2008 NRAO Postdoctoral Symposium
Presenters and Abstracts

Monday, April 28

Poonam Chandra (NRAO, Charlottesville)

Monday, April 28 – 9:00 - 9:10a

Welcome

Fred Lo (NRAO, Charlottesville)

Monday, April 28 – 9:10 - 9:20a

Welcome

Miller Goss (NRAO)

Monday, April 28 – 9:20 - 9:35

Background on new Jansky program

Anthony Remijan (NRAO, Charlottesville)

Monday, April 28 – 9:35 - 10:00

The Distribution, Excitation and Formation of Cometary Molecules: Methanol, Methyl Cyanide and Ethylene Glycol

We present an interferometric and single dish study of cometary molecules toward Comets C/1995 O1 (Hale-Bopp) and C/2002 T7 (LINEAR) using the BIMA interferometer at 3 mm and the ARO 12m telescope at 2 mm. For Comet Hale-Bopp, both the single-dish and interferometer observations indicate an excitation temperature of CH_3OH of 105(10) K and a total column density of $9(1)\times10^{14}$ cm^{-2} from the BIMA array data and $2.4(1)\times10^{14}$ cm^{-2} from the 12m data. Using a Monte Carlo solution to the Haser model assuming a nuclear origin for CH_3OH, we find a total production rate of $\sim5.9(1)\times10^{29}$ s^{-1} from the BIMA array data and $\sim1.5(1)\times10^{29}$ s^{-1} from the 12m data at $\sim$1 AU. Furthermore, from the aperature synthesis observations of CH_3OH, we find the distribution is well described by a spherical outflow with no evidence of enhanced production. We find similar results for the excitation and distribution of cometary CH_3CN. For Comet Hale-Bopp, the single-dish observations indicate an excitation temperature of CH_3CN of 200(10) K and a total column density of $2.6(1)\times10^{12}$ cm^{-2} for a total CH_3CN production rate of $\sim1.7(1)\times10^{27}$ s^{-1} at $\sim$ 1 AU. The observations of both these species suggest a nuclear origin of CH_3OH and CH_3CN. Finally, the non-detection of a previously identified transition of cometary $(CH_2OH)_2$ toward Comet Hale-Bopp with the 12m telescope indicates a compact distribution of emission, $<9''$ (<8500 km). This supports the hypothesis that the cometary production of $(CH_2OH)_2$ is direct sublimation off cometary ices from the nucleus. For the single-dish observations of Comet T7 LINEAR, we find an excitation temperature of CH_3OH of 35(5) K and a total column density of $2.2(1)\times10^{13}$ cm^{-2} for a total CH_3OH production rate of $\sim2.0(1)\times10^{27}$ s^{-1} at $\sim$ 0.3 AU which is nearly an order of magnitude smaller than what was determined by Remijan et al. (2006). Our data support current chemical models that CH_3OH, CH_3CN and $(CH_2OH)_2$ are parent nuclear species and CH_2OHCHO may be a daughter species present in the extended coma from direct photodissociation of $(CH_2OH)_2$.

Paul Demorest (NRAO, Charlottesville)

Monday, April 28 – 10:00 - 10:25

Detecting Gravitational Radiation with a Pulsar Timing Array

Pulsar timing measurements are influenced by gravitational waves (GW) along the line of sight from Earth to the pulsar. Combining timing measurements of many sources forms a GW detector that is sensitive to the nanohertz region of the GW spectrum. Current GW limits from pulsar timing are within an order of magnitude of the predicted strength of the stochastic GW background created by binary massive black hole systems. I will describe our current observational pulsar timing programs at Green Bank and Arecibo aimed at detecting GW. These include ongoing work towards improved instrumentation, data analysis techniques, and understanding of systematic effects, and could potentially result in a detection on a 5-10 year timescale.

Larry Morgan (NRAO)

Monday, April 28 – 10:50 - 11:55

Varied Mechanisms for Star Formation in Bright-Rimmed Clouds

Bright-rimmed clouds (BRCs) are potential examples of triggered star-formation regions, in which photoionization driven shocks caused by the expansion of HII regions induce protostellar collapse within the clouds. A sample of optically bright BRCs at the edge of HII regions has been observed at radio, infrared and submillimetre wavelengths, these observations reveal dense cores present within the heads of 44 observed BRCs drawn from a catalogue of IRAS sources embedded within HII regions, supportive of the scenario proposed by radiatively driven implosion (RDI) models. The physical properties of these cores indicate the presence of star formation across the majority of our sample. This star-formation appears to be predominately in the regime of intermediate to high mass and may indicate the formation of clusters. A fundamental difference appears to exist between different morphological types of BRC. Morphological variations in BRCs have previously been attributed to an evolutionary scenario of RDI. However, the physical properties of cores found within different types of BRC indicate that the strength of the ambient ionisation field is highly correlated with the attributes of certain cores, and not with others. The suggestion is that different morphological types of BRC have followed different evolutionary pathways, this is supported by the mass distributions of cores associated with the different morphologies.

Poonam Chandra (University of Virginia/NRAO)

Monday, April 28 – 11:15 - 11:40

Mystery of chromatic jet breaks in Gamma Ray Bursts

The simple picture of collimated explosion predicts an achromatic jet break in a Gamma Ray Burst (GRB) in all the wavebands. This scenario has been challenged by Swift, when Swift- XRT did not detect jet breaks in many GRBs in X-ray bands which were prominent in optical bands. To answer this question, we got an opportunity to observe one of the brightest GRB 070125 in the optical, radio and X-ray bands. We followed the GRBs for one year in radio bands. The optical jet break occurs on day 3.7, whereas X-ray shows a break in the light curve around day 10. We show that for the physical parameters derived for GRB 070125 from the multi-waveband modeling, inverse Compton scattering effects are important throughout the afterglow evolution. While inverse Compton scattering does not affect radio and optical bands, it flattens the X-ray light curve. We show that inverse Compton scattering may be a promising candidate to delay the jet break in the X-ray band. This may explain the the chromatic jet breaks seen in at least some GRB events.

Aeree Chung (NRAO/UMass)

Monday, April 28 – 11:40 - 12:05

^{12}CO Survey of Local ULIRGs using the Redshift Search Receiver

In this talk, I will present the result from the ^{12}CO (J=1-0) line survey of 28 local ULIRGs (z=0.043-0.110) conducted as part of the commissioning of the redshift search receiver in 2007 using the FCRAO 14m telescope. Redshift Search Receiver (RSR) is a ultra-wideband spectrometer that covers the entire 3mm astronomical band (75-111 GHz) simultaneously. It has been developed at UMass/FCRAO as the facility instrument for the Large Millimeter Telescope (LMT), a 50m diameter telescope, currently under-construction jointly by UMass and INAOE on a 15,000 ft hight peak in Mexico. In our early science observations, we have detected CO emission in 22 ULIRGs, including fourteen objects that were never observed in CO. In addition, I will discuss the plan for the surveys of redshifted CO emission from intermediate and high-z galaxies as part of the first light science program using the LMT during the fall/winter this year.

Neal Miller (NRAO/Johns Hopkins University)

Monday, April 28 – 12:05 - 12:30

The VLA 1.4GHz Survey of the E-CDF-S

I will provide an overview of the VLA 1.4 GHz survey of the Extended Chandra Deep Field South. The radio observations were performed over about 250 hours during the summer of 2007, and included a handful of data reduction challenges. We have produced a mosaic image covering the full 0.3 square$^\circ$ field at a typical rms sensitivity of under 8 μJy per roughly $2''$ beam. The data have numerous applications to galaxy evolution science, and I will briefly describe a few of them.

D.J. Pisano (NRAO-Green Bank)

Monday, April 28 – 1:45 - 2:10

A Multiwavelength Study of Luminous Compact Blue Galaxies

The star formation rate in the Universe has dropped by an order of magnitude in the past 8 billion years. Why? Luminous Compact Blue Galaxies (LCBGs) may account for this drop. LCBGs were common 8 billion years ago, representing about 20formation rate density at that time, but are a factor of ten rarer by the present day. While we know that LCBGs are rapidly evolving, we do not know what drives their evolution or into what type of galaxy they evolve. I will present results from our current radio studies of nearby LCBGs as part of a larger multiwavelength study of the properties of these galaxies. Our data will constrain the current evolutionary state and future evolutionary path of LCBGs. These data will also serve as a benchmark for future studies of LCBGs at all wavelengths and distances.

James Aguirre (NRAO / University of Colorado, Boulder)

Monday, April 28 – 2:10 - 2:35

First Science Results from the Bolocam 1.1 mm Galactic Plane Survey

The Bolocam 1.1 mm Galactic Plane Survey (BGPS) is the first of many planned and ongoing unbiased submillimeter surveys of the Galactic Plane. The BGPS currently covers 150 square degrees, including continuous coverage from $l = 350$ to $l = 90$ ($-0.5 < b < 0.5$) and selected regions in the outer Galaxy such as W3/4/5, the Perseus Arm, and Gem OB1. I will discuss our first scientific results, including 1) follow-up of the millimeter detected clumps and cores using the dense gas tracers CS and NH_3, 2) the identification of cold cores without embedded infrared sources from *Spitzer*-MIPSGAL, and 3) the correlation of Bolocam sources with HII regions and supernova remnants as a measure of the effects of triggered star formation.

James Miller-Jones (NRAO, Charlottesville)

Monday, April 28 – 2:35 - 3:00

High-resolution observations of the quiescent jets in X-ray binaries

Black hole X-ray binary systems spend most of their time in a low-luminosity ($L_{\rm x} < 10^{33.5}\,{\rm erg\,s^{-1}}$) 'quiescent' state. The dynamics of the accretion flow at low mass accretion rates, and the importance of jets in carrying away the liberated accretion energy in such low-luminosity systems, are not yet well understood. Collimated, partially self-absorbed outflows are inferred to exist at higher mass accretion rates in the 'hard' X-ray state, and have been directly imaged in two sources, GRS 1915+105 and Cygnus X-1. Whether these jets persist and remain well-collimated at low luminosities is still to be determined, as the inherent faintness of the systems has thus far precluded any attempt at detailed study. I will present High Sensitivity Array observations of the brightest quiescent black hole X-ray binary, V404 Cyg, which constrain the size and nature of the outflow in this system, and will go on to outline the implications for the nature of the quiescent state. I will then present archival VLA data, which, when combined with the accurate astrometric position from the HSA, can be used to derive the proper motion of the binary system.

Nissim Kanekar (NRAO-Socorro)

Monday, April 28 – 3:00 - 3:25

Probing fundamental constant evolution with radio spectroscopy

Radio spectroscopy in redshifted spectral lines provides a powerful probe of putative changes in fundamental constants across a large lookback time. I will describe the conjugate OH technique, a new method that does not appear to be affected by any known systematic effects and also provides a measurement of fractional changes in the constants from a single space-time location (rather than averaged over many space-time points). I will then report results from our recent WSRT and Arecibo studies of the conjugate OH lines at z$\sim$0.25 towards PKS1413+135, which yield strong constraints on changes in the fine structure constant α, and the electron-proton mass ratio m_e/m_p, over a large fraction of the age of the Universe. Finally, I will describe other radio techniques to probe changes in fundamental constants and summarize the improvements that are likely to be possible with the advent of new telescopes such as the EVLA and ALMA in the next decade.

Brigette Hesman (NRAO - Socorro)

Monday, April 28 – 3:45 - 4:10

Saturn's Stratospheric Acetylene and Ethane Emission

Hydrocarbons in the upper atmosphere of Saturn are known, from Voyager and early Cassini results, to vary in emission intensity with latitude. Of particular interest is the marked increase in temperature and hydrocarbon line intensity near the South Pole (which is currently in summer) as the increased line intensity cannot be simply explained by the increased temperatures observed in that region. Latitudinal variations in hydrocarbon abundances can be determined from measurements of hydrocarbon emission lines using temperatures derived from Cassini's Composite InfraRed Spectrometer (CIRS). Latitudinal, temporal, and vertical variations of stratospheric hydrocarbons provide constraints on dynamics, seasonal climate models, and photochemical models.

In an effort to monitor temporal and latitudinal variations of hydrocarbons in Saturn's southern hemisphere we are conducting a ground-based campaign using Celeste, an infrared (5-25 μm) high-resolution (<0.1 cm^{-1}) cryogenic grating spectrometer. From 2005 to 2007, we have been mapping lines of ethane and acetylene at the McMath-Pierce telescope at Kitt Peak, AZ and the NASA Infrared Telescope Facility at Mauna Kea, HI. These observations are complemented by the Cassini CIRS hydrocarbon observations. Specifically, Celeste measurements at the IRTF in October 2006 are being combined with 3 cm^{-1} spectral resolution CIRS measurements to infer molecular abundances for each species in the 1-10 mbar altitude region across the southern hemisphere of Saturn. These results will be presented.

Antonio Hales (NRAO)

Monday, April 28 – 4:10 - 4:35

Probing Planetary Formation

Current understanding of the formation of planetary systems is strongly linked to astronomical observations of gas and dust around young stars. In this talk I will describe results from radio to optical campaigns aimed at characterizing the dust and gas evolutionary processes that may lead to planet formation.

Normal stars are excellent targets to understand the incidence and persistence of cold dust disks around Main Sequence (MS) stars. ALMA's unique sensitivity will allow to extend unbiased surveys for cold circumstellar dust around MS stars beyond 50 pc with only a couple minutes integrations. Finally, I will briefly comment ALMA's capabilities for surveying mature MS systems in order to search and study other planetary systems.

Daniel Marrone (NRAO (Jansky), UChicago)

Monday, April 28 – 4:35 - 5:00

Measurements of Galaxy Clusters with the Sunyaev-Zeldovich Array

The Sunyaev-Zeldovich effect is a small distortion of the cosmic microwave background spectrum caused by Compton scattering by hot electrons in galaxy clusters. Based on simulations and simple physical considerations, the magnitude of the distortion is expected to be an excellent proxy for cluster mass, and the signal is not affected by cosmological dimming. These two properties make the SZE a unique tool for measuring the cluster mass function to the precision needed to examine dark energy in detail.The tight relationship between the SZE signal and cluster mass is only beginning to be verified. Unfortunately, there are few techniques to directly measure mass for comparison with the SZE, so nearly all investigations rely on the imperfect assumption of hydrostatic equilibrium. Using the Sunyaev-Zeldovich Array (SZA) and a gravitational lensing survey of ∼60 clusters, we hope to directly measure the relation between the SZE and mass, the deviation from hydrostatic equilibrium, and the scatter in the relationship. I will present the first comparison of the SZE signal and lensing mass for a small sample of clusters and describe the improvements expected with the expanded sample we are preparing now. I will also describe the status of the upgraded Sunyaev-Zeldovich Array (SZA), an interferometer optimized for sensitive measurements of the SZE from galaxy clusters at 30 and 90 GHz, and present a few measurements from the new 90 GHz receiver system.

David S Meier (NRAO - Socorro)

Monday, April 28 – 5:00 - 5:25

A Nearby Gas-Rich Luminous Infrared Galaxy Hiding in Plain Sight

Luminous Infrared galaxies (LIRG) provide excellent laboratories for the study of the causes and evolution of strong starbursts. Here we discuss a series of observations of the CO(1-0), radio and MIR continuum from the almost completely neglected, nearby LIRG, IRAS 04296+2923. OVRO millimeter array reveal for the first time an extremely massive molecular gas disk, making IRAS 04296+2923 one of the most gas-rich systems in the nearby universe. The observed molecular morphology shows no signs of interaction, and is consistent with pure response to a stellar bar. The radio and mid infrared continuum are dominated by non-thermal emission, not young, thermal, star clusters. Despite the high overall IR luminosity, the star formation efficiency remains modest. Implications for the evolution of star formation in this LIRG are discussed.

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Tuesday, April 29

Juergen Ott (NRAO/Caltech)

Tuesday, April 29 – 9:00 - 9:25

VLA-ANGST: Star Formation History and ISM Feedback in Nearby Galaxies

In recent years, HST revolutionized the field of star formation in nearby galaxies. Due to its high angular resolution it has now become possible to construct star formation histories of individual stellar populations on scales of a few arcseconds spanning a range of a several Gyr. ANGST (ACS Nearby Galaxy Survey Treasury) is an ambitious program to derive the detailed star formation histories for a volume filled sample of galaxies up to 4 Mpc distance (excluding the Local Group). The ANGST sample will be followed–up by high resolution VLA HI observations in the context of an approved Large Project 480 hours of allocated time). The combination of ANGST/HST and VLA data is essential to understand the triggering of star formation, the feedback of massive stars into the interstellar medium (ISM), the impact of previous episodes of star formation on the present day ISM structure, and the energy budget of the ISM on local and galaxy scales. In this context, VLA B-array data is indispensable as it is a perfect match to the resolution of the maps of reconstructed star formation histories derived from HST data.

Kristine Spekkens (Royal Military College of Canada)

Tuesday, April 29 – 9:25 - 9:50

Searching for Radio Signatures of Dark Matter Annihilations in Draco

We present deep radio observations of the Draco Dwarf galaxy with the VLA and the GBT, designed to detect synchrotron emission resulting from dark matter annihilations in its halo. Recent dynamical models predict the existence of a relatively "clean", smoothly distributed, 3-degree synchrotron halo in Draco. This signature is within the reach of the GBT provided that confusing background sources can be accurately subtracted from the total power measurements. We have devised a technique to obtain high-sensitivity L-band continuum maps with the GBT and to excise confusing background sources with complementary VLA maps. We report initial constraints on Draco's L-band flux from these observations and their implications for the nature of the dark matter.

Jeff Wagg (NRAO- Socorro)

Tuesday, April 29 – 9:50 - 10:15

The molecular gas content and large-scale environments of z∼6 quasars

Studies of the molecular gas content of objects existing soon after cosmic reionization at z>6, have so far focused on the extreme FIR luminous quasars discovered in optical wavelength surveys. Follow-up observations of molecular CO line emission have been successful in revealing the large masses of molecular gas required to fuel ongoing bursts of star-formation or AGN activity. In this talk, I will summarize recent results from an ongoing campaign to observe redshifted high-J CO line emission with the Plateau de Bure Interferometer, as well as our first attempts to detect the cold gas traced by CO J=2-1 using the GBT. These z∼6 quasars are predicted to live in overdense regions, potentially rich with luminous star-forming galaxies. I will also present preliminary results of deep 1200um MAMBO imaging of the fields of two z∼6 quasars, obtained with the purpose of identifying submm luminous star-forming galaxies associated with the large-scale quasar environments.

Maurilio Pannella (NRAO - Socorro)

Tuesday, April 29 – 10:40 - 11:05

Eight billion years of galaxy evolution in the COSMOS

Deep extragalatic surveys allow for the first time a highly significant census of environments and structures up to redshift 1 together with a full morphological description of the galaxy populations. I present a study aimed to constrain the evolution of the morphological mix mass content up to redshift one, and its dependency on the environmental density. I use deep multicolor imaging to obtain accurate photometric redshift (I $\sim$ 25 and $\Delta z/(z_{spec}+1) \approx 0.035$). I estimate galaxy stellar masses by fitting the multi-color photometry with a grid of composite stellar population (CSP) models. I quantitatively describe the galaxy morphology by fitting PSF convolved Sersic profiles to the galaxy surface brightness distributions. I find an evolution of the morphological mix with redshift: the higher the redshift the more disks become important. The morphological mix is a strong function of the local comoving density at all redshifts explored. I investigated the evolution of the specific star formation rate (SSFR) as a function of morphological type and environment, finding that the location of early and late–type galaxies in the stellar mass vs. SSFR plane are very well separated at all redshifts and in all environments. The SSFR in massive early–types is found to significantly evolve with redshift, while it remains pretty constant since z 1 in massive disks. Since the high–mass end of the galaxy populations is always dominated by early–type objects, these drive the decline in star formation rate at high masses. While in general this picture seems to be quite similar in all environments, in low density regions there is a population of relatively massive, early–type galaxies, having high SSFR and blue colours.

Veronica Strazzullo (NRAO)

Tuesday, April 29 – 11:05 - 11:30

Galaxy populations in high–redshift clusters

I present results from a work based on multi–wavelength observations of massive, X-ray luminous galaxy clusters beyond redshift one ($1.1 \leq z \leq 1.4$). This study aims to probe the star formation and mass assembly history of massive galaxies in overdense environments, and by comparison with their field contemporaries to gain insight on the relevance of the environment in the process of galaxy evolution.

Due to the large distance to these clusters, only the high-mass portion of the galaxy population ($M_* \geq 10^{10} M_\odot$) can be studied with sufficient accuracy, nonetheless such massive objects allow us to significantly constrain models of galaxy formation and evolution.

The combined study of the evolution of the stellar mass function (through the near–infrared luminosity function) and of the stellar populations (through the color–magnitude relation and spectral energy distribution fitting) yields a comprehensive view of the evolution of massive cluster galaxies over the past 9 billion years.

Wei-Hao Wang (NRAO)

Tuesday, April 29 – 11:30 - 11:55

Approach the Dark Age

Redshift of $z \sim 6-7$ is the end of the reionization and is the current frontier in observational cosmology. I will present two ongoing efforts of finding galaxies in this high redshift at long and short wavelengths. Using the SMA, we are able to identify high-redshift submillimeter galaxies that the VLA cannot not see. The first such radio-faint submillimeter galaxy we found is very likely at $z \sim 6$. It has a far-IR star formation rate of $\sim$ 4000 $M_\odot$/yr and started to form stars at $z \sim 10$. It can grow into a massive 10^{11} $M_\odot$ galaxy in just ~ 20 Myr. It is extremely faint in the rest-frame optical and UV, and even an ultradeep HST integration cannot detect it. Galaxy like this is entirely missed by existing ground and space-based optical surveys. In the near-IR, we are using the CFHT to look for rest-frame UV radiation from galaxies at $z > 7$. We found two excellent $z > 7$ galaxy candidates and we are now proposing followup observations. These candidates have stellar masses of $\sim 10^{10.5}$ M. They are luminous and rare, and are not probed by most other ultradeep near-IR surveys. All the submillimeter and near-IR selected galaxeis presented in this talk are extremely massive and luminous for the first Gyr. If their existence are confirmed, they may seriously challenge the current LCDM galaxy formation models where galaxies form hierarchically and massive galaxies appear in much later cosmic times ($z < 5$).

David Whysong (NRAO Socorro)

Tuesday, April 29 – 11:55 - 12:20

A possible Thompson scattered halo around 3C295

We are attempting to measure the density of the ionized intergalactic medium by detecting Thompson-scattered radio emission around high-redshift radio sources. This is unreasonably difficult, however the technical problems are simpler if one looks for scattering around a radio source in a dense cluster medium, such as that around 3C295. Preliminary results indicate a possible detection of the scattered halo, however the data quality are poor.

Vladislav Kondratiev (West Virginia University)

Tuesday, April 29 – 1:30 - 1:55

Probing the limits of the giant pulse population

We have carried out the radio observations of three pulsars — B0031−07, B1112+50, and J1752+2359 — with the Robert C. Byrd Green Bank Radio Telescope at 350 MHz using the pulsar SPIGOT backend. These pulsars were reported to manifest giant pulses (GPs), the phenomena of extremely bright isolated bursts with unique properties known only for a handful of pulsars. However, their parameters are very different from those of GP pulsars. They are long-period (0.4–1.6 s), middle-aged (10^5–10^7 yr) pulsars with very low values of magnetic field at the light cylinder (4–770 G) — the parameter supposed to be related with GP activity. Thus, the question whether they are giant pulse emitters or not is crucial to ongoing efforts to constrain the elusive radio pulsar emission mechanism. Single-pulse studies revealed that they do not meet the criteria to be called GP pulsars. Being broad and clustering preferentially to the center of the average profile, their pulses resemble better the bright "spiky" emission from the pulsar B0656+14. We will present the results of our detailed analysis of single pulses, their energy distributions and microstructure. We will also discuss the possibility of strong subpulses being similar to giant micropulses from the Vela pulsar and bursty emission seen in rotating radio transients.

Min Yun (University of Massachusetts)

Tuesday, April 29 – 1:55 - 2:20

Nature of Submillimeter Galaxies Identified by the AzTEC 1100 Micron Surveys

We have imaged over 1 square degree of the sky at 1100 micron continuum using the AzTEC camera on JCMT during the winter of 2006-2007 season and have discovered a large number of the most luminous submillimeter galaxies (SMGs) known so far. Further surveys of SMGs in the directions of highly biased environments such as high-z clusters and radio galaxy fields are currently underway using the ASTE telescope at the ALMA site in northern Chile. I will discuss the highlights of these AzTEC surveys and some interesting new insights we obtained through the detailed multi-wavelength follow-up observations.

Marsha Bishop (NRAO, Charlottesville)

Tuesday, April 29 – 2:20 - 2:35

You Have Written a Paper - Now What?

Dale Frail (NRAO, Socorro)

Tuesday, April 29 – 2:35 - 2:45

Thanks and Closing Remarks