Jacob Turner (GBO)

Cyclic Spectroscopy-Aided Studies of the ISM in PTA Observing Setups

We use cyclic spectroscopy to perform high frequency-resolution analyses of multi-hour baseband Arecibo observations of the millisecond pulsar PSR B1937+21. This technique allows for both the examination of scintillation features in far greater detail than is otherwise possible under most pulsar timing array observing setups. We measure scintillation bandwidths and timescales in each of eight subbands across a 200 MHz observing band in each observation. Through these measurements we obtain robust intra-epoch scintillation bandwidth and timescale scaling estimations. Thanks to our high frequency resolution and the narrow scintles of this pulsar, we resolve the frequency-dependent evolution of scintillation arc features within individual observations. We observe the dimming of prominent arc features at higher frequencies, possibly due to a combination of decreasing flux density and undetermined effects due to the interstellar medium. We also find agreement with arc curvature frequency dependence predicted by Stinebring et al. (2001). Thanks to the frequency resolution improvement provided by cyclic spectroscopy, these results show strong promise for future such analyses with millisecond pulsars, particularly for pulsar timing arrays, where such techniques can lead to high-cadence estimates of scattering delay, and thus the means for correcting for pulse arrival times the sub-100 ns level, as well as valuable studies of scintillation and scintillation arc evolution.

Tao-Chung Ching (NRAO)

Interferometric Observations of Spectral-line Polarization toward Low-mass Dense Cores

Spectral-line observations of Zeeman effect and Goldreich-Kylafis effect trace interstellar magnetic fields with the velocity information that is not available for dust polarization observations. However, credible observations of Zeeman effect and Goldreich-Kylafis effect remain sparse owing to the weak signals, particularly for interferometric observations at high angular resolutions. Here I report the VLA observations of the HI narrow self-absorption Zeeman effect toward prestellar core L1544 and the ALMA observations of the CO Goldreich-Kylafis effect toward Class 0 core NGC1333 IRAS 4A. Our VLA results detect a magnetic spot of 0.1 mG in the envelope of L1544. The distribution of the magnetic field strength and the correlation between magnetic field strength and gas density are different from the predictions of ambipolar diffusion models. The ALMA results of NGC1333 IRAS 4A show an increment of the deflection between CO and dust polarization angles from low to high speed. The CO polarization shows a helical magnetic field structure which is different from the hourglass structure inferred from dust polarization. The combination of spectral-line polarization and dust polarization provides a potential to resolve the magnetic field structure along the line of slight.

Cosima Eibensteiner (NRAO)

PHANGS-MeerKAT and MHONGOOSE HI observations of nearby spiral galaxies: physical drivers of the molecular gas fraction, Rmol

Understanding the molecular gas fraction is of crucial relevance to the evolution of the interstellar medium (ISM) for star formation in galaxies. Mass flows from the outermost regions (atomic gas) fuel galaxy centers (where it gets converted to molecular gas) with fresh material for star formation. In my talk, I show where the atomic gas becomes molecular (surface density of atomic gas ~ surface density of molecular gas) in nearby galaxies using new high-quality observations from MeerKAT and ALMA, for HI and CO, respectively, and how it depends on global galaxy properties.

We define the transition from atomic to molecular dominated phase similar to other studies as R_mol = Sigma_mol / Sigma_atom = 1 and measure how R_mol depends on local conditions in the galaxy disks supported by multi-wavelength observations (from GALEX, SPITZER, WISE and MUSE). For this we use a compiled dataset containing new observations from the MeerKAT telescope targeting the galaxies NGC 1512, NGC 4535, and, NGC 7496, from the first results of the PHANGS-MeerKAT survey and together with the galaxies IC1954, NGC 1566, NGC 1672, NGC 3511, and NGC 5068 from the MHONGOOSE survey (deBlok+2016) form a sample of eight nearby (D = 5.2 - 19.4 Mpc) spiral galaxies that have the required multi-wavelength observations available. With upcoming high-sensitive and high-resolution observations with MeerKAT, the analysis I present forms a first step towards the investigation of how global galaxy properties (stellar mass, star formation rate, or morphology) impact the conversion from atomic to molecular gas in nearby galaxies (D < 20 Mpc or z < 0.005).

Lankeswar Dey (West Virginia University)

Exploring the Influence of Polarization Calibration Techniques on Pulsar Timing with NANOGrav GBT Data

Pulsar Timing Array experiments aim to detect nanohertz gravitational waves by timing an ensemble of millisecond pulsars, and generating accurate and precise times of arrival (ToAs) of pulses from pulsar observations is a critical aspect of these experiments. Incorrect polarization calibration of the observed pulsar profiles could be a source of error in the ToAs. Further, many studies (e.g., Manchester et al. 2013, van Straten 2013) have shown that robust polarization calibration of pulsar profiles can reduce the noise in the pulsar timing data and lead to better timing solutions. In NANOGrav data releases, the pulsar profiles are calibrated using Ideal Feed Assumption (IFA) which assumes the receivers to be perfectly orthogonal. In this talk, I will present our ongoing efforts to explore the improvements in timing solutions in NANOGrav data taken with the GBT when we use Measurement Equation Modelling (MEM) and Measurement Equation Template Matching (METM) to perform a more robust polarization calibration.

Julia Blue Bird (NRAO)

High Redshift HI & H2 With CHILES

Measurements of hydrogen are important in our understanding of the Universe. Following reionization at z ∼ 6, most of the hydrogen outside galaxies is in an ionized state. Within galaxies, hydrogen passes through a neutral phase as it cools and collapses into molecular hydrogen and then to stars. We know that cosmic star formation peaks at z ∼ 2 and sharply declines to the present, yet we know very little about gas reservoirs in individual galaxies that lead to star formation through these redshifts. The COSMOS HI Large Extragalactic Survey (CHILES) is a 1000-hour program, using the Karl G. Jansky Very Large Array, that images HI in a redshift range of 0 < z < 0.5. We present images of HI gas in galaxies at high-redshift combined with observations of CO (tracing H2) and analyze atomic + molecular hydrogen gas in a small sample of galaxies three, four, and five billion years back in time.

Samantha Scibelli (NRAO)

Complex Chemistry at the Earliest Stage of Low-mass Star Formation

Before low-mass (M ≤ few solar masses) stars like our Sun are formed, they are conceived inside cold (~10 K) and dense (> 10^5 cm^-3) regions of gas and dust known as starless or dynamically evolved prestellar cores. It is essential to study the chemical complexity and evolution of prestellar cores because they set the initial conditions of star and planet formation. In recent years, it has been the detection of interstellar complex organic molecules (or COMs; any molecule with at least one carbon atom and six total atoms) in prestellar cores that has sparked interest in the star formation and astrochemistry communities, as COMs are believed to be important precursors to more biologically relevant species such as amino acids, DNA and RNA. And, it is with the use of single-dish submillimeter radio observing facilities, including the Arizona Radio Observatory (ARO) 12m, Yebes Observatory 40m, and Green Bank Observatory 100m Telescope (GBT), that we are able to systematically observe faint molecular lines at prestellar core scales (~ a few thousand AU). Here we present results from several surveys targeting a large (> 60) sample of starless and prestellar cores across two different molecular clouds – Taurus and Perseus. New COM detections are reported, including for methanol, CH3OH, methyl cyanide, CH3CN, acetaldehyde, CH3CHO, vinyl cyanide CH2CHCN, methyl formate, HCOOCH3 and dimethyl ether, CH3OCH3, which has more than doubled COM detection statistics in cold cores. Our results reveal COMs are prevalent earlier than previously thought and seeded early on before the formation of stars and planets.

Hendrik Müller (NRAO)

Tools for recovering full Stokes movies for the EHT

It is one of the major and highly anticpiated science goals of the EHT to recover a movie of the accretion flow in SgrA* at the event horizon scales. However, this is a very challenging data analysis problem due to the small number of telescopes, the need for super-resolution, the small signal to noise ratio, the rapid variability of the source and the existence of scattering screen that is variable in time as well. Many different approaches have been proposed to recover a movie and deal with certain aspects of the problem, but only recently have been combined into a full pipeline. In this talk, I will give an overview over the tools and methods that are needed to recover time-dynamic information from EHT observations of SgrA*.

Rebecca Charbonneau (NRAO)

Celebrating Successes: Women in Radio Astronomy

While the history of science is often utilized to provide critiques of science in the hopes of bringing attention to challenges that need addressing, it can also serve to remind us of our successes. In this presentation, I delve into the historical involvement of women in astronomy, showcasing how astronomy has served as a beacon of progress for gender equality in the physical sciences. Focusing on our specific case at the National Radio Astronomy Observatory, I highlight how a small decision in 1960 to welcome women into our undergraduate summer research program sparked a transformative and long-lasting shift in female participation in science. Through this case study, I aim to demonstrate how seemingly small decisions by individuals can have a significant ripple effect, ultimately leading to greater diversity--and even new discoveries--in the field of astronomy and sciences more broadly.

David Monasterio (NRAO CDL)

Multiband architecture for the next generation of radio-astronomy receivers

The increase of IF bandwidth is one of the main priorities for the next generation of heterodyne receivers. One alternative approach to this problem is to increase the number of IF outputs. In this work, we will present an analysis of how multiband receivers work, showing their advantages and limitations, and we will show some practical examples. Additionally, we will explain the possibility of using a multiband heterodyne receiver architecture in conjunction with digital sideband separation to achieve complete RF coverage with multiple IF outputs.

Alex Saffer (NRAO)

What Pulsar Timing Arrays Can Teach Us About Gravity

Supermassive black hole binaries produce gravitational waves of frequencies in the nano-Hertz range. Pulsar timing arrays, which make use of the radio timing of millisecond pulsars, can probe this area and allow for the study of gravitational physics surrounding the black holes. In this talk I will explain how we can (and do) use pulsar timing arrays to probe the fundamental laws of nature surrounding these supermassive black hole binaries. I will also discuss how deviations in radio timing of pulsars can shed light on our understanding general relativity and other theories of gravity.

Dillon Dong (NRAO)

Demographics of the ~GHz transient sky

In each new epoch of the VLA Sky Survey, we are finding ~10^3 radio point sources that have suddenly appeared in the sky. These 3 GHz transients and high-amplitude variables are produced by a wide variety of objects, including stars and compact objects in the Milky Way, stellar explosions and low-velocity SMBH outflows in the local universe, and relativistic jets out to cosmological distances. Each transient provides a glimpse at the dynamic processes that together make up the universe's most prolific particle accelerators. Depending on the source, we might learn about their magnetic fields, the outflows they launch, the environments they help shape, or the fate of their remnants. The first step in unlocking this information is developing a robust and scalable classification scheme that can assemble statistical samples of common transient/variable classes, and identify rare/new populations. In this talk, I will discuss our ongoing efforts to develop such a scheme for the VLA Sky Survey using data from multi-wavelength sky surveys, follow-up observations, and order-of-magnitude theory. For a variety of branches in the resulting decision tree, I will also discuss how the radio transients can help us make progress on open questions about the objects that produce them.

Ross Jennings (West Virginia University)

Developing a Cyclic Spectroscopy Backend for the Green Bank Telescope

In signal processing, there is a fundamental limit to the simultaneous frequency resolution that can be achieved with any filterbank. Because traditional pulsar observations are produced by folding filterbank data, they are subject to the same limit. However, by taking into account the statistically periodic, or "cyclostationary", nature of pulsar signals from the beginning, it is possible to overcome this limit for pulsar data. For the past several months, I have been working with scientists and engineers at Green Bank Observatory to create a new software backend, the first of its kind in the world, that will allow this technique, called cyclic spectroscopy, to be applied to pulsar data as it is observed. I will describe the nature and goals of cyclic spectroscopy, the hardware and software architecture we plan to implement, and some of the challenges we have faced in implementing this novel system.