Large Array (VLA) was used at a wavelength of 3 cm to search for accretion signatures from intermediate-mass black holes (IMBHs) in 19 globular clusters (GCs) in NGC 3115, an early-type galaxy at a distance of 9.4 Mpc. The 19 are massive, with a mean stellar mass $\overline{M_\star} \sim 1.8 \times 10^6\ M_\odot$. None were detected. Stacking and applying a semi-empirical accretion model led to an IMBH mass $\overline{M_{\rm IMBH}} < 1.7 \times 10^5\ M_\odot$ and mass fraction $\overline{M_{\rm IMBH}}/\overline{M_\star} < 0.095$. These limits approach values predicted in a recent semi-analytical model for GC evolution. A robust test of that model demands deeper radio observations of dozens of individual GCs. Simulated observations with a next-generation VLA (ngVLA) are used to show the path forward. Finding IMBHs in GCs would validate a formation channel for seed black holes in the early universe and inform event predictions for gravitational wave facilities.

P24. WANTED DEAD OR ALIVE — Classifying Dying Radio Galaxy J2241.3-1625 with Radio Spectral Modeling

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Dying radio galaxies are rare relic radio sources originating from preceding them AGN radio activity. The prominent features of radio galaxies (radio core, jets, hotspots) are fed by continuous supply of energy from the central supermassive black hole in the host galaxy, but once the jet activity stops, these features will disappear very quickly ($10^4 - 10^5$ years) and the lobe plasma will continue to expand and cool via synchrotron and inverseCompton losses, creating a 'relic' or 'dying' radio galaxy. We observed a dying radio galaxy candidate, J2241.3–1626, with Very Large Array from 4 to 12 GHz to probe the shape of the steepening radio spectral energy distribution (SED) of the ageing synchrotron plasma, and derive duration of the inactive AGN phase of this source. Together with available radio survey data at lower frequencies, we created and modeled broadband SED of the radio galaxy (70 MHz to 12 GHz). We will present the radio SED and images of the radio galaxy. Interestingly, the SED of this source does not show any break up to 12 GHz, which may mean that the AGN switched off very recently.

P25. DEAD VULTURES: The nature and evolution of the weakest CIV absorbers in quasar spectra

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We study the evolution of ~ 2000 CIV absorbing systems – at $1 < z < 5$ – found in the spectra of ∼400 quasars observed with the highest resolution (∼45000) spectrographs on Keck (HIRES) and VLT (UVES). The superior spectral resolution allow us to fully characterize the population of the weakest CIV absorbers (with Equivalent

Width, $W < 0.3$Å) for the first time. We find that absorbers with EQWs $0.01 < W < 0.3$ do not show a monotonous decrease with redshift in the number of absorbers per redshift path as stronger ($W > 0.3$Å) absorbers do. Unlike previous studies, we find that a Schechter function, instead of an exponential, is required to accurately model the Equivalent Width Distribution (EWD) of CIV, showing a rising function at $W < 0.3$Å. Assuming absorbers are associated with galaxy halos, we calculate the characteristic sizes of the weakest absorbers to be on the order of 100 kpc - a few times larger than that of the stronger absorbers, implying that the former population is likely found in the outer circumgalactic medium (CGM) of galaxies or possibly even associated with the intergalactic medium (IGM). These weak absorbers can offer crucial insights into the galaxy-IGM interface and the baryon cycle that regulates galaxy evolution.

P26. The Search for More Low Redshift Lyman Alpha Nebulae

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Extended emission line nebulae allow us to study the gas reservoir outside of galaxies, which is the fuel for star formation. At high redshifts, the focus has been on finding giant Lyman-alpha nebulae, as redshifted Lyman-alpha is one of the brightest emission lines accessible from the ground. Searching for these nebulae at lower redshifts gives us the opportunity to study their evolution, which could give us insight into how the gas outside galaxies is evolving over cosmic time. There are currently only 17 objects, selected due to their unusual "green" colors in Sloan Digital Sky Survey (SDSS) imaging, that have been identified as low redshift extended Lyman-alpha nebulae. These rare objects, colloquially named "Green Beans," are powered by Type 2 AGN. They have high [OIII] luminosities and excess flux in the far ultraviolet band, which contains Lyman-alpha at this redshift. Since this "Green Bean" sample was initially selected with optical color-cuts, there are likely additional low redshift Lyman-alpha nebulae that have been overlooked. Therefore, our main goal is to identify more objects that are similar to the "Green Beans" by searching through existing data from SDSS and the Galaxy Evolution Explorer (GALEX). Using follow-up APO/DIS spectroscopy and APO/ARCTIC imaging, we are studying the properties and kinematics of these candidate low redshift Lyman-alpha nebulae, and investigating the relationship between these systems and the existing "Green Bean" sample.

P27. Prediction and Detection of High-Mass galaxies in CHILES

Monica Sanchez-Barrantes[1,2], Patricia Henning[1], Emmanuel Momjian[2], Jacqueline Van Gorkom[3] & the CHILES team
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P28. CARTA: Cube Analysis and Rendering Tool for Astronomy

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CARTA is the 'Cube Analysis and Rendering Tool for Astronomy', a new image visualization and analysis tool designed for the ALMA, VLA, SKA pathfinders, and the ngVLA. The mission of CARTA is to provide usability and scalability for the future by utilizing modern web technologies and computing parallelization. To account for large images that are hosted remotely, CARTA applies a remote server approach that is accessible from a local web-based client. A desktop version bundles the server-client structure in a single application. Our focus on performance is reflected in short, progressive loading times, with only seconds to load TB sized multi-dimensional image cubes (FITS, CASA, MIRIAD, HDF5-IDIA). The current version of CARTA (v.1.2) includes flexible coordinate transformations of images, image statistics and histograms, spatial and spectral profiles, cube animators and Stokes analysis, regions of interest and configurable layouts. World-coordinate support for image overlays and a scripting language are some of the core functionalities that are currently under development.