http://kicp-workshops.uchicago.edu/carma2013/

SYMPOSIUM PRESENTATIONS

The Kavli Institute for Cosmological Physics (KICP) at the University of Chicago will host the 2013 CARMA Science Symposium on July 8-9, 2013. The two-day meeting will feature presentations relevant to the wide range of interdisciplinary science pursued with CARMA. In particular, there will be presentations from the community on potential future directions for CARMA-related research. These presentations include potential collaboration with new observatories, and science for which CARMA is uniquely suited.

Contributions from outside CARMA member institutions are welcome. Graduate students and postdocs are encouraged to submit a presentation.

Scientific Organizing Committee

Manuel Fernandez Lopez
University of Illinois at Urbana-Champaign

David Fisher
University of Maryland

Chat Hull
University of California, Berkeley

Luca Ricci
California Institute of Technology

Andreas Schruba
California Institute of Technology

Local Organizing Committee

Aimee Giles
Kavli Institute for Cosmological Physics

Megan Gralla
Johns Hopkins University

Christopher Greer
University of Arizona

Adam Mantz
University of Chicago

Helen Pates
Kavli Institute for Cosmological Physics

Valerie Smith
University of Chicago

1. **Zubair M Abdulla**, University of Chicago
   Talk: ***CARMA Measurements of the Sunyaev-Zel'dovich Effect in MS 0735+7421***

   July 8, 2013 (4:15 PM - 4:30 PM)

   Co-authors: Thomas J. Plagge, Daniel P. Marrone, John E. Carlstrom, Christopher H. Greer, James W. Lamb, Erik M. Leitch, Adam Mantz, Stephen Muchovej
   I demonstrate the Sunyaev-Zel'dovich (SZ) effect imaging capabilities of the Combined Array for Research in Millimeter-wave Astronomy (CARMA) by presenting an SZ map of the galaxy cluster MS 0735+7421 (MS0735). MS0735 contains the most powerful AGN burst currently known. X-ray images show large regions of decreased brightness on either side of the cluster, associated with under-dense "cavities" evacuated by AGN jets. By observing MS0735 with the SZ effect at sub-arcminute resolution, I attempt to constrain the thermal properties of the X-ray cavities. Using the full capabilities of CARMA-23 centimeter observations during the February 2013 commissioning run, I am able to constrain the central radio source and present evidence of cavities in the SZ measurement at the sub-arcminute scale, illustrating the value of high resolution SZ measurements for cluster astrophysics. Additionally, I discuss the deconvolution method involved with restoring a map from a heterogeneous array and the details of the February 2013 1 centimeter hardware commissioning run.

2. **Katey Alatalo**, Caltech/IPAC
   Talk: ***Determining the Importance of Shocks on Galaxy Evolution in Compact Groups: a Herschel and CARMA View***

   July 9, 2013 (1:15 PM - 1:30 PM)

   Co-authors: Philip Appleton, Ute Lisenfeld, Michelle Cluver, Emily Freeland, Theodoros Bitsakis, Pierre Guillard, Vassilis Charmandaris
   Understanding the evolution of galaxies from starforming blue cloud objects into quiescent red sequence galaxies has been revolutionized by observations taken with the Herschel Space Observatory, allowing astronomers to probe both the cold dust as well as the cool ISM in a large set of galaxies, with unprecedented sensitivity. Previous Herschel observations of Stephan's Quintet (HCG92) show strong evidence for [CII] enhancement in shocks. CARMA CO observations of these [C II]-bright HCGs therefore shed light on the impact of shocks on the excitation of the ISM, as well as the starforming (molecular) material. I will present preliminary results from our Herschel-CARMA combined observations of HCGs, which are able to tell us about the synergistic relationships between shocks, star formation and the cool ISM in the context of galaxy evolution.

3. **Bradford Benson**, University of Chicago
   Invited Talk: ***Sunyaev-Zel'dovich Surveys and Cluster Cosmology***

   July 8, 2013 (2:45 PM - 3:05 PM)

   I will review the present status of surveys (e.g., SPT, ACT, Planck, SPTpol) designed to find clusters of galaxies using the Sunyaev-Zel'dovich effect. I will discuss recent cosmological constraints using SZ cluster surveys, current challenges, and how SZ measurements will contribute to future cluster surveys.

4. **Leo Blitz**, University of California, Berkeley
   Talk: ***Finding Black Holes in Galactic Centers with CARMA***

   July 8, 2013 (2:30 PM - 2:45 PM)

   Co-authors: Tim Davis, Martin Bureau, Marc Sarzi, Michele Cappellari
   We report the discovery of a Black Hole in the center of the S0 galaxy NGC 4526 using CO as a kinematic and mass tracer. The mass of 4.7 x 10^8 +/- 0.17 Msun is one of the most precisely measured BH masses in any galactic center. We show that it is possible to measure many more BH masses with CARMA and to use CARMA as a stepping stone to measure hundreds of BH masses with ALMA. En passant, we have made the first complete map of GMCs in a galaxy outide of the Local Group that resolves all GMCs down to 20 pc and a mass of ~10^4 Msun.

5. **Geoffrey C Bower**, University of California, Berkeley
Talk: ***From the Event Horizon to the Bondi Radius: CARMA Polarimetry of Sagittarius A****

July 8, 2013 (2:15 PM - 2:30 PM)

Co-authors: Dick Plambeck, Chat Hull, Dan Marrone
High resolution very long baseline interferometry (VLBI) images of nearby massive black holes have the power to address fundamental questions about the physics of black holes, including the Milky Way's own Sagittarius A*. However, we do not fully understand the physical processes that are driving accretion and outflow in these sources, limiting our ability to characterize fundamental black hole physics. We need to know, for instance, whether a jet or outflow is present, what effect different modes of accretion have upon the source images that we will obtain, or how stable accretion flows are. In addition, the periastron passage of the G2 gas cloud in 2013/2014 with Sgr A* at ~1000 Schwarzschild gives us an unprecedented opportunity to study a wide range of astrophysical models for accretion and outflow. CARMA millimeter polarimetry provides a powerful tool for probing intrinsic source structures on the scales of a few Schwarzschild radii and the accretion flow on scales of hundreds to thousands of Schwarzschild radii. I describe our recent observations and what we hope to see in the coming year.

6. **Mark Brodwin**, University of Missouri - Kansas City
Talk: ***The Massive Distant Clusters of WISE Survey (MaDCoWS)***

July 8, 2013 (4:45 PM - 5:05 PM)

Co-authors: Dan Gettings, Anthony Gonzalez, Adam Stanford, Tom Plagge, Dan Marrone, John Carlstrom, Peter Eisenhardt, Dan Stern, Greg Zeimann, Dominika Wylezalek
The Massive Distant Clusters of WISE Survey (MaDCoWS) is a comprehensive program to detect and characterize massive z>~1 galaxy clusters over the full extragalactic sky. The foundation for this program is data from the NASA Wide-field Infrared Survey Explorer (WISE). The depth is sufficient to identify galaxy clusters over a wise range of masses (2-20 x 10^14 Msun) out to z=1.4 as overdensities of galaxies that are red in the two shortest WISE wavelength passbands. A crucial component of this program is CARMA/SZA follow-up of MaDCoW clusters in order to measure reliable ICM-based total masses. These measurements permit a characterization of the mass-richness relation for WISE-selected clusters, enabling meaningful studies of the formation and evolution of galaxies in the most overdense regions at z~1.

7. **John E Carlstrom**, University of Chicago
Talk: ***Welcoming Remarks***

July 8, 2013 (9:00 AM - 9:10 AM)

8. **Richard M Crutcher**, University of Illinois at Urbana-Champaign
Talk: ***CARMA Studies of Magnetic Fields in Molecular Clouds***

July 8, 2013 (9:55 AM - 10:10 AM)

Co-authors: Nicholas Hakobian
The role of magnetic fields in star formation remains unsettled. CARMA mapping observations of dust continuum polarization (see Hull et al.) and of spectral-line circular (Zeeman) and linear polarization can significantly advance this field. I will show CARMA maps of N=1-0 CN lines toward molecular cores with single-dish Zeeman detections and discuss what physical conditions CN samples. I will also discuss the approved program to map the Zeeman effect in the N=2-1 CN lines, show why such high angular resolution mapping of magnetic fields are likely to be successful, and how these observations will provide new tests of theory. Finally, I will discuss the additional probe provided by mapping of linearly polarized spectral lines and show how CARMA mapping can lead to information about the 3D structure of magnetic fields in molecular clouds. The conclusion is that there is a bright future for CARMA to make very significant contributions to our knowledge of the role of magnetic fields in the star formation process.

9. **Manuel Fernandez Lopez**, University of Illinois at Urbana-Champaign
Talk: ***CARMA mm view over three selected star-forming regions: intrigues of outflow activity***

July 8, 2013 (10:25 AM - 10:40 AM)

Co-authors: several
In this brief talk I'll present new results of CARMA observations toward different star-forming regions. IRAS18162-2048 is a massive star-forming region in which we have characterized a network of poorly known outflows (some of them monopolar in addition). L1157 is a paradigmatic Class 0 protostar. High angular resolution CARMA CO(2-1) observations of the whole outflow are the starting point of a precession fit in 3D (position + radial velocity) we are carrying out. Serpens Main is a classical very active low-mass star-forming region. Inside the CLASSy project, we have mapped the densest parts of the molecular cloud with 3 molecules. The preliminary analysis of the N2H+ emission shows a new view on the region kinematics and the high angular resolution has allowed to resolve some filaments for the first time.

10. **Erin Grand**, University of Maryland
Poster: ***Characterizing the Dense Gas in the Eagle and Pelican Nebulae***

July 8 - 9, 2013

Co-authors: Marc Pound, Lee Mundy
Molecular pillars are formed in HII regions at the boundary between ionized gas and molecular clouds through the effects of photoionization, ablation, and recombination. Two set of models exist for the formation mechanism of the pillars (1) the growth of radiative hydrodynamic instabilities and (2) shadowing of the ionization front due to clumps in the molecular cloud. We test these two models with CARMA observations of high density gas. We observed two pillar sources. the Eagle and the Pelican, in order to provide observational evidence for one or both of the formation models. We find that the data are consistent with the shadowing model, but until the models present more complete velocity information, we cannot rule out either formation mechanism.

11. **Christopher Greer**, University of Arizona
Talk: ***Current and Near-term CARMA SZ Results***

July 8, 2013 (3:05 PM - 3:20 PM)

I will review the current status of CARMA SZ Science, including surveys of the LoCuSS, maxBCG, and (possibly) BCS Galaxy Cluster samples. I'll highlight the collection of CARMA SZ detections to date and discuss forthcoming analyses.

12. **Assaf Horesh**, California Institute of Technology
Talk: ***Exploring the dynamic radio sky***

July 9, 2013 (2:00 PM - 2:15 PM)

Co-authors: Shri Kulkarni, Dale Frail, Chris Stockdale, John Carpenter, Derek Fox, Gregg Hallinan, Kunal Mooley, Stephen Bourke
The field of time domain is going through a revolution. Not only that the current large optical transient surveys allow the discovery of a plethora of supernovae, but an increasing number of supernovae are discovered at a young age, a few hours to a day after explosion. Combined with radio observations, this enables a comprehensive pan-wavelength study of supernovae at an early stage. I will review our results from early radio observations of supernovae in the last year. In short, through our campaign, we were able to rule out a subset of type Ia supernova progenitors, learn about the microphysical parameters of type IIb supernova shockwaves and discover a fast evolving radio supernova. In addition to follow-up observations of supernovae, it is now clear that this is the time to bring the time-domain revolution into the radio regime. Therefore, we conducted a pilot time-domain survey in which we discovered several transients. I will present the results from our pilot survey and will discuss the future of radio time-domain astronomy.

13. **Chat Hull**, University of California, Berkeley
Talk: ***Are magnetic fields and outflows aligned in protostellar cores?***

July 8, 2013 (10:10 AM - 10:25 AM)

Co-authors: Dick Plambeck, and the TADPOL collaboration
We present new results from the 1.3 mm full-Stokes polarimeter at CARMA, highlighting dust polarization observations of 16 nearby, low-mass protostars, mapped with ~2.5" resolution as part of the TADPOL survey. Contrary to the theoretical models of star formation that assume that bipolar outflows are parallel to the mean magnetic-field direction in protostellar cores, the results show that the magnetic fields in the cores on scales of ~1000 AU are not tightly aligned with the outflows from the protostars. Rather, the data are consistent with scenarios where outflows and magnetic fields are preferentially misaligned (perpendicular), or where they are randomly aligned. If one assumes that outflows emerge along the rotation axes of circumstellar disks, then our results imply that the disks are not aligned with the fields in the cores from which they formed.

14. **Chat Hull**, University of California, Berkeley
Poster: ***The TADPOL survey: polarization in forming stars***

July 8 - 9, 2013

We present new results from TADPOL, a 1.3 mm survey of dust polarization in forming stars. The survey used the full-Stokes polarimeter at CARMA to observe 37 low- and high-mass forming stars in the C, D, and E arrays (1-4" resolution). Here we feature the high-mass regions, as well as selection of low-mass objects.

15. **Garrett "Karto" Keating**, University of California, Berkeley
Talk: ***The CO Cosmological Origins and Abundances (COCOA) Project: The Search for Molecular Gas at z=3***

July 9, 2013 (1:30 PM - 1:45 PM)

Co-authors: Dan Marrone, Geoff Bower, Dave Deboer, Carl Heiles
Molecular gas, observed through tracers such as CO rotational transitions, is a vital component of galactic evolution and star formation. Recent detections of the CO molecule in massive galaxies at redshifts as high as $z = 6.42$ have demonstrated its existence in the early Universe, and have motivated its use as a means of exploring large-scale structure and as a probe of galaxy evolution in the early Universe. But many questions about molecular gas and the evolution of galaxies in the early Universe still remain. How do feedback, metal enrichment and dust contribute to star formation? How abundant is molecular gas throughout the history of the Universe, and what impact does it have on the properties of galaxies? Answers to these questions are still so poorly observationally constrained that theoretical models of the global abundance and distribution of CO at $z=3$ span more than an order of magnitude. The Sunyaev-Zeldovich Array (SZA), an 8-element array originally designed to measure inverse Compton scattering of CMB photons by hot gas in massive galaxy clusters, offers a unique opportunity to begin exploring the distribution of CO at redshift $zsim3$ through a technique known as "intensity mapping". Unlike direct imaging techniques, which are only currently capable of observing the most massive and luminous of systems (typically containing $10^{10} M_{odot}$ and star formation rates of $100 M_{odot} rm{ yr}^{-1}$), intensity mapping allows for the detection of the presumably dominant population of smaller galaxies ($M_{gas}=10^8 M_odot; SFRsim1 M_odotrm{ yr}^{-1}$). Using 500 days of archival data spread across 44 individual fields, we explore the distribution of CO (through the $J=1rightarrow0$ transition) from redshift $z=2.3-3.3$. We establish upper bounds for CO matter power spectrum for this redshift range, and present the tools and techniques used for converting data normally used for aperture synthesis imaging into non-imaging cosmological measurements.

16. **Katherine Lee**, University of Illinois at Urbana-Champaign
Talk: ***Early Stages of Protocluster Formation: Substructure and Kinematics of Starless Cores in Orion***

July 9, 2013 (9:45 AM - 10:00 AM)

Co-authors: Leslie Looney (UIUC), Scott Schnee (NRAO), Zhi-Yun Li (U. of Virginia)
We study the structure and kinematics of nine 0.1 pc-scale cores in Orion with the IRAM 30-m telescope and at higher resolution eight of the cores with CARMA, using CS(2-1) as the main tracer. The single-dish moment zero maps of the starless cores show single structures with central column densities ranging from 7 to 42 * 10^23 cm^-2 and LTE masses from 20 to 154 solar masses. However, at the higher CARMA resolution (5"), all of the cores except one fragment into 3 - 5 components. The number of fragments is small compared to that found in some turbulent fragmentation models, although inclusion of magnetic fields may reduce the predicted fragment number and improve the model agreement. This result demonstrates that fragmentation from parsec-scale molecular clouds to sub-parsec cores continues to take place inside the starless cores. The starless cores and their fragments are embedded in larger filamentary structures, which likely played a role in the core formation and fragmentation. Most cores show clear velocity gradients, with magnitudes ranging from 1.7 to 14.3 km/s/pc. We modeled one of them in detail, and found that its spectra are best explained by a converging flow along a filament toward the core center; the gradients in other cores may be modeled similarly. We infer a mass inflow rate of 2 times 10^-3 Msol/yr, which is in principle high enough to overcome radiation pressure and allow for massive star formation. However, the core contains multiple fragments, and it is unclear whether the rapid inflow would feed the growth of primarily a single massive star or a cluster of lower mass objects. We conclude that fast, supersonic converging flow along filaments play an important role in massive star and cluster formation.

17. **Adam Leroy**, NRAO
Invited Talk: ***Millimeter Observations of Nearby Galaxies***

July 9, 2013 (10:45 AM - 11:15 AM)

I was asked to give an overview of recent mm-wave work on nearby galaxies. I will review some of the great science that CARMA has been doing in this area, first results from ALMA, and a few highlights from PdBI and the SMA.

18. **Ashley E Lindley**, University of Alabama in Huntsville
Talk: ***Measurement of the Gas Mass Fraction via Sunyaev-Zel'dovich Effect Observations of a Complete Sample of Galaxy Clusters***

July 8, 2013 (4:00 PM - 4:15 PM)

Co-authors: Massimiliano Bonamente
We present measurements of the gas mass fraction out to r$_{500}$ via Sunyaev-Zel'dovich (SZ) Effect observations for 32 galaxy clusters. The sample is selected from the most luminous galaxy clusters in the Brightest Cluster Sample, in the redshift range $0.15 , leqtext{ z }leq , 0.3$. The data were analyzed using two independent cluster models, and the mass was determined using a method that makes use of the Virial Theorem. This cluster sample has been observed with the Sunyaev-Zel'dovich Array (SZA), an interferometric array of the Combined Array for Research in Millimeter-wave Astronomy (CARMA) observatory. The SZA is optimized for accurate measurement of the SZ effect in clusters of galaxies at 30 and 90 GHz. We find that masses calculated utilizing the Virial method within r$_{500}$ are consistent with the X-ray masses for the same cluster sample only for certain values of the gas mass fraction, thus providing a unique method for measuring the gas mass fraction using SZ data. We measure emph{f$_{gas}$}(r$_{500})=0.1706^{+0.0053}_{-0.0060}$ and emph{f$_{gas}$}(r$_{500})=0.1976^{+0.0099}_{-0.0079}$ for the two cluster models, in statistical agreement with the gas mass fraction from the X-ray data published by Landry et al. (2013). The agreement suggests that there are no significant sources of systematic error within r$_{500}$ that affect the SZ Effect observations.

19. **Leslie Looney**, University of Illinois at Urbana-Champaign
Talk: ***Disks around the Youngest Protostars***

July 8, 2013 (11:15 AM - 11:30 AM)

Co-authors: John Tobin (NRAO), and Hsin-Fang Chiang (Hawaii)
Circumstellar disk formation begins during the earliest phase of the star formation process-- the so-called Class 0 stage when the nascent protostar is still surrounded by a dense envelope of gas and dust. Our recent detection of an edge-on R ~ 150 AU disk around the Class 0 protostar L1527 is a shining example. Simultaneous observations of the 13CO (J=2-1) transition were found to trace the disk rotation curve providing evidence of an 0.19 +/- 0.04 M_sun protostar. Building on these results, we have conducted a small survey with CARMA at 1.3 mm in C and B configurations toward 9 protostars in Perseus finding a few examples of possible disk-like structures and rotation. Using the VLA, we have observed 3 of these protostars at a resolution of 0.06", finding two to be 100 AU binaries. CARMA follow up in BCD configurations toward one source at 1.3 mm detectan apparent circumbinary disk with a strong indication of Keplerian rotation. The rotating circumbinary disk is an indication that disk fragmentation may have produced the companion source. The sensitivity and resolution of CARMA show that large Keplerian disks can form during the earliest phase of the star formation process and that disks are capable of fragmentation to form close binary systems.

20. **Melissa Louie**, Stony Brook University
Poster: ***Geometrical offsets between gas compression and star formation across spiral arms***

July 8 - 9, 2013

Co-authors: Jin Koda, Fumi Egusa
Geometrical offsets between gas spiral arms and associated star formation are a suggested measure of the star formation timescale and test of the density wave theory. There is a discrepancy between recently reported offsets measured in nearby spiral galaxies. Large and ordered offsets are found between CO and H$alpha$, where as small and non-ordered offsets are found between HI 21 cm and 24 $micron$ emissions. The latter is evidence against gas flow through spiral arms and could be evidence against the conventional density wave theory. We report measurements of geometrical offsets in grand-design spiral galaxy M51 and investigate potential causes. We find consistent offsets with previous measurements and find the difference in gas tracer, HI verse CO, to be the primary cause for the discrepancy. The HI emission is contaminated by the gas photodissociated by recently formed stars and can coincide spatially with the star forming regions, leading to small offsets. We find mostly positive offsets with substantial scatter between CO and H$alpha$, suggesting that gas is flowing through the spiral arms but the spiral pattern may not be constant or stationary.

21. **Swarnima Manohar**, California Institute of Technology
Talk: ***Ultra Luminous Infrared Galaxies: Mergers in the Local Universe***

July 9, 2013 (11:45 AM - 12:00 PM)

Co-authors: Prof. Nick Scoville (Caltech), Kartik Sheth (NRAO)
Understanding the galactic merger process is key to furthering our grasp of the evolution and buildup of galaxies we observe in the local universe. NGC 6240 and Arp 220 can be considered the founding members of a very active class of objects called Ultraluminous Infrared Galaxies or ULIRGs. They are in different stages of mergers and hence are excellent case studies to enhance our knowledge about the merging process. Multilevel excitation observations and analysis with CARMA in conjunction with ALMA of various high density molecular gas probes like HCN, CS and HCO+ transitions will enable in depth understanding of the gas dynamics and gas properties such as temperature and density. This forms the core of my thesis and some of the results will be presented here.

22. **Adam Mantz**, University of Chicago
Talk: ***Physics and Cosmology of Galaxy Clusters from cm to X-ray Wavelengths***

July 8, 2013 (4:30 PM - 4:45 PM)

As this session attests, SZ studies of clusters have been advancing rapidly. I will say a few words about the larger context for (much of) this work -- using the cluster population as a probe of fundamental cosmology -- from the perspective of a cantankerous, old X-ray astronomer.

23. **Dan Marrone**, University of Arizona
Talk: ***CARMA and eROSITA***

July 8, 2013 (5:05 PM - 5:25 PM)

Discussing the critical role CARMA will play in the study of the eROSITA X-Ray galaxy cluster survey.

24. **Lee Mundy**, University of Maryland
Invited Talk: ***Large-Scale Molecular Mapping***

July 9, 2013 (9:00 AM - 9:30 AM)

Invited Talk on Large-Scale Molecular Mapping. Detailing current results of CLASSy and how mapping large-scale can be a focal point of CARMA in the coming years. (CHG)

25. **Laura Perez**, NRAO
Invited Talk: ***Understanding Star and Planet Formation with CARMA***

July 8, 2013 (9:25 AM - 9:55 AM)

Observations at millimeter wavelengths are indispensable for understanding the formation process of stars and planets. Over the last several years, CARMA has been providing high sensitivity and high angular resolution millimeter-wave observations, that trace both the gas and dust inside regions of star formation across the Galaxy. This reservoir of material is transformed under gravity, pressure forces, magnetic fields, turbulence, and environmental effects, and eventually is converted into new stars and planets. In this talk I will review our current knowledge on the process of star formation, going from the young protostellar envelope phase to the mature debris disk stage, and I will showcase several recent results obtained with CARMA that provide new clues about this process.

26. **Daniel Perley**, California Institute of Technology
Talk: ***Millimeter Observations of GRB Afterglows***

July 9, 2013 (2:30 PM - 2:45 PM)

Co-authors: Alessandra Corsi, Bradley Cenko, Assaf Horesh, Dale Frail
Observations of GRBs in the millimeter band provide a window into the explosion that other wavelength regimes do not, particularly in the first few hours after the explosion. In the past several years CARMA has emerged as the leading observatory for carrying out rapid follow-up at these wavelengths, and an understanding of the diversity of early-time behavior is beginning to emerge. I will present a status report of GRB observations at CARMA and highlight observations of two recent nearby GRBs showing divergent behavior in the millimeter, illustrating the diversity of GRB outflow and environment properties and the unique contributions of millimeter observations relative to other wavelengths.

27. **Dick Plambeck**, University of California, Berkeley
Talk: ***Phasing CARMA for the EHT***

July 8, 2013 (12:15 PM - 12:30 PM)

Co-authors: Christiaan Brinkerink, Mel Wright, Geoff Bower, Dave MacMahon, Matt Dexter
For 1-mm VLBI observations with the Event Horizon Telescope, 8 CARMA antennas are phased together to provide collecting area equivalent to that of a 26-m single dish. Signals are combined in a set of beamformers that remove the phase switching pattern from each antenna's waveform, making it possible to observe normally with the CARMA spectral line correlator during VLBI scans. This allows accurate calibration of the system equivalent flux density (SEFD) of the phased sum, and makes it possible to rephase the telescopes every 10 sec to help track atmospheric fluctuations. Typical phasing efficiencies are 80 to 90 percent. The existing beamformers are fed from the spectral line downconverters that will become obsolete when CARMA's new correlator is installed. Rebuilding the beamformers to work with the new correlator, to increase the VLBI bandwidth, and to further improve the phasing efficiency is a challenge for the future.

28. **Marc W Pound**, University of Maryland
Poster: ***A 3mm Survey of the the Galactic Center***

July 8 - 9, 2013

Co-authors: Farhad Yusef-Zadeh, Douglas Roberts
We present a 3mm spectral line and continuum survey of the Galactic Center, made with CARMA-15 and CARMA-8. The survey covers approximately 0.26 square degrees from $-0.15 leq ell leq 0.5$ and $-0.2 leq b leq 0.2$ in spectral lines SiO, N2H+, HCN, HCO+, and CS. The spectral data have been combined with MOPRA and NRO singledish data. This is the first large-scale 3mm interferometric map of the region.

29. **Anthony Remijan**, NRAO
Talk: ***Investigating Molecular Complexity with CARMA***

July 9, 2013 (10:00 AM - 10:15 AM)

Co-authors: Ryan Loomis (University of Virginia), Brett McGuire (Caltech)
Over the past year, CARMA has been utilized to investigate the molecular complexity in astronomical environments including 1) testing the formation models of complex organic species in the ISM and 2) mapping the spatial distribution of complex molecules toward high mass star forming regions. In this talk, I will present results from our CARMA observations in our attempts to search for favorable, high line strength transitions of hydroxylamine (NH$_2$OH) toward the shocked regions in L1157. In addition, I will present a comparative study on the distribution of several complex molecules toward the Orion KL region taken in CARMA E and B array configurations.

30. **Demerese Salter**, University of Maryland
Talk: ***The millimeter synchrotron flare emission from the DQ Tau T Tauri binary system***

July 9, 2013 (2:15 PM - 2:30 PM)

DQ Tau is a T Tauri spectroscopic binary that was first observed to flare at millimeter wavelengths in 2008. Our initial and continuing scenario for this phenomenon is a powerful star-star magnetic reconnection event every 15.8 days when the two stellar magnetospheres collide and reorganize near periastron as the stars approach a minimum separation of 8 stellar radii. The flares are attributed to synchrotron emission from highly relativistic particles trapped in closed magnetic field lines that temporarily connect the two stars during closest approach. Here, we present revised orbital parameters from optical spectrographs in Chile that are allowing us to calculate the exact orbital phases and stellar positions during our observations. Combined with our long-term CARMA SZA and OVRO 40m radio monitoring programs, we have established that the activity only occurs around periastron. Our recent high-resolution (~2 mas or 0.3 AU) VLBA observations constrain the emitting region to the size of the stellar orbits. The VLBA data also allow us to track the centroid of the flare emission, showing that over an 8-hour period, the peak emission can move on spatial scales equivalent to the stellar separation (~0.4 mas or 0.06 AU). We will also discuss what we are learning about the evolution and shape of the non-thermal radio emission spectrum over a 24-hour period for a single flare event targeted by a coordinated CARMA + JVLA + ATCA observation. These multi-wavelength observations and the DQ Tau system in particular are providing a unique opportunity to study the magnetospheres of young stars and their interactions.

31. **Dominique M. Segura-Cox**, University of Illinois at Urbana-Champaign
Poster: ***Core Properties and Gas Structures in Serpens Main***

July 8 - 9, 2013

Co-authors: Katherine Lee, Manuel Fernandez, Leslie Looney, Shaye Storm, Lee Mundy
We present the properties of continuum sources, gas structures, and a comparison between protostellar sources and gas in the Serpens Main region of the CARMA Large Area Star formation Survey (CLASSy). The main goal of CLASSy is to study the star formation process from large to small scales by utilizing CARMA-23 and single-dish modes. One of the five CLASSy targets, Serpens Main, is a nearby region (415 pc) of active low- to intermediate-mass clustered star formation. We identify twenty-two 3 mm continuum sources with derived masses ranging from 0.2 to 6.3 solar masses and spectral indices ranging from 0.6 to 1.2. We compare the distribution of these sources with Spitzer YSO counterparts and previously identified 850 micron and 1 mm sources. We also present the gas structures traced by N2H+(1-0); there are two primary subclusters within Serpens Main, and the high-resolution observations resolve several gas peaks and prominent filamentary structures for the first time. The NW subcluster presents a better correlation between the gas peaks and 3 mm continuum sources than the SE subcluster. Furthermore, the distributions of Spitzer YSOs and dense gas have been compared for the first time with high angular resolution. The results show that the dense gas correlates well with young sources at the Class 0/I phases, but poorly correlates with more evolved protostars.

32. **Patrick D Sheehan**, University of Arizona
Talk: ***Measuring Disk Masses of Class I Protostars***

July 8, 2013 (11:30 AM - 11:45 AM)

Co-authors: Josh Eisner
Planets form within the circumstellar disks of gas and dust which surround young stars as they form. Previous investigators have measured the mass of material within these disks for Class II pre-main-sequence stars, young stars surrounded only by their protoplanetary disks, and have found that the majority of these objects do not contain enough mass within their disks to form giant planets, as determined by the Minimum Mass Solar Nebula. Class I protostars, young stars which are surrounded by both protoplanetary disks and their natal envelopes, are presumably younger and have been estimated to have higher disk masses. We aim to test whether disk mass, as traced by millimeter wavelength emission, evolves between Class I and II sources. Such evolution might occur due to dust grain growth over this interval, and might help explain why Class II disk masses appear low compared with expectations. We use CARMA 1.3 mm visibilities along with broadband SEDs, scattered light images, and detailed radiative transfer modeling to accurately determine the mass within the Class I disks, and test whether these younger disks are sufficiently massive to form giant planets.

33. **Shaye Storm**, University of Maryland
Talk: ***Dendrogram analysis of the first CARMA Large Area Star formation Survey regions***

July 9, 2013 (9:30 AM - 9:45 AM)

Co-authors: Lee Mundy, Peter Teuben, Leslie Looney, Katherine Lee, Manuel Fernandez-Lopez, Erik Rosolowsky, the CLASSy Collaboration
The CARMA Large Area Star formation Survey (CLASSy) is mapping molecular emission across large areas of two nearby clouds: the Perseus and Serpens Molecular Clouds. CLASSy achieves the angular resolution needed to probe dense gas on scales from a few thousand AU to parsecs with CARMA-23 and single-dish observations. The resulting maps of N2H+, HCN, and HCO+ J=1-0 trace the kinematics and structure of the high-density gas in regions covering a wide range of intrinsic star formation activity. This presentation focuses on the dendrogram analysis that CLASSy is using to characterize the emission structure. We have chosen a dendrogram analysis over traditional clump finding because dendrograms better encode the hierarchical nature of cloud structure and better facilitate analysis of cloud properties across the range of size scales probed by CLASSy. We will present a new dendrogram methodology that allows for non-binary mergers of kernels, which results in a gas hierarchy below the strongest kernels in a tree that is more true to limitations of the S/N in the data. We use the resulting trees from completed CLASSy targets to derive physical parameters of the identified gas structures, and to probe the kinematic relationship between gas at different spatial scales and the velocity coherence within structures on different scales. The derived properties of the dense gas hierarchies can be used to explore our ability to distinguish between current theories for star formation in turbulent molecular clouds.

34. **Peter Teuben**, University of Maryland
Talk: ***MIRIAD in the ALMA era***

July 9, 2013 (2:45 PM - 3:00 PM)

An overview of the current MIRIAD is given, with examples of recent and near future work. Impact of the summer school as a catalist for annual releases. The carmafiller is presented, which converts miriad data to (casa) measurement set, and some comparisons between MIRIAD and CASA can be made.

35. **Nikolaus Volgenau**, CARMA
Talk: ***CARMA Technical Developments 2011-Present***

July 8, 2013 (9:10 AM - 9:25 AM)

In the time between the second and third Science Symposia, CARMA has enabled new capabilities for the benefit of the user-community and made improvements that increase the efficiency of operations. This presentation will review CARMA's progress over the past 28 months and report on projects currently underway: the new CARMA3G correlator and the 3mm dual-polarization MMIC receivers.

36. **Tony Wong**, University of Illinois at Urbana-Champaign
Talk: ***The Molecular Disks of Galaxies as Seen by CARMA***

July 9, 2013 (11:15 AM - 11:30 AM)

Co-authors: Jin Koda, David Rebolledo, Melissa Louie, Yu-Ting Wu, et al.
I will present an update on two recent/ongoing CO extragalactic projects, a study of Coma cluster galaxies and the CANON (CARMA-Nobeyama Nearby Galaxies) survey. I will discuss the role of internal and external processes in determining the molecular gas distribution in a galaxy.

37. **Rui Xue**, University of Illinois at Urbana-Champaign
Talk: ***CARMA SURVEY TOWARD INFRARED-BRIGHT NEARBY GALAXIES: Atomic-to-Molecular Transition***

July 9, 2013 (11:30 AM - 11:45 AM)

Co-authors: Tony Wong, Alberto D. Bolatto, et al.
We present a detailed comparison of molecular and atomic gas distributions in 18 nearby galaxies from the CARMA Survey Toward IR-Bright Nearby Galaxies (STING) at sub-kpc and kpc scales. The molecular gas data are from CARMA CO J = 1 - 0 observations, and the atomic gas data are from VLA H I 21cm observations retrieved from the NRAO Archive. We derive atomic gas and molecular gas column density maps, and carry out a pixel-by-pixel basis comparisons, at the limits of available ob- servational spatial resolutions and sensitivities. We also examine how the atomic to atomic-molecular gas distribution is related to the galaxy global properties, in terms of metallicities, morphology, star formation rate, and optical/IR luminosity. Although the uneven qualities of HI data across our sample limits our capability to trace atomic and molecular gas relation in individual giant molecular cloud (GMC) scales (~100pc) for all of galaxies, our result shows that the atomic gas column density threshold is a strong function of metallicities.

38. **Farhad Yusef-Zadeh**, Northwestern University
Talk: ***Star Formation near and Past Activity of Sgr A****

July 8, 2013 (2:00 PM - 2:15 PM)

Co-authors: M. Royster, M. Wardle, M. W. Pound, R. Arendt, H. Bushouse, D. C. Lis, D. A. Roberts, B. Whitney and A. Wootten
I will focus on two topics related to star formation near Sgr A* and its past activity when there was a burst of star formation a few million years ago. I will discuss how young stellar disks are formed in the context of the passage of a giant molecular cloud interacting with Sgr A*. I will present ALMA and CARMA measurements supporting on-going star formation near Sgr A*. A fraction of the material associated with the gaseous disk will accrete onto Sgr A* and may be responsible for the origin of the gamma-ray Fermi bubbles.

39. **Bevin A Zauderer**, Harvard University
Talk: ***A Millimeter View of the Transient Universe: Time Domain Astronomy with CARMA***

July 9, 2013 (1:45 PM - 2:00 PM)

Co-authors: Edo Berger (Harvard), Sayan Chakraborti (Harvard), Poonam Chandra (TIFR, India), Roger Chevalier (Viriginia), Laura Chomiuk (Michigan State), Jason Dittman (Harvard), Vikram Dwarkadas (Illinois), Suvi Gezari (Maryland), Atish Kamble (Harvard), Tanmoy Laskar (Harvard), Raffaella Margutti (Harvard), Brian Metzger (Columbia), Re'em Sari (Hebrew University, Israel), Alicia Soderberg (Harvard), Sylvain Veilleux (Maryland)
On behalf of a larger collaboration, I will present a summary of the first year of observations conducted as part of the Key Project, A Millimeter View of the Transient Universe. These observations utilize CARMA's continuum sensitivity and rapid-response capability to explore the following themes in time-domain astrophysics: (i) the dynamical evolution, structure, and energetics of non- to highly relativistic outflows; (ii) particle acceleration in fast shocks; and (iii) the parsec-scale environments around massive stars and dormant super-massive black holes as probes of mass-loss and quiescent accretion. I will summarize how we explore these themes through observations of supernovae, gamma-ray bursts and tidal disruption events, concluding with a census of our findings to-date.