8th Annual
NRAO Postdoctoral Symposium

March 26 – 28, 2012
Pete V. Domenici Science Operations Center
NRAO, Socorro, NM

NPS diverse thinking outside the box ... ymposium

NRAO

Associated Universities, Inc.

NSF

8th Annual NRAO Postdoctoral Symposium

March 25 (Sunday) 19:00 – Welcome reception at Macey Center "North Patio"

March 26 (Monday)

09:00 – 09:30	Registration & Welcome
09:30 – 10:15	Michael Busch: Asteroid 4179 Toutatis: Spin state changes and internal structure
10:15 – 11:00	Michal Drahus: Line variability in comets: What does it tell us about the nucleus?
11:00 – 11:30	Coffee Break
11:30 – 12:30	Yancy Shirley: Bolocam Galactic Plane Survey: A census of embedded star formation in the Milky Way (invited talk)
12:30 – 14:00	Lunch Break
14:00 – 14:45	Robin Pulliam: Exposing the molecular complexity of Sgr B2(N): The interstellar detection of methyl isocyanate (CH_3NCO) from the PRIMOS survey
14:45 – 15:30	Nuria Marcelino: The chemical structure of Orion KL: A 2D spectral line survey at 1mm
15:30 – 16:00	Coffee Break
16:00 – 16:45	Sui Ann Mao: Magnetic fields in the Milky Way halo
16:45 – 17:30	Laura Chomiuk: The mysteries of recurrent nova T Pyxidis
18:30 –	Dinner with local scientific staff

March 27 (Tuesday)

09:00 – 09:45	Amy Reines: Massive black holes in dwarf galaxies
09:45 – 10:30	Juan Munoz-Mateos: The role of bars in shaping disk breaks as probed by S4G
10:30 – 11:00	Coffee Break
11:00 – 11:45	Brian Lacki: From ten Kelvin to ten TeraKelvin: Insights on the interaction between cosmic rays and gas in starbursts
11:45 – 12:30	Amanda Kepley: How do stars form in extreme galaxies?
12:30 – 14:00	Lunch Break
14:00 – 14:45	Amy Kimball: The radio luminosity function of optically-selected QSOs: Star formation and AGNs
14:45 – 15:30	Ran Wang: Star formation in the quasar host galaxies at redshift 6
15:30 – 16:00	Coffee Break
16:00 – 16:45	Kimberly Scott: Tracing the evolution of massive galaxies through mm wavelength surveys with AzTEC
16:45 – 17:30	Huib Intema: Mpc-scale radio emission from merging galaxy clusters
18:30 –	Conference Dinner at El Sombrero

March 28 (Wednesday)

09:30 – 10:15	Nirupam Roy: Tiny scale HI opacity fluctuations towards 3C 138
10:15 – 10:45	Coffee Break
10:45 – 11:45	Rick Perley: The Jansky Very Large Array (invited talk)
11:45 – 12:00	Concluding remarks and Vote of thanks
12:00 – 13:00	Urvashi Rao: Correcting for wide-band primary-beam effects during imaging and deconvolution (Lunch talk)
13:30 – 17:30	EVLA Tour with Rick Perley

March 31 (Saturday) EVLA dedication ceremony

Participants

We are pleased to have Yancy Shirley, who is a former Jansky Postdoc and is currently an astronomer at the Steward Observatory (University of Arizona), as our Keynote Speaker this year. Following is the complete list of registered participants including posdocs, invited speakers, organizers and registered local scientific staff:

Lori Appel (NRAO, Socorro)
Michael Busch (UCLA and NRAO)
Claire Chandler (NRAO, Socorro)
Laura Chomiuk (Harvard and NRAO)
Stuartt Corder (ALMA and NRAO)
Michal Drahus (UCLA and NRAO)
Miller Goss (NRAO, Socorro)
Huib Intema (NRAO, CV)
Amanda Kepley (Univ of Virginia)
Amy Kimball (NRAO, CV)
Brian Lacki (IAS and NRAO)
Sui Ann Mao (Univ Wisconsin Madison and NRAO)
Nuria Marcelino (NRAO, CV)
Juan Carlos Munoz-Mateos (NRAO, CV)
Rick Perley (NRAO, Socorro)
Robin Pulliam (NRAO, CV)
Urvashi Rau (NRAO, Socorro)
Amy Reines (NRAO, CV)
Antonette Romero (NRAO, Socorro)
Scott Rowe (NRAO, Socorro)
Nirupam Roy (NRAO, Socorro)
Kimberly Scott (NRAO, CV)
Yancy Shirley (Univ of Arizona)
Jessica Utley (NRAO, CV)
Ran Wang (Univ of Arizona and NRAO)
Theresa Wiegert (Queen's University)

Talk abstracts

01. Michael Busch: Asteroid 4179 Toutatis: Spin state changes and internal structure

The near-Earth asteroid 4179 Toutatis has been observed with radar every four years since 1992. It is an elongated object, ~ 4.5 km in length, in a non-principal axis rotation tumbling rotation state. Comparing radar images over a twenty-year baseline, I find that Toutatis' spin state is changing significantly due to tides from the Earth during each flyby and tides from the Sun during each perihelion passage. Toutatis' reactions to the tides imply that its interior is non-uniform density, consistent with its previously having been two objects in orbit around one another which then recombined.

02. Michal Drahus: Line variability in comets: What does it tell us about the nucleus?

Millimeter and submillimeter spectroscopy is a powerful tool with which to investigate comets. The technique is sensitive to cometary molecules through their rotational transitions and therefore has been widely used to measure the composition of cometary atmospheres. However, time-resolved mm/submm spectroscopy is a completely new and potentially revolutionary angle of research in cometary astronomy. That is because temporal resolution, when added to the traditionally-available excellent resolution in radial velocity, makes it possible to observe periodic modulation of the line profiles caused by the rotation of cometary jets. The modulation can be used to determine the nucleus rotation period and also the poorly established characteristic timescale on which it evolves under the action of the outgassing torques. This timescale is of particular importance, because it is a proxy for lifetime, considering centripetal disruption as the primary destruction process of comets. Moreover, we can link the observed line variations with the properties of different regions of the nucleus, successively exposed to sunlight over the course of rotation. In this way, we can determine the compositional structure of the body, which is a fingerprint of its formation and evolution. I will illustrate these concepts with my recent observations of comet 103P/Hartley 2, for which detailed information on the rotational dynamics and compositional structure were obtained. I will also discuss the prospects for time-resolved spectroscopy of comets with ALMA.

03. Yancy Shirley: Bolocam Galactic Plane Survey: A census of embedded star formation in the Milky Way (invited talk)

The Bolocam Galactic Plane Survey (BGPS) is a 1.1mm dust continuum survey of over 170 square degrees of the Milky Way Galactic Plane in the 1st and 2nd quadrants. Due to the incredible sensitivity of 1.1mm emission to cold dust, the BGPS can detect dense clumps of gas and dust of only 10s of solar masses across the Galaxy. The BGPS has discovered over 8400 sources in the 1st quadrant of the Galaxy. These sources include the "starless" precursors to star formation as well as the most complete census to date of embedded star forming regions in our Galaxy. In order to determine the basic properties (size, mass, luminosity, etc.) of this new population of dense clumps, we must first determine the kinematic distances. I shall describe a spectroscopic followup observing program using the HCO^+ and N_2H^+ molecules at the University of Arizona to determine kinematic distances for all BGPS sources in the 1st Galactic quadrant. The initial results from observations of ~ 2500 BGPS sources plus comparison to existing infrared and radio surveys (e.g. GLIMPSE, CORNISH) reveal the evolution of the physical and chemical properties of these BGPS clumps.

04. Robin Pulliam: Exposing the molecular complexity of Sgr B2(N): The interstellar detection of methyl isocyanate (CH_3NCO) from the PRIMOS survey

Methyl isocyanate is one of just a few interstellar molecules that contain H, C, N, and O, all of which are constituents of the simple amino acid, glycine, which has yet to be detected in the interstellar medium. Methyl isocyanate is thus an important molecule in bridging the gap to more complex, organic biomolecules. Using data from the publicly available PRIMOS survey towards Sgr B2(N), we have observed 16 rotational transitions of this species. The spectral regions are free of molecular line confusion and the features are consistent with the source structure of Sgr B2(N) with an LSR velocity of +64 and +73 km/s. It is likely that CH_3NCO is produced in a neutral-radical reaction with the neutral reactant HNCO, which is ubiquitous in SgrB2(N), and the radicals CH_2 or CH_3.

05. Nuria Marcelino: The chemical structure of Orion KL: A 2D spectral line survey at 1mm

The Orion KL nebula is the prototype of high-mass star forming region and one of the best studied regions in our galaxy. Many spectral line surveys of this region have been performed over the last 20 years, revealing a spectacularly prolific line spectrum. The molecular inventory of Orion KL, which includes complex molecular species, is the result of the interaction of the newly formed stars with their environment and grain mantle evaporation. However the chemical complexity of Orion cannot be completely understood without the study of its spatial distribution. After the completion of the spectral line survey of Orion-IRc2 in the full frequency domain of the IRAM 30m telescope (80–280 GHz), we started a mapping line survey at 1mm over a region $2\times2'$ around Orion-IRc2. With the 9–11$''$ beam size of the 30m telescope at 1mm, the different components of Orion (Extended and Compact Ridge, Hot Core, and Plateau) can be resolved, and a deep view of the physical and chemical conditions of the cloud as a function of position can be obtained. In this talk I will present the first results of this 2D line survey (200–282 GHz). The data reveal the different emission distributions and peak positions depending on the observed molecular species, providing important clues to its chemical formation pathways. By obtaining a systematic view of the spatial distribution of the molecular emission in Orion, we will be in the best conditions to improve our understanding of the physics and chemistry of high-mass star forming regions. The combination of the IRAM surveys with Herschel/HIFI data from the Guaranteed Time Key Program "Herschel observations of EXtra-Ordinary Sources (HEXOS)", and its possible use as zero spacing data for future interferometric observations (e.g. with IRAM PdBI or ALMA), demonstrates the legacy nature of this project.

06. Sui Ann Mao: Magnetic fields in the Milky Way halo

In this talk, I will present an observational investigation into the origin of large-scale coherent magnetic fields in the Milky Way using Faraday rotation measure of polarized extragalactic sources.

Based on rotation measures of 1,000 extragalactic sources toward the Galactic poles, I find a lack of vertical field symmetry across the Galactic mid-plane. The observed RMs could be the superposition of a symmetric disk field and an anti-symmetric field produced by a separate dynamo effect in the Galactic halo. Furthermore, I demonstrate that existing Galactic halo magnetic field models cannot successfully reproduce extragalactic rotation measures at mid-Galactic latitudes in the second Galactic quadrant. I suggest that halo fields consist of magnetic spirals could potentially account for the observed rotation measure pattern.

07. Laura Chomiuk: The mysteries of recurrent nova T Pyxidis

The recurrent nova T Pyx is a unique source with the power to shed light on accretion in binary systems, thermonuclear explosions, and the progenitors of Type Ia supernovae. T Pyx went into outburst last March for the first time in the modern astronomy era, and we have intensively monitored it in the radio with EVLA and in the X-ray with Swift. Our observations reveal surprising phenomena that challenge nova theory. Here I will discuss these observations, their interpretation, and their implications for white dwarfs approaching the Chandrasekhar mass.

08. Amy Reines: Massive black holes in dwarf galaxies

Supermassive black holes (BHs) are thought to reside in the nuclei of essentially all massive galaxies with bulges, however the origin of these BHs is largely unknown. Dwarf galaxies with low masses and relatively quiet merger histories are potential hosts of the least-massive BHs, and can provide valuable constraints on the properties of the first primordial "seed" BHs as well as their formation mechanism. Observationally, however, few dwarf galaxies are known to host massive BHs. The serendipitous discovery of an accreting massive BH in the bulgeless, dwarf starburst galaxy Henize 2-10 (Reines et al. 2011) has important implications for our understanding of the co-evolution of galaxies and their central BHs, and opens up an entirely new class of host galaxies in which to search for the smallest BHs. It is clearly important to search for other examples of massive black holes in nearby star-forming dwarf galaxies to begin to characterize them as a population and help constrain theoretical models for the formation of the first high-redshift black holes. The combination of sensitive, high-resolution radio observations with the Jansky VLA and X-ray observations with the Chandra X-ray Observatory are ideally suited to hunt for the radiative signatures of black hole growth that can be hidden at optical wavelengths by intense star formation.

09. Juan Carlos Munoz-Mateos: The role of bars in shaping disk breaks as probed by S4G

The different processes governing the secular evolution of galactic disks are encoded in the present-day stellar density profiles of nearby galaxies. It is now widely known that most disks exhibit a broken exponential profile, with an inner disk followed by a steeper outer one. Radial rearrangement of stars and angular momentum can play a significant role here, thus making disk breaks a key probe of secular evolution. From an observational perspective, most of what we know about breaks comes from optical data, which can be biased by radial variations in extinction, metallicity and stellar age. I will present results of a study of disk breaks framed within the Spitzer Survey of Stellar Structure in Galaxies (S4G). This is a volume-, magnitude- and size-limited survey of over 2300 nearby galaxies imaged at 3.6 and 4.5 microns, which allows us to peer through dust at the old stellar backbone of disks. I will describe the main structural properties of breaks at this wavelength regime. In particular, I will highlight the similarities and differences between breaks in barred and unbarred galaxies as a function of the total stellar mass, and discuss the corresponding implications on disk evolution scenarios.

10. Brian Lacki: From ten Kelvin to ten TeraKelvin: Insights on the interaction between cosmic rays and gas in starbursts

Recent work has both illuminated and mystified our attempts to understand cosmic rays (CRs) in starburst galaxies. I discuss my new research that explores how CRs interact with the ISM in starbursts. In the densest molecular clouds, gamma rays can provide ionization, leading to "Gamma Ray Dominated Regions". These cold regions could have ionization rates up to those found in Milky Way molecular clouds. I then consider the free-free absorption of low frequency radio emission from starbursts. I argue that the absorption comes from many small, discrete H II regions rather than from a "uniform slab", and that the synchrotron emission mostly arises outside H II regions. Finally, noting that the hot superwind gas phase fills most of the volume of starbursts, I suggest that it has turbulent-driven magnetic fields powered by supernovae, and that this phase is where most synchrotron emission arises. I show how such a scenario could explain the far-infrared-radio correlation, in context of my previous work. A great issue with this scenario is that the gamma-ray observations and flat radio spectra indicate that CRs also interact with dense gas. Understanding how this can be so requires a more advanced understanding of turbulence and CR propagation.

11. Amanda Kepley: How do stars form in extreme galaxies?

How stars form in galaxies with properties very different from those of the Milky Way is not well understood. The lower masses, lower metallicities, and/or higher star formation rates in these galaxies strongly affect the fundamental processes governing star formation including the formation of spiral arms, dust formation and shielding of molecular gas, and the interstellar radiation field. The study of young star-forming regions in extreme galaxies provides important clues about how these environmental changes affect star formation. Unfortunately, young star forming regions are highly obscured making typical optical and infrared tracers much less effective. This talk will explore how we can understand star formation in these extreme galaxies by looking at tracers of the obscured ionized gas in the young star-forming regions of extreme galaxies using state of the art observations with newly updated Expanded Very Large Array (EVLA) and the Green Bank Telescope (GBT).

12. Amy Kimball: The radio luminosity function of optically-selected QSOs: Star formation and AGNs

Despite decades of study, it remains unclear whether there are distinct radio-loud and radio-quiet populations of quasi-stellar objects (QSOSs). New 6 GHz EVLA observations allow us for the first time to obtain nearly complete radio detections in a volume-limited, color-selected sample of 179 QSOs from the SDSS in the narrow redshift range $0.2 < z < 0.3$. We were able to detect sources as faint as 20 microJy, which is equivalent to $\log(L_{6GHz}) = 21.5$ at $z = 0.25$, well below the radio luminosity, $\log(L_{6GHz}) = 22.5$, that separates star-forming galaxies from radio-loud active galactic nuclei (AGNs) driven by accretion onto a super-massive black hole. I will show that the radio luminosity function of QSOs, now fully characterized for the very first time, can be explained by the combination of two radio emission components, with AGN emission dominating at the bright end and starbursting host galaxies dominating at the faint end. ALMA will help determine whether the radio emission from the radio-quiet QSOs is due to star formation, according to the radio/far-infrared (or in this case, radio/submillimeter) correlation for star-forming galaxies.

13. Ran Wang: Star formation in the quasar host galaxies at redshift 6

Observations of high-redshift quasars probe the growth of supermassive black holes (SMBH) and their connections to galaxy formation at the earliest epoch. We have been carrying out a systematic survey of the star formation and ISM properties in the host galaxies of $z \sim 6$ quasars using millimeter dust continuum and molecular CO emission. In this survey, we have detected millimeter dust continuum emission in about 30% of the $z \sim 6$ quasars. The average FIR-to-AGN UV luminosity ratio of the optically faint quasar (rest frame 1450 $\mathring{A}$ magnitude of $m_{1450} > 20.2$) is about two times higher than that of the bright quasars at $z \sim 6$ ($m_{1450} \leq 20.2$). A fit to the average FIR and AGN bolometric luminosities of both the UV/optically faint and bright $z \sim 6$ quasars, and the average luminosities of samples of submillimeter/millimeter-observed quasars at $z \sim 2$ to 5, yields a relationship of $L_{FIR} \sim {L_{bol}}^{0.62}$. However, the bright millimeter detections follow a shallower relation of $L_{FIR} \sim {L_{bol}}^{0.45}$ defined by the starburst-AGN systems in local and high-z Universe. The results argue for massive star formation in the host galaxies of the millimeter bright quasars at $z \sim 6$ and the higher FIR-to-AGN luminosity ratio found in the millimeter-detected $m_{1450} > 20.2$ quasars also suggests a higher ratio between star formation rate and supermassive black hole accretion rate than the UV/optically most luminous quasars at $z \sim 6$. We have an ongoing ALMA project to observe the [C II] 158 micron fine structure line emission from five of the millimeter bright $z \sim 6$ quasars. The ALMA observations will directly probe of the intense star formation in the central (a few kpc) region of the starburst quasar hosts.

14. Kimberly Scott: Tracing the evolution of massive galaxies through mm wavelength surveys with AzTEC

Galaxies that are selected by their redshifted, thermal dust emission at sub-millimeter and millimeter wavelengths ("SMGs") are thought to play a major role in the rapid build-up of the stellar populations within massive systems. Their redshift distribution ($1 < z < 3$) and high star formation rates ($> 100\,M_\odot\,\mathrm{yr}^{-1}$) imply that these galaxies are observed during an important starburst or active phase in their evolution, en route to becoming massive elliptical galaxies at $z = 0$. Their basic statistical properties - such as their number density, redshift distribution, and clustering strength - hold important clues to how the most massive galaxies assemble over time. We have carried out several deep, wide-area surveys at 1.1 mm with the AzTEC camera on the James Clerk Maxwell Telescope and the Atacama Sub-millimeter Telescope Experiment, mapping five square degrees of sky to depths of 0.4-2.0 $\mathrm{mJy\,beam}^{-1}$ towards some of the most widely studied fields at all wavelengths. In this talk, I present some of the latest results derived from these AzTEC surveys. In particular, I discuss the analysis of the combined source counts from all blank-field AzTEC surveys, which provide the strongest constraints to date on the 1.1 mm counts at flux densities from 1-12 mJy. Previously, the counts at lower flux densities (< 3 mJy) had not been well sampled, and compared to predictions from existing semi-analytical and phenomenological models of galaxy evolution, we see significant discrepancies. Our new results either mandate modifications to existing evolutionary models, or highlight our limited knowledge of the spectral energy distributions of low luminosity galaxies in the local Universe.

15. Huib Intema: Mpc-scale radio emission from merging galaxy clusters

In this talk I report on the low radio frequency detection and follow-up of synchrotron emission originating from the disturbed intra-cluster medium. The presence of large-scale radio emission in and around clusters of galaxies is a strong indicator of merger activity. The number of known diffuse cluster sources is still limited, but steadily increasing in the last few years. Increasing this number, performing radio spectral studies, and complementing this with X-ray, optical and other wavelength studies, is crucial to better understand the physical origin of these sources.

16. Nirupam Roy: Tiny scale HI opacity fluctuations towards 3C 138

The interstellar medium is known to have significant structures over a wide range of scales. These structures are generally interpreted as the signature of turbulence in the ISM. The structure function of opacity fluctuations is a useful statistical tool to study such tiny scale structures of neutral hydrogen. In this talk, I will present the results from high resolution observation of H I absorption towards 3C 138, and estimated structure function of opacity fluctuations from the combined VLA, MERLIN and VLBA data. Over 5 - 100 AU, the structure function is found to be well represented by a power law with power law index of 0.33 corresponding to a power spectrum $P(U) \sim U^{-2.33}$. This is slightly shallower than the earlier reported power law index of $\sim 2.5 - 3.0$ at $\sim$ 1000 AU to few pc scales. The amplitude of the derived structure function is a factor of $\sim 20 - 60$ times higher than the extrapolated amplitude from observation of Cas A at larger scales. On the other hand, extrapolating the AU scale structure function for 3C 138 predicts the observed structure function for Cas A at the pc scale correctly. These results clearly establish that the atomic gas has significantly more structures in AU scales than expected from earlier pc scale observations. The observational evidence of a shallower slope and the presence of rich small scale structures may have implications for the current understanding of the interstellar turbulence.

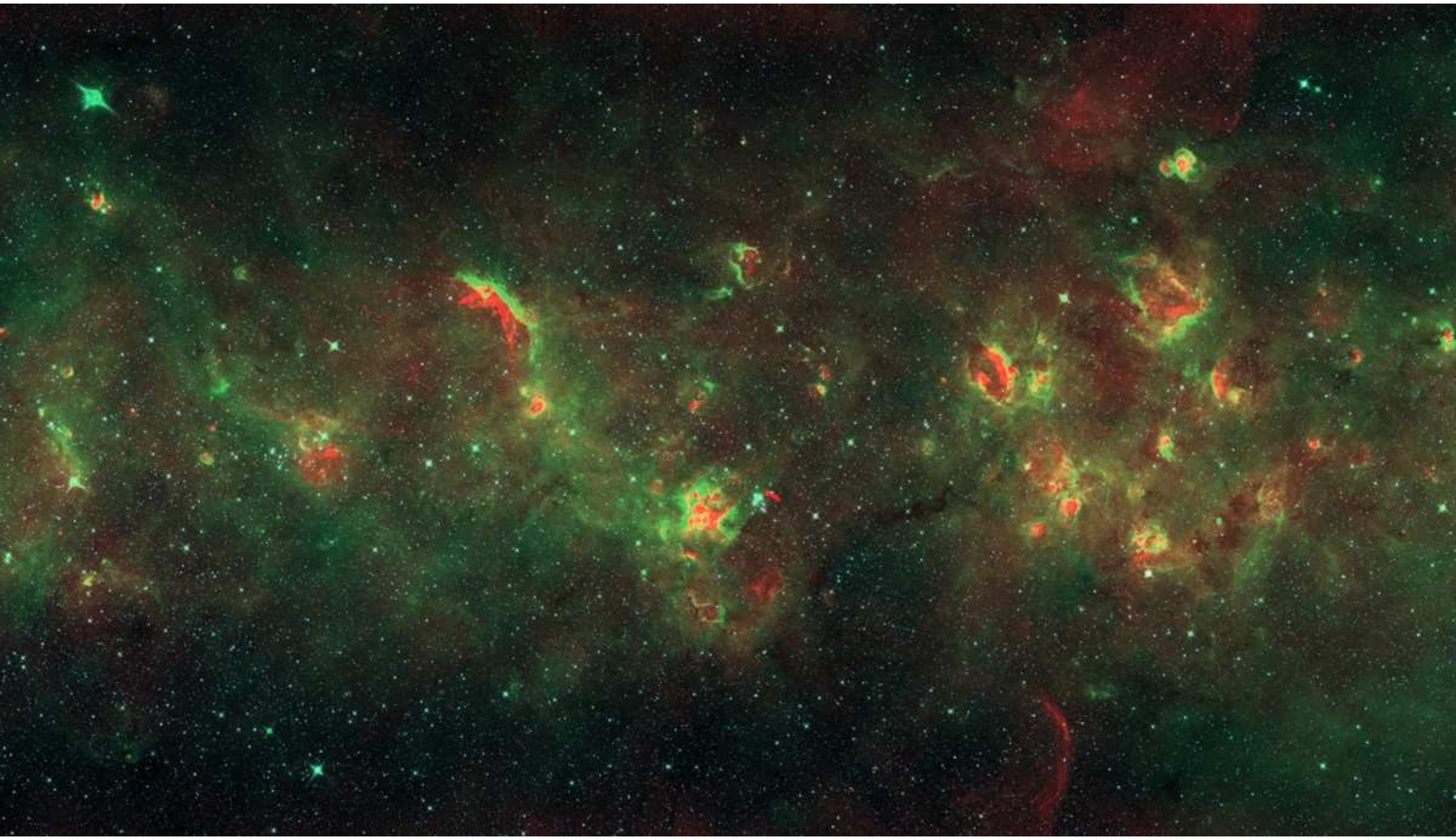
17. Rick Perley: The Jansky Very Large Array (invited talk)

A review talk on the Jansky Very Large Array capabilities, scientific prospects and possibilities in near future.

18. Urvashi Rao: Correcting for wide-band primary-beam effects during imaging and deconvolution

The frequency-dependence of the primary beam introduces several effects that must be accounted-for in imaging as well as deconvolution, before imaging results can be interpreted for astrophysics. In this talk, I will discuss three methods of doing this, and report on recent progress on two of them, applied to EVLA tests and simulations.

Notes



Front and back cover image credit: NRAO/AUI and (Rick White, STScI) (Bob Becker, IGPP/LLNL & UC-Davis) (David Helfand, Columbia)