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Submillimeter Array Newsletter

Number 40, July 2025

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FROM THE DIRECTOR

Dear SMA Newsletter readers,

It is an exciting time for the staff of the Submillimeter Array who have been focused on bringing the array forth into the era of the "wideband SMA" (wSMA). I am pleased to report that in June 2025, first interferometric fringes with the wSMA instrumentation were seen on both the 1.3 mm and 850 μm receiver bands, on Mars and Venus respectively. The process of fully commissioning the new instrument is well underway, and while there is still much work to do before integration is complete, first scientific observations with the new receivers have begun, and in the years to come we look forward to offering you the enhanced scientific capabilities that the wSMA will provide. Reaching this first-light milestone marks the culmination of a multi-year, collaborative effort across multiple teams of technicians, scientists, and engineers; and is a testament to the dedication and perseverance of everyone involved. Expect to see more details on the new instrumentation in subsequent newsletters.

I am also very excited to announce that the SMA has received a very generous donation of $1.1M from Dr. Colin R. Masson and his wife, Mrs. Leslie M. Masson, to help fund the SMA Solar project, which will afford the SMA powerful new capabilities for studying the dynamic Sun, and enable the array to embark on a new era of solar science. I want to thank Dr. and Mrs. Masson for this wonderful gift, and on behalf of the SMA Team, we look forward to getting some exceptional science from the new capabilities. I also want to thank and acknowledge the hard work of Abigail Unger, Vanessa Marquez, and Daniel Durusky, who were key in the early engineering studies of this new mode, as well as our own summit crew for their support in facilitating that work. Mahalo!

I have been excited to see some exceptional work coming out of the SMA, some of which you can read about further on in this newsletter. This includes the results from the first "frequency phase-transfer" experiments at 1.3 mm, which are an exciting step forward for enabling future multi-frequency VLBI experiments. Additionally, scientists using the SMA have recently made a first detection of polarized emission coming from the core of an ultra-luminous infrared galaxy (link: **https://cfa.harvard.edu/news/astronomers-detect-missing-ingredient-cooking-stars**), giving a peek into the role of magnetic fields regulating star-formation in such tumultuous starburst environments. I was also excited to see the results from the REASONs survey (link: **https://cfa.harvard.edu/news/astronomers-announce-largest-collection-exocomets-found**), which in part leveraged the SMA for probing exocomet belts.

Finally, I note that we are delaying announcement on a call for proposals for the 2025B semester, due in part to upcoming facility work and antenna upgrades (including that required for the SMA Solar effort). While these upgrades will help expand operating capabilities and improve uptime on the array, part of the upcoming work will necessitate shutting down the air handler system for our correlator for an extended period. We are working with site contractors to finalize a schedule prior to publishing a call for proposals. Expect to see further details in August.

We thank you for your continued support of the SMA, and wish you clear skies and successful observations in the months to come.

Garrett "Karto" Keating
Deputy Director, Submillimeter Array

THE SMA HELPS PROBE POSSIBLE OVERDENSITIES OF DUSTY STAR FORMING GALAXIES LEADING UP TO COSMIC NOON

Kirsten R. Hall[1], Jake B. Hassan[2], Richard M. Feder[3,4], Tobias A. Marriage[5], and Michael Zemcov[6,7]

Dusty star-forming galaxies (DSFGs) are increasingly recognized as key players in galaxy evolution and cluster formation. Number densities and clustering strengths of DSFGs indicate that they are progenitors of the most massive local ellipticals, which formed during the most intense bursts of galaxy formation at the earliest epochs (Thomas et al. 2025, Hall et al. 2018, Long et al. 2023). As with classical submillimeter galaxies in 850μm surveys (e.g., Barger et al. 1998), the UV and optical light from DSFGs is heavily obscured, recycled by dust into thermal radiation extending from millimeter wavelengths to the far-infrared. Interferometers such as ALMA, NOEMA, and the SMA have enabled high-resolution, (sub-)millimeter follow-up of high-z DSFGs (z>3) and proto-cluster cores (e.g., Oteo et al 2018, Hill et al 2020, Cox et al 2023).

The Atacama Cosmology Telescope (ACT) collaboration has been identifying DSFGs as bright point sources in their survey maps for over a decade (Marsden et al. 14, Gralla et al. 2020). Source populations selected at millimeter wavelengths have cooler dust (around 40 K, Su et al. 17) and higher redshifts than those selected at shorter wavelengths (Reuter et al. 2020), so understanding these populations is imperative to unraveling the complex details of massive galaxy assembly at and beyond the peak epoch of cosmic star formation, z > 2.

So far, ACT -- along with other wide-area surveys from the *Herschel* Space Observatory, the South Pole Telescope (SPT), *Planck*, and SCUBA2 on JCMT -- has unveiled very bright submillimeter galaxies/DSFGs that exist on the high-mass tail of galaxy distribution functions. Higher resolution follow-up of these rare, bright sources has largely confirmed that most are lensed, some have complicated morphologies suggestive of starbursting mergers, while a few others have led to confirmation of some of the highest redshift protocluster environments (Miller et al. 2018, Oteo et al. 2018, Gruppioni et al. 2020, Zavala et al. 2021). The latest ACT source catalog of DSFGs pushes to even higher sensitivity at 150 and 220 GHz, with uncertainties of approximately 3 mJy, and lower fluxes. At this survey depth, a significant fraction of the recovered DSFGs are predicted to be unlensed, high-redshift systems (Gralla et al. 2020, Wang et al. 2021, Calvi et al. 2023, Garratt et al. 2023), probing the fainter, median star formation population leading up to Cosmic Noon.

In Hall et al. 2025, we cross-match the flux-limited, ACT-selected DSFGs with *Herschel* maps and obtain a sample of 71 sources covered by both telescopes. We run the *Herschel* fields through a probabilistic cataloging (PCAT) algorithm to perform blind source detection and photometry using forward modeling. We then use the extracted *Herschel* flux densities of the counterparts in combination with the ACT fluxes to model the broad-band spectral energy distributions (SEDs) of the sources, inferring the photometric redshift, cutoff dust temperature, apparent dust mass, size, and far-infrared luminosity, and we also report on the number of flux components predicted by PCAT. We then use the power of the SMA to observe nineteen of our sources at higher angular resolution to look for evidence of source multiplicity.

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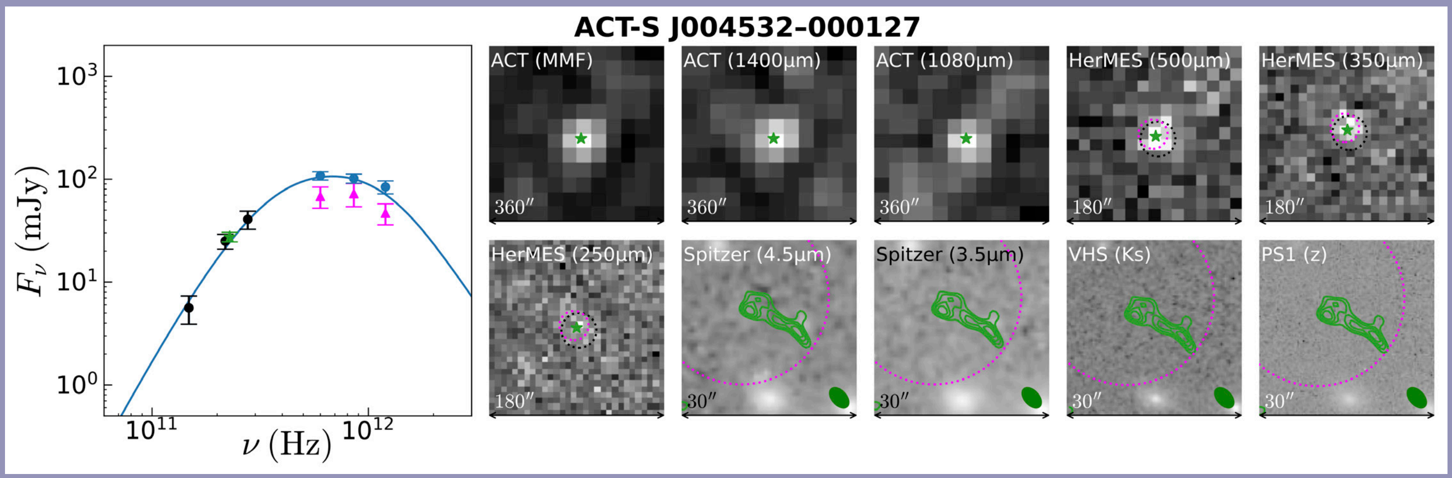

Figure 1: ACT-S J004532-000127 is a point source in the Atacama Cosmology Telescope observations (black points on SED and first three thumbnails). The PCAT algorithm predicts the *Herschel* emission (blue points on SED) is extended and likely composed of two components (with magenta points on SED the brightest flux component), and higher resolution SMA observations (green star on SED is the total flux) reveal 3-5 source peaks separated by approximately 15" (green contours at right). The green star on the thumbnails is the location of the brightest SMA flux component, and the magenta circle encompasses 90% of the *Herschel* flux as determined by PCAT.

Figure 1 shows an example of a source, ACT-S J004532-000127, which when observed by the SMA (green contours over the Spitzer, VHS, and PAN-STARRS1 images) resolves into multiple sources spread out over approximately 15 arcseconds. The leftmost panel in Figure 1 displays the SED with the ACT (black points), *Herschel* ensemble (sum of all PCAT-predicted components, blue points), *Herschel* brightest component (magenta triangles), and total SMA flux (summed over all sources, green star). The thumbnails on the right show the cut-outs from ACT, *Herschel*, Spitzer, VHS, and PS1 with green stars marking the location of the peak flux from the SMA image, and the magenta circles indicating the area inside of which 90% of the *Herschel* flux lies, as determined by PCAT. The PCAT algorithm outputs the likelihood that the *Herschel* data is composed of multiple sources, and in this case predicts a maximum likelihood of there being two source components. When we image with the SMA, we identify several (at least three, but up to five) source peaks. The SMA beam is shown in the lower right corner of the near-infrared and optical thumbnails; it has size 2.5"x4.1", which is not high enough to fully resolve all of the sources. While we do not have confirmed redshifts of each of these source components, the structure is too extended to be lensed, and all of the sources are so close that they are likely co-located rather than chance projections. We fit a single modified blackbody dust spectrum to the SED (blue curve) and determine the ensemble redshift to be z = (4.0 +/- 1.0). That is, it is highly likely that this is a proto-cluster environment at z > 3.

We implement the so-called ensemble SED modeling for all 71 of our sources and report on the median of all of the posterior distributions of the physical parameters used to describe them in the model. We find this population of lower flux-limited DSFGs to have a population median redshift of z = (3.3 +/- 0.7), apparent size d = (5.2 +/- 2.4) kpc, apparent dust mass log10($M_d/M_\odot$) = (9.14 +/- 0.12) and apparent FIR luminosity log10($L_{IR}/L_\odot$)=(13.6 +/- 0.3). When compared against the physical parameters of other samples of DSFGs, ours are most similar to those that are lensed and/or probe the brightest end of the population's luminosity function (Figure 2), but we expect, and now know, that a non-negligible fraction of our lower flux-limited sample are composed of multiple sources rather than just one.

We find that 14 out of the 19 sources that we observed with the SMA show evidence of multiplicity, either through direct detection of at least one additional source in the field or through our comparison of the total SMA flux density compared to what we expect from the ensemble SED model at the observed frequency (Figure 3). We unambiguously determine five of our ACT sources are composed of at least two sources, and the other nine (of the 14) are likely unlensed and have SMA flux densities at least 3σ below the expected value from our ensemble SED modeling.

Largely owing to the power of the SMA, we conclude that this sample of DSFGs is most likely tracing an intermediate luminosity/mass range of the overall DSFG population. Evidence in Hall et al. 2025 suggests that this sample contains a higher fraction of unlensed galaxies and possibly a high fraction of multiplicity in comparison to the high-flux/high-luminosity DSFGs identified in the most comparable millimeter-selected survey sample to which we can compare (Reuter et al. 2020).

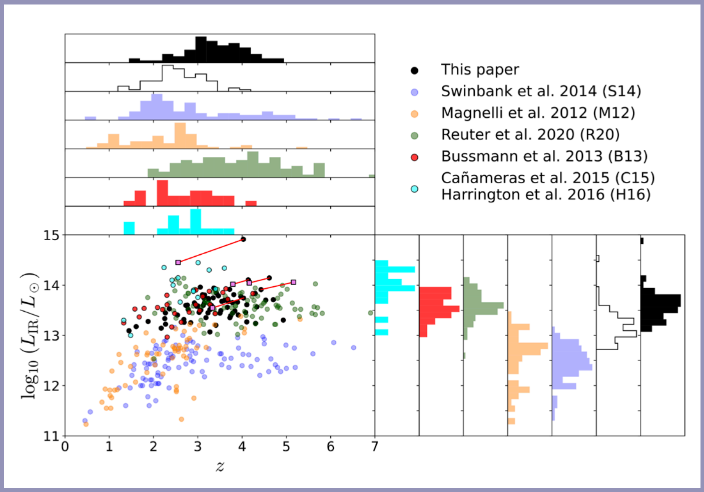

Figure 2: A comparison of redshifts and apparent FIR luminosities from various millimeter and submillimeter-selected samples of DSFGs. Reuter et al. 2020, Bussmann et al. 2013 and Cañameras et al. 2015/Harrington et al. 2016 are lensed, while those from Magnelli et al. 2012 and Swinbank et al. 2014 are unlensed. ACT results using a fixed spectroscopic redshift are shown with violet squares, and are connected to their photometric redshift results by red lines.

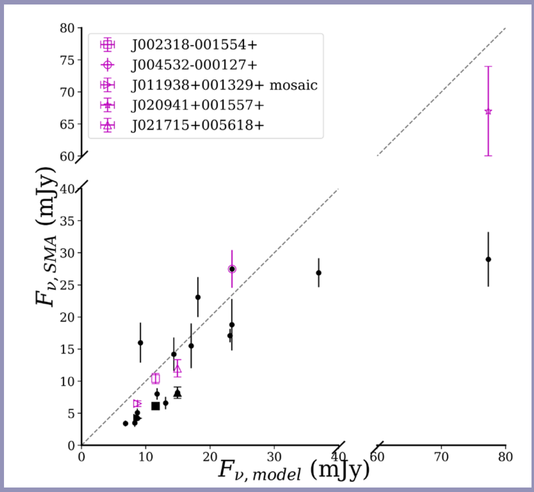

Figure 3: SMA flux density versus the ensemble model flux density determined from the median SED. For all sources, the filled black symbols are the flux densities of the source closest to the ACT source. Sources with multiple SMA detections are listed in the legend. For these, the matched unfilled magenta symbols include the recovered flux from the additional source(s) in the SMA data.

We continue to probe this population with higher resolution facilities, including targeting of CO lines to obtain more spectroscopic redshifts in order to fully characterize the physical properties of this sample of millimeter flux-limited DSFGs and probe the build-up of mass prior to cosmic noon and into the present day Universe.

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UNRAVELING THE CHEMISTRY OF MASSIVE STAR-FORMING REGIONS WITH THE SMA

Charles J. Law[1], Qizhou Zhang[2], Arielle C. Frommer[2], Karin I. Öberg[2], Roberto Galván-Madrid[3], Eric Keto[2], Hauyu Baobab Liu[4], Paul T. P. Ho[5], Andrés F. Izquierdo[6], and L. Ilsedore Cleeves[1]

The formation of high-mass stars (>8 $M_\odot$) is still poorly understood due to their relative rarity, obscured nature, high gas optical depths, fast evolutionary timescales, and large distances (several to tens of kpcs) compared to their low-mass counterparts (e.g., Motte et al. 2018). A further complication arises due to the complex process of forming massive protostars, which substantially alter their surroundings as they become energetic enough to ionize their natal molecular clouds. Classically, a massive young stellar object (MYSO) is formed via gravitational collapse, which is then followed by the appearance of a compact, dense, and hot molecular core (HMC). These cores then evolve into hypercompact (HC) H II regions (~0.01 pc), which then expand into ultracompact (UC) H II regions (~0.1 pc), and ultimately with time, compact H II regions, before the material surrounding the newly-formed stars is destroyed or dispersed by powerful stellar winds (e.g., Churchwell 2002). In reality, the separation of these stages is not distinct and instead, several phases often coexist within one region as multiple young stars are being formed in close proximity.

During this process, these regions exhibit an extremely rich and diverse chemistry, as the elevated temperatures and densities generated from collapsing material leads to the produc-

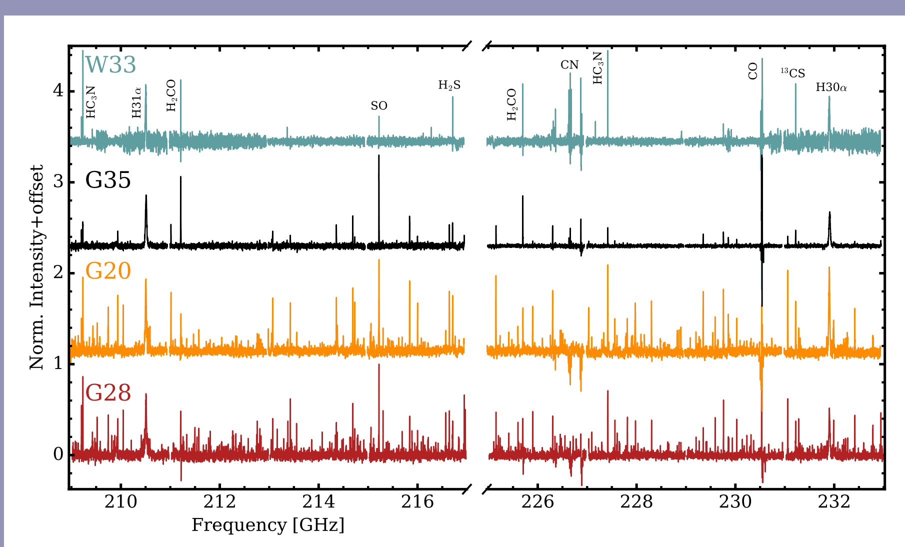

Figure 1: SMA spectra from ≈209 to 233 GHz of four high-mass star-forming regions, which are ordered by evolutionary stage from top (most evolved) to bottom (youngest). A few selected lines are labeled. Note these spectra represent only one-half of the total spectral coverage of the wideband survey presented in Law et al. (2025).

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tion of numerous molecular species, including many complex organic molecules (COMs; e.g., van Dishoeck & Blake 1998). The chemical complexity associated with massive protostars thus provides a powerful opportunity to trace the underlying physical gas conditions. However, this requires high angular resolution to localize distinct but contemporaneous evolutionary phases within a single star-forming region; and sufficiently large bandwidth to cover multiple molecular tracers and transitions across a wide range of excitation conditions. Only with such observations is it possible to confront a variety of outstanding questions, including what types of molecules best trace key gas properties (e.g., UV fields, temperature, density, shocks); and how COMs are formed, i.e., ice vs. gas-phase formation routes and the importance of chemical inheritance from the pre-stellar phases.

To address these questions, Law et al. (2025) conducted a new wideband (≈32 GHz) chemical survey of four massive star-forming regions (G28, G20, G35, W33 Main) using the SMA. Each region was observed using both the compact and very extended configurations, which allowed for high sensitivity to molecular line emission at subarcsecond resolutions. By doing so, Law et al. (2025) detected and spatially-resolved 100s of lines from over 60 different molecules, including multiple COMs and isotopologues (Figures 1 & 2). Together, these data enabled a comprehensive characterization of the chemistry in each source and provided a powerful demonstration of the astrochemical utility of the SMA's wideband capabilities.

One of the main findings of Law et al. (2025) is that the chemical richness of the observed sample of star-forming regions is consistent with an evolutionary sequence, as can be clearly seen in Figure 1. The youngest regions of G28 and G20, which host hot cores and HC H II regions, are the most line-rich, followed by the more chemically-modest UC H II regions in G35 and then the molecule-poor H II region W33 Main, which shows the most advanced signs of star formation. This trend is in line with theoretical expectations and previous observations (e.g., Gerner et al. 2014) that indicate molecular abundance, complexity, and detection rates peak with the emergence of hot cores, but then decline once evolved H II regions are formed as powerful stellar radiation destroys molecular material.

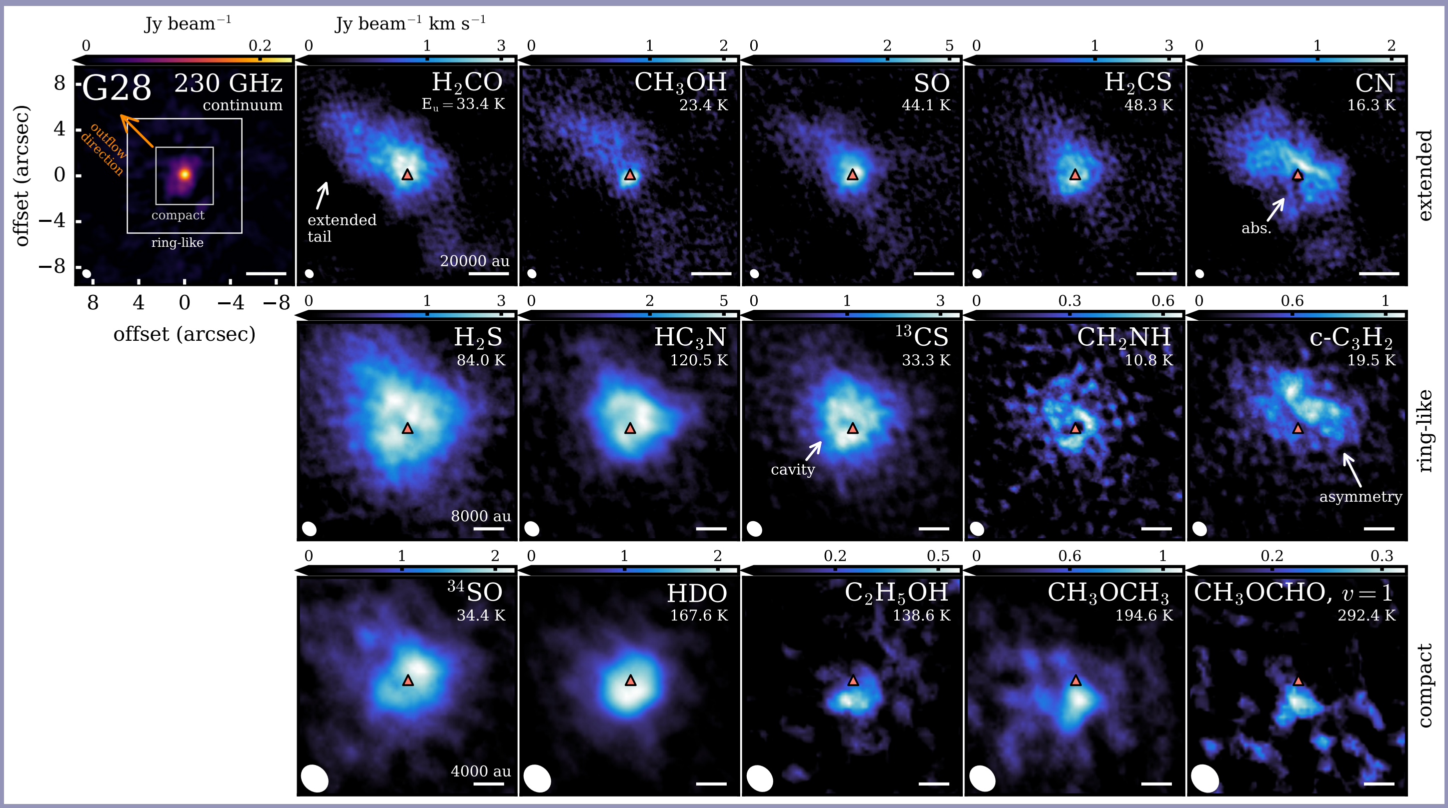

Figure 2: Integrated-intensity maps of representative lines demonstrating multiple emission components in G28. The continuum peak is shown as a pink triangle and the synthesized beam is marked in the lower left of each panel. The boxed regions in the continuum image show zoom-ins with scale bars of 20000 au, 8000 au, or 4000 au, respectively, in each panel. The outflow direction, as traced by SiO emission (Gorai et al. 2024), is marked in the continuum image.

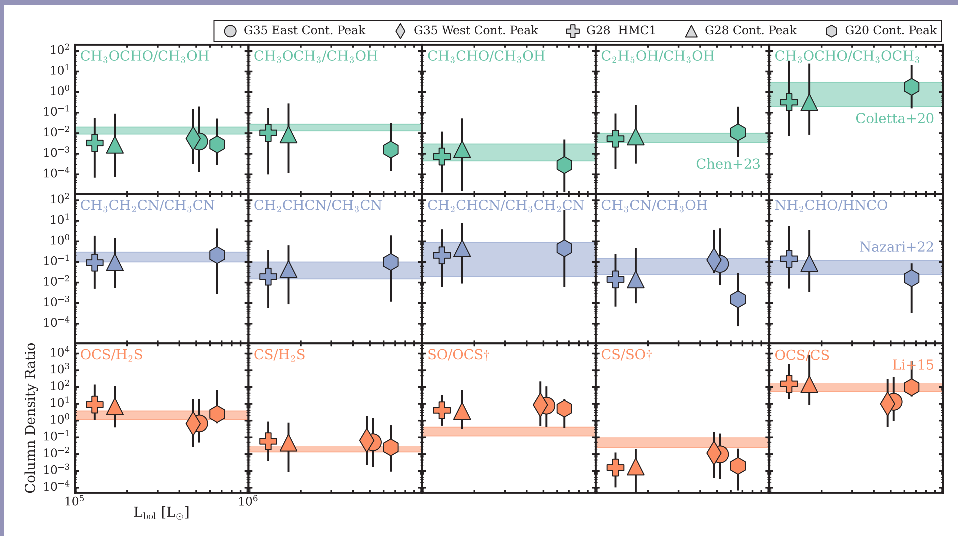

Figure 3: Column density ratios of select molecules (columns) at a few positions across four massive star-forming regions as a function of bolometric luminosity (Law et al. 2025). Shaded bands show the typical abundance ratios observed in literature star-forming regions for oxygen- (green), nitrogen- (blue), and sulfur-bearing (orange) species (rows). The ratios marked by a cross (†) symbol indicate those derived using likely optically-thick SO emission (Li et al. 2015).

In addition to establishing a molecular inventory of each source, Law et al. (2025) used observations incorporating the SMA's very extended configuration to spatially resolve nearly all of the detected lines, which provides key insight into the gas distributions around massive protostars. All regions showed evidence of compact, hot-core-like chemistry occurring near the central protostars in addition to a diffuse, extended emission component whose orientation matches that of known molecular outflows. Additional line emission substructures (e.g., rings, cavities, emission plateaus, asymmetries) are observed in each region, which highlights the complex interplay between chemistry and physical gas conditions in these environments. Figure 2 illustrates the multi-component nature of the observed molecular line morphology, as seen toward the G28 region.

Due to the wideband nature of the SMA observations, Law et al. (2025) detected lines across a range of excitation conditions ($E_u \approx 20$ to $\gtrsim 800$ K) and from numerous isotopologues, which enabled robust estimates of gas properties, including excitation temperatures and column densities. In particular, COM column density ratios have been used to gain insight into molecule formation mechanisms (e.g., Bisschop et al. 2007), and recent surveys have identified nearly constant abundance ratios in sources across a wide range of bolometric luminosities, including both high- and low-mass protostars (e.g., Nazari et al. 2022, Chen et al. 2023). For this to be the case, complex organics, or their precursors, must share a common formation environment, i.e., on pre-stellar ices. As shown in Figure 3, Law et al. (2025) also found remarkably consistent ratios across all four high-mass star-forming regions. The derived ratios are also largely in agreement with literature abundance ratios, which provides further support for the notion that COM abundances are set during the pre-stellar evolutionary stage.

Overall, the results of Law et al. (2025) demonstrate that the SMA's unique combination of high sensitivity, spatial resolution, and large bandwidth serves as a powerful tool to untangle the complex molecular gas structures associated with massive star formation and provides a key first step to establishing an interpretative framework for future astrochemical efforts. All data associated with Law et al. (2025) is publicly available on Zenodo doi: 10.5281/zenodo.13342640.

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A PANCHROMATIC VIEW OF SGR A*'S FIRST-DETECTED MID-IR FLARE WITH JWST/MIRI AND THE SMA

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The Milky Way's central supermassive black hole (SMBH), Sgr A*, with a mass of 4 million solar masses, is unique due to its relative proximity to Earth. One of only two SMBHs whose event horizons can be directly resolved with very long baseline interferometry (Event Horizon Telescope Collaboration, 2019a, 2022a), it is also the source of hourly-timescale variability, including sporadic bright peaks in the light curve—phenomenologically referred to as "flares"—that have been detected in the radio, submillimeter, infrared (IR), and X-rays. Coordinated observations via multiwavelength campaigns have also demonstrated a possible causal connection between flares at different frequencies, suggesting they may originate from single, unpredictable, energetic events within the accretion flow, such as magnetic reconnection (B. Ripperda et al., 2020). Such events might be the origin of transient, high-brightness temperature locations in the accretion flow, known as "hotspots," that have been canonically used to model the temporal evolution of Sgr A*'s light curves.

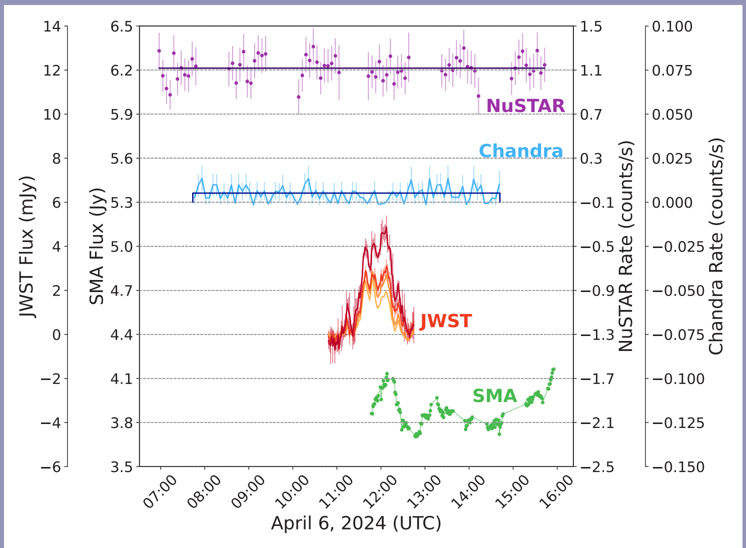

Figure 1: Multiwavelength light curves of Sgr A* on 6 April 2024 using NuSTAR, Chandra (X-ray), JWST/MIRI (mid-IR), and 220 GHz SMA (millimeter). The solid lines overplotted on the X-ray light curves are the Bayesian block results, showing no X-ray flares occurred. The gray-shaded region denotes the ~60-minute period over which the mid-IR flare event lasted. All times have been barycenter corrected. Plot reproduced from S. von Fellenberg et al., 2025a.

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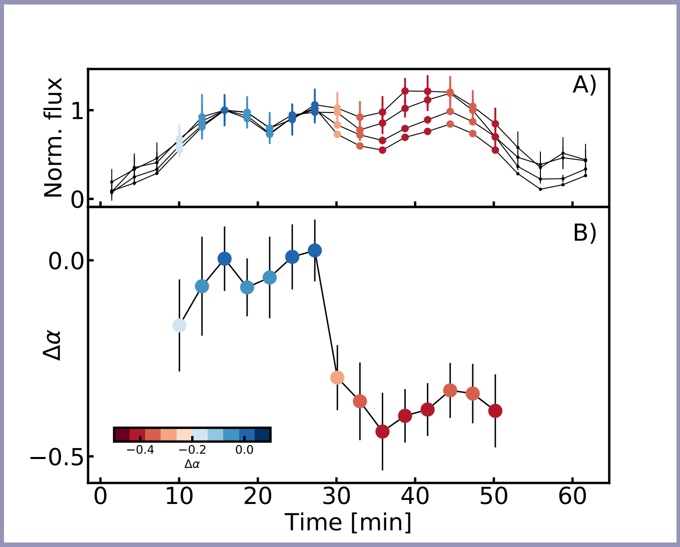

Figure 2: A) Normalized mid-IR light curves of Sgr A* during the flaring period. All light curves have been normalized to 1 relative to a single instance in time. B) The relative change in the spectral index, *Δα*, across the mid-IR band with JWST/MIRI during the same time range. A sudden decrease of |*Δα*|=0.5 occurs near t = 30 minutes, signifying a cooling break has formed. Plot reproduced from S. von Fellenberg et al., 2025a.

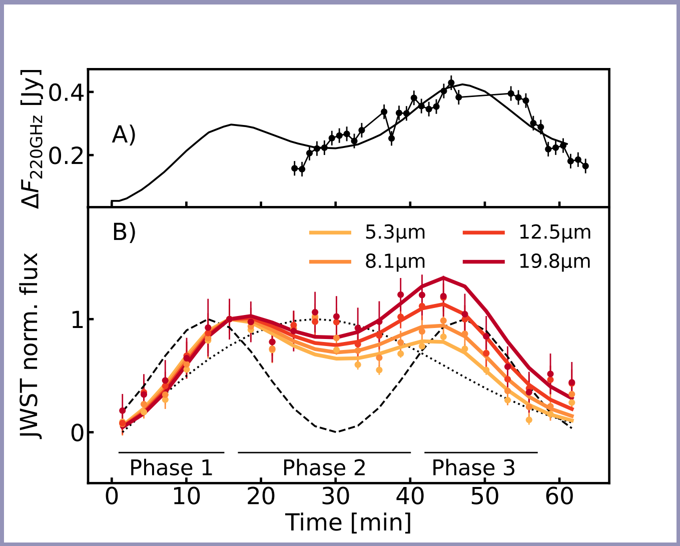

Figure 3: A) Observed SMA 220 GHz light curve (black points); the 220 GHz best-fit orbiting hotspot model is overlaid in solid black. B) JWST/MIRI data (colored points) and best-fit models (solid lines) are shown. The dashed black line denotes the Doppler boosting profile as the hotspot orbits Sgr A*, and the dotted black line shows the best-fit electron injection profile. Note that the electron injection profile's peak matches that of the spectral index change seen in Figure 2. Important events during phases 1 - 3 are described in the text. Plot reproduced from S. von Fellenberg et al., 2025a.

For many decades, there has been a critical missing link in the mid-IR, sitting between the submillimeter emission, which probes emission from thermal and nonthermal electrons in the accretion flow, and the near-IR, which is almost exclusively powered by nonthermal electrons. The mid-IR sits at a crossroads that directly probes the IR and X-ray flare mechanisms as the degeneracy between synchrotron- and synchrotron-self-Compton-dominated emission models is broken in this portion of the electromagnetic spectrum (G. Witzel et al., 2021). Especially important is the mid-IR spectral index and its evolution, as a single power law indicates pure synchrotron emission, whereas a characteristic spectral upturn at short wavelengths suggests self-Compton processes (G. Witzel et al., 2021).

However, one confounding factor in probing the mid-IR variability is the large presence of warm dust residing at the Galactic Center, particularly within the minispiral. This requires a telescope with high sensitivity, superior photometric stability, and sufficient spatial resolution. Until the launch of JWST and its MIRI instrument on Christmas Day 2021—which offers simultaneous spectral measurements at four mid-IR wavelengths in its MRS configuration—no ground- or space-based telescope had all three of these essential capabilities. The most sensitive mid-IR observations of the region around Sgr A* to that point were published in C. Dinh et al. (2024) using the VISIR instrument at 8.6 µm; we estimate a non-reddened 3σ upper limit on Sgr A*'s mid-IR variability at approximately 9 mJy from those data (S. von Fellenberg et al., 2025a).

As part of Cycle 2 observations, we observed Sgr A* in April 2024 for approximately 28 hours over four epochs in concert with other multiwavelength facilities, including the SMA. In this first paper (S. von Fellenberg et al., 2025a), we analyzed a portion of the light curve on 6 April 2024, which showed the strongest mid-IR flare of the April 2024 campaign window and is displayed in Figure 1 along with the SMA and X-ray light curves. No X-ray flare was detected—common during near-IR flares (H. Boyce et al., 2019)—yet still place strong constraints on the high-energy section of the electron spectrum powering the mid-IR flare. The SMA detected an increase of about 10% in Sgr A*'s 220 GHz flux during the final mid-IR peak, which was time-delayed by approximately 10 minutes. Time delays between submillimeter and IR flares are also common (e.g., J. Michail et al., 2021c, 2024), signaling they are causally connected.

The peaks in the MIRI light curve are approximately evenly spaced in time. Likewise, its morphology is reminiscent of signatures of hotspots orbiting Sgr A*, consistent with other observations (such as astrometric measurements during IR flares with GRAVITY, e.g., GRAVITY Collaboration et al., 2020d, and the variability of linearly polarized emission during the submillimeter flare, e.g., M. Wielgus et al., 2022b). Additionally, MIRI's simultaneous spectral coverage in four mid-IR filters allowed us to measure the relative changes in the mid-IR spectral index in time (Figure 2), where we find a sudden decrease of ~0.5, suggesting a synchrotron cooling break. These two features motivated us to use a simple orbiting hotspot model producing synchrotron emission from injected electrons originating from the accretion flow to explain the temporal and spectral evolution. The best-fit mid-IR and submillimeter light curves are shown in Figure 3. Overall, we find that the first and last peaks of the mid-IR light curve are predominantly caused by Doppler boosting of the synchrotron emission on its orbital path toward Earth (phases 1 and 3). The sudden shift in the mid-IR spectral index occurs once the rate of injected electrons begins to decrease (phase 2), creating a synchrotron cooling break. We infer this hotspot has a magnetic field strength ranging between 40 to 70 Gauss and an electron number density of ~10^6 cm^{-3}.

These are consistent with general relativistic magnetohydrodynamic (GRMHD) simulations, which suggest magnetic reconnection events as their origin. These simulations show that the magnetic reconnection produces highly coherent vertical magnetic fields (perpendicular to the accretion flow), move material away from the reconnection site, and create low-density regions embedded within the accretion flow. Rayleigh-Taylor instabilities at the boundary advect the hot accretion flow material into the low-density region, leading to the formation of a local orbiting hotspot (e.g., B. Ripperda et al., 2022) with potential correlated changes in the submillimeter linear polarization as tracked by Stokes Q-U loops. These submillimeter polarization light curves will be the focus of a forthcoming paper (J. Michail et al. 2025, in prep.).

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FIRST FREQUENCY PHASE TRANSFER FROM THE 3 MM TO THE 1 MM BAND ON AN EARTH-SIZED BASELINE

Sara Issaoun [1,2], Dominic W. Pesce[1,2], María J. Rioja[3,4], Richard Dodson[3], Lindy Blackburn[1,2], Garrett K. Keating[1], Sheperd S. Doeleman[1,2], Bong Won Sohn[5], Wu Jiang (江悟)[6], Dan Hoak[7], Wei Yu (于威)[1], Pablo Torne[8], Ramprasad Rao[1], Remo P. J. Tilanus[9], Iván Martí-Vidal[10,11], Taehyun Jung[5], Garret Fitzpatrick[1], Miguel Sánchez-Portal[8], Salvador Sánchez[8], Jonathan Weintroub[1], Mark Gurwell[1], Carsten Kramer[12], Carlos Durán[8], David John[8], Juan L. Santaren[8], Derek Kubo[13], Chih-Chiang Han[14], Helge Rottmann[15], Jason SooHoo[7], Vincent L. Fish[7], Guang-Yao Zhao[15], Juan Carlos Algaba[16], Ru-Sen Lu (路如森)[6,15,17], Ilje Cho[5,18], Satoki Matsushita[14], and Karl-Friedrich Schuster[12]

Frequency Phase Transfer (FPT) is a technique to increase coherence and sensitivity in interferometric observations via the use of phase, delay, and rate solutions from lower frequencies to calibrate higher frequencies (see Rioja & Dodson 2020 and references therein). Optimal FPT requires simultaneous observations of a source at two or more different frequencies along the same line-of-sight or optical path, and it requires that the source be detected at the lower frequency within the coherence timescale at the highest frequency, such that phase variations within this timescale can be tracked at the lower frequency. Provided that the observing equipment is well-calibrated and stable, these phase variations originate in the troposphere and are primarily non-dispersive, meaning that the magnitude of the variations is proportional to the observing frequency. A scaled-up version of the lower frequency phase solution can thus be used to calibrate the higher frequency data, with the potential to substantially increase the coherent integration time — and therefore sensitivity — at the higher frequency.

The potential benefit of FPT for calibrating high-frequency radio observations has been recognized for several decades, and multiple different strategies have been devised and employed within the context of connected-element interferometers. The most direct application of FPT requires simultaneous observations at multiple frequencies with each antenna in the array, a strategy first demonstrated by the Submillimeter Array (SMA; Masson 1989; Hunter et al. 2005). But FPT-enabled calibration improvements can also be realized using a "paired-antenna" mode in which nearby telescopes observe simultaneously at two different frequencies, such as those used by the Nobeyama Millimeter Array (NOEMA; Asaki et al. 1996,1998) and the Combined Array for Research in Millimeter-wave Astronomy (CARMA; Pérez et al. 2010; Zauderer et al. 2016). Another alternative is to conduct fast frequency-switching observations, such as the "band-to-band" calibration used at the Atacama Large Millimeter/submillimeter Array (ALMA; Asaki et al. 2020a, 2020b, 2023; Maud et al. 2020, 2022, 2023).

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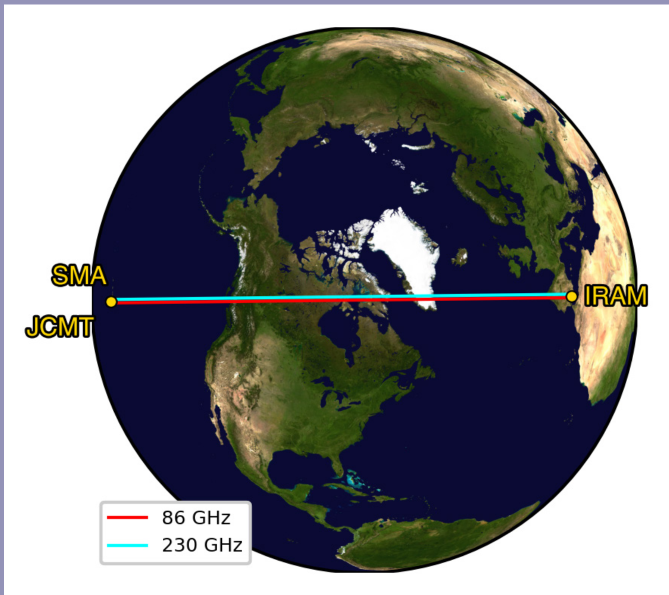

Figure 1: The array used for the observations presented in Issaoun et al. (2025), as seen from the source J0958+6533. The IRAM–JCMT baseline at 86 GHz is shown in red, the IRAM–SMA baseline at 215 GHz is shown in cyan. Antenna 6 was the SMA reference antenna for our observations.

The FPT technique has been well exercised at frequencies up to 130 GHz, thanks in large part to many years of development by the Korean VLBI Network (KVN; Han et al. 2013; Rioja et al. 2015). However, FPT has remained untested at higher frequencies on VLBI baselines, largely due to the lack of (sub) millimeter facilities with VLBI-capable dual-band setups. Motivation for developing the FPT capability has been building in recent years, as higher-frequency VLBI observations form a cornerstone of near-term (The Event Horizon Telescope Collaboration 2024) and next-generation EHT science goals (Doeleman et al. 2023).

In Issaoun et al. (2025), we describe the first successful demonstration of FPT between 86 and 215 GHz on an Earth-sized VLBI baseline. We present results from simultaneous dual-frequency VLBI observations that were carried out at 86 GHz on the IRAM-JCMT baseline and at 215 GHz on the IRAM-SMA baseline on 2024 January 24. The IRAM 30-m observed at both frequencies simultaneously, while the JCMT and phased-SMA acted as a paired antenna on Hawai`i (see Figure 1). We observed two bright northern AGN, J0958+6533 and OJ287, obtaining strong fringes on three scans. The visibility phases at both frequencies exhibit a high degree of correlation that follows the trend expected for non-dispersive atmospheric fluctuations, enabling the first demonstration of FPT up to 1.3 mm wavelength (see Figure 2). Transferring the scaled phases from 86 GHz to 215 GHz systematically increases the 215 GHz coherence on all averaging timescales for both targets.

While there remain challenges in understanding higher-order effects in the atmosphere above spatially separated receivers, the use of the JCMT and SMA as a single dual-frequency antenna in this experiment demonstrates for the first time that FPT is feasible in paired-antenna mode for VLBI (Rioja & Dodson 2020). Paired-antenna FPT has practical applications for the participation of connected-element interferometers like the SMA in multi-frequency VLBI observations. For instance, while ALMA does not have the capability to conduct multi-band observations (nor will planned upgrades provide

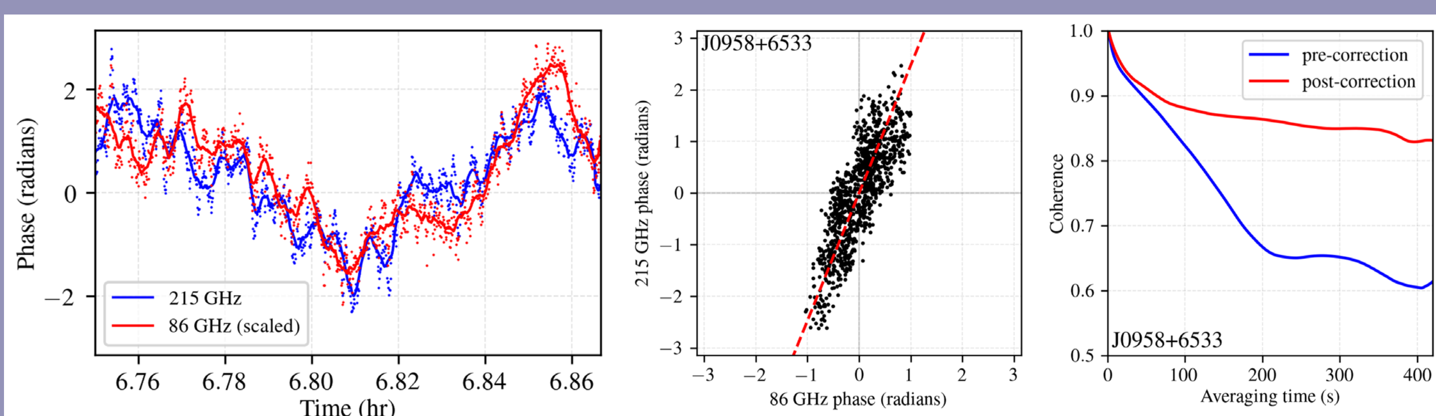

Figure 2: Demonstration of correlated phases at 86 and 215 GHz towards the source J0958+6533, as presented in Issaoun et al. (2025). **Left:** The interferometric phase time series at the two observing frequencies, after scaling the 86 GHz phases by the frequency ratio; the two phase time series visually track each other well. **Center:** The interferometric phase at 215 GHz versus the phase at 86 GHz, showing a strong correlation with a slope equal to the frequency ratio (red dashed line). **Right:** Coherence of the averaged 215 GHz visibility as a function of averaging time, before (blue) and after (red) applying the scales 86 GHz phase solution; we see a substantial coherence improvement after correction, staying above 80% coherence on averaging times of multiple minutes.

this capability; see Carpenter et al. 2023), dividing the array into sub-arrays that observe at different frequencies could use a paired-antenna FPT calibration scheme. Such a mode could also form a natural component of the ngVLA's Long Baseline Array (LBA) operation; each of the ten locations of the LBA will host three antennas (Selina et al. 2018), which could make use of FPT to boost sensitivity at the highest observing frequencies via a paired-antenna approach.

The observations presented in Issaoun et al. (2025) retire a key uncertainty associated with the FPT technique, demonstrating that the technique remains viable up to an observing wavelength of ~1 mm, even with paired antennas. The ability to use high-sensitivity observations at lower frequencies to calibrate lower-sensitivity observations at higher frequencies will expand VLBI science to fainter targets than can currently be observed, enable more routine observations at weather-limited sites, and extend reliable ground-based VLBI observing frequencies up to 345 GHz and potentially higher.

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SMA HAWAI'I OUTREACH HIGHLIGHTS

In our second year of restructured formal outreach, the SMA Hawai'i team led by Pamela Nehls continued to expand efforts to connect with schools, students, and communities across the island. From summit tours and classroom visits to public events and the launch of our new mobile lab initiative, it's been a productive year focused on sharing science, building relationships, and supporting education through meaningful engagement.

Nā Hōkū Hele

APAIP Grant Award

We're proud to share that SMA Hawai'i was awarded funding through the Smithsonian Institution FY 2025 Asian Pacific American Initiatives Pool (APAIP) to launch *Nā Hōkū Hele* (Traveling Stars), our new mobile astronomy lab. This initiative will bring hands-on STEM education and Hawaiian celestial knowledge to keiki across Hawai'i Island—particularly in rural and underserved areas. With tools like telescopes, virtual reality, and robotics, paired with lessons in celestial navigation and cosmology, we hope to spark curiosity while honoring place, culture, and community.

Science School Nights

August 2024 to March 2025

We've had a full school year of evening outreach! In partnership with the Hawai'i Science Museum and the Department of Education, SMA participated in a series of Science Nights across East Hawai'i, offering hands-on activities and engaging families in fun, meaningful learning. Here's where we showed up:

- August 20, 2024 – Kea'au Elementary
- September 11, 2024 – E.B. deSilva Elementary
- November 15, 2024 – Waiākea Waena Elementary
- December 11, 2024 – Waiākea Elementary
- February 5, 2025 – Kaumana Elementary
- March 7, 2025 – Hilo Union Elementary

Through these events, we connected with hundreds of students and their 'ohana, reminding them that science is for everyone—and that the stars are for all of us.

AstroBash

August 3, 2024

AstroBash returned to the Thelma Parker Memorial Library in Waimea for the first time since 2019, thanks to NASA@My Library. The event welcomed more than 300 attendees. SMA's Nick Smith and Angelu Ramos hosted an interactive booth highlighting Pōwehi and the SMA, inviting keiki and kūpuna alike to learn about black holes and our observatory's work. The event closed out the summer reading program and welcomed the new school year with a sense of wonder and connection.

Tipping Points Strategy Session

October 11–12, 2024

SMA joined colleagues from across the Maunakea Observatories at Gemini Headquarters in Hilo for a two-day Tipping Points Strategy Session facilitated by Nā'ālehu Anthony and Norma Wong. This workshop offered a space for honest reflection and collaborative planning around the future of astronomy on Maunakea. SMA staff participated in deep, meaningful conversations focused on shared kuleana, respectful engagement, and aligning science with cultural stewardship. We are proud to contribute to this collective effort to navigate complex spaces with care, humility, and responsibility.

Journey Through the Universe
February 2025

SMA was honored to take part in Hawai'i Island's largest annual astronomy education program, visiting classrooms throughout the Hilo-Waiākea area. SMA staff engaged students through interactive presentations and activities. Highlights included a robotics demo by Shelbi Hostler Schimpf, solar system talks by Kristen Laguana, and career conversations with Director Tim Norton at Hilo High School. Adam Mills and Pamela Nehls also served as outreach ambassadors. These visits remind students—especially those from our local communities—that they can find their place among the stars.

Kama'āina Observatory Experience (KOE)
April 5, 2025

SMA was proud to be the first observatory to resume in-person summit tours through the KOE program post-COVID. We welcomed kama'āina for a full day of learning and exploration, beginning with cultural protocol at the Visitor Information Station, followed by breakfast and presentations at Hale Pōhaku, and concluding with a tour of the SMA facility at the summit. SMA staff led discussions on science, safety, cultural respect, and telescope operations. The experience reaffirmed our commitment to transparency, accessibility, and responsible stewardship of Maunakea.

AstroDay
April 2025

SMA Hawai'i was proud to participate in the 23rd annual AstroDay at Prince Kūhiō Plaza, a fun-filled community event celebrating astronomy, science, and discovery. Our booth featured a gravity well demonstration, coloring sheets, and engaging science questions for all ages. Telescope Operator Nick Smith also shared an overview of the SMA, sparking great conversations about our work and the universe beyond.

'Imiloa Collaboration
May 2025

SMA leadership met with Dr. Devon Chu, the new Astronomer in Residence at 'Imiloa Astronomy Center. A graduate of Hilo High and a respected astronomer, Dr. Chu brings deep local insight and scientific excellence to his work. We look forward to building a strong partnership and collaborating on future outreach that blends science and Hawaiian c ultural perspectives.

Spotlight on Angelu Ramos and Nick Smith

SMA Telescope Operator Angelu Ramos had a great start to the year. She represented SMA at the American Astronomical Society (AAS) conference in Washington, D.C., and visited Senator Brian Schatz with the MKO delegation. She was also featured in *Hana Hou* magazine.

Angelu returned to her hometown of Kohala and visited Kohala Middle School, where she shared her journey from local student to telescope operator. She also led workshops on career prep and life skills. Her story shows what's possible when you stay rooted in your community and dream big.

Nick Smith has also been doing amazing work in outreach. He's attended nearly every MKO AOC event, and science night, and has talked to more students than anyone. Nick brings energy, kindness, and knowledge wherever he goes.

He'll also be working on the APAIP Initiative *Nā Hōkū Hele*, helping create learning materials that will reach even more students and families.

We're proud of both Angelu and Nick. Their work shows the power of sharing your story, giving back, and leading with aloha. Mahalo to you both!

Looking Ahead

As we reflect on the past year, we're proud of the connections we've made, the programs we've launched, and the students we've inspired. With two strong years of outreach behind us, SMA Hawai'i remains committed to growing this effort with humility, authenticity, and a focus on community.

We're also looking forward to welcoming more of our colleagues from Cambridge to Hawai'i classrooms—to share their science, skills, and mana'o with local students and help us deepen our reach.

Mahalo to everyone who has supported our journey. Together, we're building something meaningful—grounded in place, and reaching for the stars.

SMA 2025B SEMESTER CALL FOR PROPOSALS

Due to the uncertain timing of critical infrastructure upgrades, particularly for digital and analog equipment cooling, we have not yet been able to determine how 2025B will proceed, and without that information it is difficult to plan for the proposal deadline (since those upgrades will affect what capabilities the SMA can offer and over what time range). We will send out a notification email to all Newsletter recipients and SMA users as soon as the situation becomes clear. We apologize for the delay.,

Mark Gurwell, SAO Chair, SMA TAC

PROPOSAL STATISTICS FOR 2025A

The 2025A proposal deadline was Thursday, 6 March 2025, 01:00 GMT. The three SMA partner institutions received a total of 52 standard proposals (SAO: 49, ASIAA: 2, UH: 1). SAO further received one Large Scale proposal. The 53 total 2025A proposals were divided among science categories as follows:

CATEGORY	PROPOSALS
high mass (OB) star formation, cores	11
local galaxies, starbursts, AGN	10
protoplanetary, transition, debris disks	10
low/intermediate mass star formation, cores	5
evolved stars, AGB, PPN	4
other	4
submm/hi-z galaxies	4
galactic center	2
GRB, SN, high energy	2
solar system	1

We are concurrently running two accepted SAO Large Scale and one ASIAA Key Project programs (in addition to the new SAO Large Scale proposal).

2025A TRACK ALLOCATIONS BY WEATHER REQUIREMENT AND CONFIGURATION

To best accommodate the highest ranked programs from each of the partners, including Large Scale (SAO) and Key Project (ASIAA) programs, as well as a planned science hiatus to allow time for wSMA focused upgrades, the TAC Chairs determined that the 2025A configuration schedule will be:

COMPACT >> EXTENDED >> COMPACT >> SUBCOMPACT >> COMPACT

While we received requests for the very extended configuration, major storm damage to infrastructure along the west road beyond pad 14 that occurred in summer 2024 has not yet been repaired, and likely will not be until sometime in 2026. Until that repair can happen, we cannot offer very extended configuration.

Standard tracks were allocated in the following manner:

PWV[1]	SAO	ASIAA	UH[2]
< 4.0mm	22A + 56B	1A	0
< 2.5mm	12A + 18B	1A	8
< 1.0mm	2A + 6B	0	0
Total	**36A + 80B**	**2A**	**8**

Configuration	SAO	ASIAA	UH[2]
Subcompact	2A + 5B	0	0
Compact	20A + 55B	0	5
Extended	4A + 9B	0	3
Very Extended	4A + 9B	0	0
Any	10A + 11B	2A	0
Total	**36A + 80B**	**2A**	**8**

[1]Precipitable water vapor required for the observations.

[2]UH allocations do not use A/B priority indicators.

SAO additionally allocated 30 SUB tracks toward the SAO Large Scale proposal received for 2025A. In total, that signifies that three SAO Large Scale and one ASIAA Key Project programs are allocated approximately 45 <4.0mm and 45 <2.5mm tracks; one SAO program is a time domain project with variable triggering rates based upon random source activity, thus allocations per semester are somewhat uncertain and could deviate from these expectations.

TOP-RANKED 2025A SEMESTER PROPOSALS

The following is the listing of SAO, ASIAA and UH proposals with at least one A-rank track allocation, along with the newly accepted SAO Large Scale program.

EVOLVED STARS, AGB, PPN

2025A-S001 Joel Kastner, Center for Imaging Science, Rochester Institute of Technology
Mapping CO across the Helix Planetary Nebula (NGC 7293) with the SMA's New OTF Mode

2025A-S020 Jaime Alonso Hernández, Centro de Astrobiología (CSIC-INTA)
CO emission survey in X-ray emitting AGB stars

2025A-S036 Megan Lewis, Leiden Observatory
The enigmatic SiO maser spectrum of ad3a-09310: a possible nascent pre-planetary nebula

GALACTIC CENTER

2025A-S037 Joseph Michail, Center for Astrophysics | Harvard & Smithsonian
Round and Round She Goes: Probing hotspot orbits around Sgr A with full polarization SMA observations*

2025A-S038 Xing Pan, Center for Astrophysics | Harvard & Smithsonian
What's the role of core-scale magnetic field in the CMZ?

GRB, SN, HIGH ENERGY

2025A-A001 Tomoki Matsuoka, Institute of Astronomy and Astrophysics, Academia Sinica
A Target of Opportunity Observation of a Type IIn Supernova Revealing Unknown Mass Loss Activity of Massive

2025A-A002 Kuiyun Huang, CYCU
Electro-magnetic wave candidate of IceCube Neutrino event

LOCAL GALAXIES, STARBURSTS, AGN

2025A-S049 Eileen Meyer, University of Maryland, Baltimore County
The origin of the sub-mm emission in changing-look AGN 1ES 1927+654

2025A-S042 Ioannis Myserlis, Institut de Radioastronomie Milimétrique (IRAM)
SMAPOL: SMA Monitoring of AGNs with POLarization

2024B-S057 Eric Koch, Center for Astrophysics | Harvard & Smithsonian
A complete CO(2-1) Map of M31 with SMA OTF mapping [new SAO Large Scale Project]

OTHER

2025A-S004 Anna Ho, Cornell
Millimeter-wavelength Monitoring of a Galactic Nova

2025A-S046 Michael McCollough, Smithsonian Astrophysical Observatory
SMA Observations during a Multi-Wavelength VLBA Campaign of Cygnus X-3

PROTOPLANETARY, TRANSITION, DEBRIS DISKS

2025A-S013 Joshua Lovell, Center for Astrophysics, Harvard-Smithsonian
A giant, eccentric circumbinary disk in Cepheus? Determining the origin of asymmetric sub–structure in Dracula's disk

2025A-S024 David Wilner, CfA
Compact Millimeter Emission from Herbig Be Stars: Dust or Ionized Gas?

2025A-S033 Alice Booth, Center for Astrophysics Harvard and Smithsonian
Probing Circumstellar Dust in Young Transiting Exoplanet Systems

SOLAR SYSTEM

2025A-S015 Alex Akins, Jet Propulsion Laboratory
An SMA Spectral Survey of Venus' Mesosphere

SUBMM/HI-Z GALAXIES

2025A-S044 Kirsten Hall, Center for Astrophysics | Harvard & Smithsonian
Elucidating the dust spectrum of WISSH QSO J1549's Companion: Towards a measurement of the hottest phase of quasar winds via the thermal Sunyaev-Zel'dovich Effect

STANDARD, DDT, LARGE SCALE AND KEY PROJECTS OBSERVED DURING 2024B

SMA Semester 2024B encompassed the period Nov 15, 2024 through May 15, 2025; listed below are projects that were at least partially completed during the semester.

EVOLVED STARS, AGB, PPN

2024B-S041 Nimesh Patel, Center for Astrophysics | Harvard & Smithsonian
Imaging Cold Dust around Wolf-Rayet Stars - III

GALACTIC CENTER

2024B-S031 Garrett "Karto" Keating, Center for Astrophysics | Harvard & Smithsonian
Polarimetric VLBI for the 2025 Event Horizon Telescope Campaign

2024B-S044 Thushara Pillai, MIT Haystack Observatory
*VEX Follow up Towards A Compact Source near SgrA**

GRB, SN, HIGH ENERGY

2022B-S046 Edo Berger, Harvard University
POETS: Pursuit of Extragalactic Transients with the SMA [SAO Large Scale Project]

HIGH MASS (OB) STAR FORMATION, CORES

2024B-H001 Edwin Boogert, Institute for Astronomy, University of Hawaii
Physical conditions toward icy massive young stellar object

2024B-S005 Melisse Bonfand, University of Virginia
A Spectral Line Survey of Nearby High- and Intermediate Protostars to Probe the Astrochemical Evolutionary Sequence

LOCAL GALAXIES, STARBURSTS, AGN

2024A-A008 Bovornpratch Vijarnwannaluk, ASIAA
A SMA Investigation of the Evolution of ISM Density in AGN Host Galaxies [ASIAA Key Project]

2024B-A010 Geoffrey Bower, ASIAA
The Black Hole Magnetosphere: High Cadence Polarimetric Monitoring of M87

2024B-S013 Jakob den Brok, Center for Astrophysics | Harvard & Smithsonian
What drives the unusually high SFR in the elliptical+spiral pair Arp 142?

2024B-S018 Jakob den Brok, Center for Astrophysics | Harvard & Smithsonian
Completing the SMA molecular line survey in the starburst M82

2024B-S019 Eric Koch, Center for Astrophysics | Harvard & Smithsonian
Revealing the resolved molecular gas across the M81 group

2024B-S020 Gerrit Schellenberger, Center for Astrophysics | Harvard & Smithsonian
PROBING THE HIGH FREQUENCY VARIABILITY OF NGC5044: THE KEY TO AGN FEEDBACK

2024B-S029 Ioannis Myserlis, Institut de Radioastronomie Milimétrique (IRAM)
SMAPOL: SMA Monitoring of AGNs with POLarization

2024B-S042 Kirsten Hall, Center for Astrophysics | Harvard & Smithsonian
Direct, observational evidence of AGN feedback on host galaxies' molecular gas, part 3

2024B-S054 Jakob den Brok, Center for Astrophysics | Harvard & Smithsonian
DDT: AY191 project – Targeting the Merger System Arp 299

LOW/INTERMEDIATE MASS STAR FORMATION, CORES

2024B-A005 Jo-Shui Kao, NTHU/ASIAA
Exploring the Magnetic Field Structure of Collapsing Cores in Orion A

2024B-S043 Bo Huang, Institute of Space Sciences (ICE-CSIC)
Connecting magnetic fields from core scales to envelope scales

PROTOPLANETARY, TRANSITION, DEBRIS DISKS

2022B-S047 Karin Oberg, Center for Astrophysics | Harvard & Smithsonian
SMA-SPEC: the SMA Survey of Protoplanetary disks to Explore their Chemistry [SAO Large Scale Project]

2024B-A001 Chia-Ying Chung, National Sun Yat-sen University
Grain growth efficiency in compact protoplanetary disks

2024B-S016 Alice Booth, Center for Astrophysics | Harvard & Smithsonian
Revealing the typical mass and composition of disks around intermediate mass stars

2024B-S051 Ian Rabago, Universita Degli Studi di Milano
DDT: Long-Term Thermal Monitoring of a Polar Protoplanetary Disk

2025A-S052 Alice Booth, Center for Astrophysics | Harvard & Smithsonian
DDT: Pies in the sky: A first look into the newly discovered edge-on disk Sheppard's Pie

SOLAR SYSTEM

2024B-S036 Arielle Moullet, NRAO
Thermal Studies of Near-Earth Asteroids: SMA campaign #3

2024B-S039 Alex Akins, Jet Propulsion Laboratory
An SMA Spectral Survey of Venus' Mesosphere

SUBMM/HI-Z GALAXIES

2024B-S012 Ayushi Parmar, Imperial College London
The Nature of SPIRE-dropouts in the Herschel-SPIRE Deep Field

RECENT PUBLICATIONS

TITLE: Comprehensive Radio Monitoring of the Black Hole X-ray Binary Swift J1727.8-1613 during its 2023-2024 Outburst
AUTHOR(S): Hughes, A. K., Carotenuto, F., Russell, T. D., Tetarenko, A. J., Miller-Jones, J. C. A., Bahramian, A., Bright, J. S., Cowie, F. J., Fender, R., Gurwell, M. A., Khaulsay, J. K., Kirby, A., Jones, S., Lescure, E., McCollough, M., Plotkin, R. M., Rao, R., Vrtilek, S. D., Williams-Baldwin, D. R. A., Wood, C. M., Sivakoff, G. R., Altamirano, D., Casella, P., Corbel, S., DeBoer, D. R., Del Santo, M., Echiburu-Trujillo, C., Farah, W., Gandhi, P., Koljonen, K. I. I., Maccarone, T., Matthews, J. H., Markoff, S. B., Pollak, A. W., Russell, D. M., Saikia, P., Castro Segura, N., Shaw, A. W., Siemion, A., Soria, R., Tomsick, J. A., van den Eijnden, J.
PUBLICATION: *arXiv e-prints, arXiv:2506.07798*
PUBLICATION DATE: 06/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250607798H*
DOI: 10.48550/arXiv.2506.07798

TITLE: The Role of Pressure in the Structure and Stability of GMCs in the Andromeda Galaxy
AUTHOR(S): Lada, C. J., Forbrich, J., Krumholz, M. R., Keto, E.
PUBLICATION: *The Astrophysical Journal, 986, 12*
PUBLICATION DATE: 06/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...986...12L*
DOI: 10.3847/1538-4357/adcf9d

TITLE: SYMPHANY- SYnergy of Molecular PHase And Neutral hYdrogen in galaxies in A2626
AUTHOR(S): Deb, T., Keating, G. K., Zabel, N., Moretti, A., Bacchini, C., Davis, T. A., Poggianti, B. M., Gullieuszik, M., Vulcani, B., Jeffé, Y., Tomicic, N., Brown, T.
PUBLICATION: *arXiv e-prints, arXiv:2505.15060*
PUBLICATION DATE: 05/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250515060D*
DOI: 10.48550/arXiv.2505.15060

TITLE: Origin of the X-ray emission in blazars through multiwavelength polarization
AUTHOR(S): Liodakis, I., Zhang, H., Boula, S., Middei, R., Otero-Santos, J., Blinov, D., Agudo, I., Böttcher, M., Chen, C.-T., Ehlert, S. R., Jorstad, S. G., Kaaret, P., Krawczynski, H., Peirson, A. L., Romani, R. W., Tavecchio, F., Weisskopf, M. C., Kouch, P. M., Lindfors, E., Nilsson, K., McCall, C., Jermak, H. E., Steele, I. A., Myserlis, I., Gurwell, M., Keating, G. K., Rao, R., Kang, S., Lee, S.-S., Kim, S., Cheong, W. Y., Jeong, H.-W., Angelakis, E., Kraus, A., José Aceituno, F., Bonnoli, G., Casanova, V., Escudero, J., Agís-González, B., Morcuende, D., Sota, A., Bachev, R., Grishina, T. S., Kopatskaya, E. N., Larionova, E. G., Morozova, D. A., Savchenko, S. S., Shishkina, E. V., Troitskiy, I. S., Troitskaya, Y. V., Vasilyev, A. A.
PUBLICATION: *arXiv e-prints, arXiv:2505.13603*
PUBLICATION DATE: 05/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250513603L*
DOI: 10.48550/arXiv.2505.13603

TITLE: Origin of the ring ellipticity in the black hole images of M87*

AUTHOR(S): Dahale, R., Cho, I., Moriyama, K., Wiik, K., Tiede, P., Gómez, J. L., Chan, C.-. kwan ., Gold, R., Bernshteyn, V. Y., Foschi, M., Jeter, B., Pu, H.-Y., Georgiev, B., Joshi, A. V., Cruz-Osorio, A., Natarajan, I., Broderick, A. E., Salas, L. D. S., Chatterjee, K., Akiyama, K., Albentosa-Ruíz, E., Alberdi, A., Alef, W., Algaba, J. C., Anantua, R., Asada, K., Azulay, R., Bach, U., Baczko, A.-K., Ball, D., Baloković, M., Bandyopadhyay, B., Barrett, J., Bauböck, M., Benson, B. A., Bintley, D., Blackburn, L., Blundell, R., Bouman, K. L., Bower, G. C., Bremer, M., Brissenden, R., Britzen, S., Broguiere, D., Bronzwaer, T., Bustamante, S., Ferreira Carlos, D., Carlstrom, J. E., Chael, A., Chang, D. O., Chatterjee, S., Chen, M.-T., Chen, Y., Cheng, X., Christian, P., Conroy, N. S., Conway, J. E., Crawford, T. M., Crew, G. B., Cui, Y., Curd, B., Davelaar, J., De Laurentis, M., Deane, R., Dempsey, J., Desvignes, G., Dexter, J., Dhruv, V., Dihingia, I. K., Doeleman, S. S., Dzib, S. A., Eatough, R. P., Emami, R., Falcke, H., Farah, J., Fish, V. L., Fomalont, E., Ford, H. A., Fraga-Encinas, R., Freeman, W. T., Friberg, P., Fromm, C. M., Fuentes, A., Galison, P., Gammie, C. F., García, R., Gentaz, O., Geertsema, G., Goddi, C., Gómez-Ruiz, A. I., Gu, M., Gurwell, M., Hada, K., Haggard, D., Hesper, R., Heumann, D., Ho, L. C., Ho, P., Honma, M., Huang, C.-W. L., Huang, L., Hughes, D. H., Ikeda, S., Impellizzeri, C. M. V., Inoue, M., Issaoun, S., James, D. J., Jannuzi, B. T., Janssen, M., Jiang, W., Jiménez-Rosales, A., Johnson, M. D., Jorstad, S., Jones, A. C., Jung, T., Karuppusamy, R., Kawashima, T., Keating, G. K., Kettenis, M., Kim, D.-J., Kim, J.-Y., Kim, J., Kim, J., Kino, M., Koay, J. Y., Kocherlakota, P., Kofuji, Y., Koch, P. M., Koyama, S., Kramer, C., Kramer, J. A., Kramer, M., Krichbaum, T. P., Kuo, C.-Y., La Bella, N., Lee, S.-S., Levis, A., Li, Z., Lico, R., Lindahl, G., Lindqvist, M., Lisakov, M., Liu, J., Liu, K., Liuzzo, E., Lo, W.-P., Lobanov, A. P., Loinard, L., Lonsdale, C. J., Lowitz, A. E., Lu, R.-S., MacDonald, N. R., Mao, J., Marchili, N., Markoff, S., Marrone, D. P., Marscher, A. P., Martí-Vidal, I., Matsushita, S., Matthews, L. D., Medeiros, L., Menten, K. M., Mizuno, I., Mizuno, Y., Montgomery, J., Moran, J. M., Moscibrodzka, M., Mulaudzi, W., Müller, C., Müller, H., Mus, A., Musoke, G., Myserlis, I., Nagai, H., Nagar, N. M., Nair, D. G., Nakamura, M., Narayanan, G., Nathanail, A., Navarro Fuentes, S., Neilsen, J., Ni, C., Nowak, M. A., Oh, J., Okino, H., Raúl Olivares Sánchez, H., Oyama, T., Özel, F., Palumbo, D. C. M., Paraschos, G. F., Park, J., Parsons, H., Patel, N., Pen, U.-L., Pesce, D. W., Piétu, V., PopStefanija, A., Porth, O., Prather, B., Principe, G.

PUBLICATION: *arXiv e-prints, arXiv:2505.10333*

PUBLICATION DATE: 05/2025

ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250510333D*

DOI: 10.48550/arXiv.2505.10333

TITLE: Submillimeter observations of the white dwarf pulsar AR Sco

AUTHOR(S): Barrett, P. E., Gurwell, M. A.

PUBLICATION: *arXiv e-prints, arXiv:2505.06468*

PUBLICATION DATE: 05/2025

ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250506468B*

DOI: 10.48550/arXiv.2505.06468

TITLE: High Optical-to-X-Ray Polarization Ratio Reveals Compton Scattering in BL Lacertae's Jet

AUTHOR(S): Agudo, I., Liodakis, I., Otero-Santos, J., Middei, R., Marscher, A., Jorstad, S., Zhang, H., Li, H., Di Gesu, L., Romani, R. W., Kim, D. E., Fenu, F., Marshall, H. L., Pacciani, L., Escudero Pedrosa, J., Aceituno, F. J., Agís-González, B., Bonnoli, G., Casanova, V., Morcuende, D., Piirola, V., Sota, A., Kouch, P. M., Lindfors, E., McCall, C., Jermak, H. E., Steele, I. A., Borman, G. A., Grishina, T. S., Hagen-Thorn, V. A., Kopatskaya, E. N., Larionova, E. G., Morozova, D. A., Savchenko, S. S., Shishkina, E. V., Troitskiy, I. S., Troitskaya, Y. V., Vasilyev, A. A., Zhovtan, A. V., Myserlis, I., Gurwell, M., Keating, G., Rao, R., Kang, S., Lee, S.-S., Kim, S., Cheong, W. Y., Jeong, H.-W., Angelakis, E., Kraus, A., Blinov, D., Maharana, S., Bachev, R., Jormanainen, J., Nilsson, K., Fallah Ramazani, V., Casadio, C., Fuentes, A., Traianou, E., Thum, C., Gómez, J. L., Antonelli, L. A., Bachetti, M., Baldini, L., Baumgartner, W. H., Bellazzini, R., Bianchi, S., Bongiorno, S. D., Bonino, R., Brez, A., Bucciantini, N., Capitanio, F., Castellano, S., Cavazzuti, E., Chen, C.-T., Ciprini, S., Costa, E., De Rosa, A., Del Monte, E., Di Lalla, N., Di Marco, A., Donnarumma, I., Doroshenko, V., Dovčiak, M., Ehlert, S. R., Enoto, T., Evangelista, Y., Fabiani, S., Ferrazzoli, R., García, J. A., Gunji, S., Hayashida, K., Heyl, J., Iwakiri, W., Kaaret, P., Karas, V., Kislat, F., Kitaguchi, T., Kolodziejczak, J. J., Krawczynski, H., La Monaca, F., Latronico, L., Maldera, S., Manfreda, A., Marin, F., Marinucci, A., Massaro, F., Matt, G., Mitsuishi, I., Mizuno, T., Muleri, F., Negro, M., Ng, C.-Y., O'Dell, S. L., Omodei, N., Oppedisano, C., Papitto, A., Pavlov, G. G., Peirson, A. L., Perri, M., Pesce-Rollins, M., Petrucci, P.-O., Pilia, M., Possenti, A., Poutanen, J., Puccetti, S., Ramsey, B. D., Rankin, J., Ratheesh, A., Roberts, O. J., Sgrò, C., Slane, P., Soffitta, P., Spandre, G., Swartz, D. A., Tamagawa, T., Tavecchio, F., Taverna, R., Tawara, Y., Tennant, A. F., Thomas, N. E., Tombesi, F., Trois, A., Tsygankov,

S. S., Turolla, R., Vink, J., Weisskopf, M. C., Wu, K., Xie, F., Zane, S.
PUBLICATION: *The Astrophysical Journal, 985, L15*
PUBLICATION DATE: 05/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...985L..15A*
DOI: 10.3847/2041-8213/adc572

TITLE: A Multiline Analysis of the Distribution and Excitation of CS and H₂CS in the HD 163296 Disk
AUTHOR(S): Law, C. J., Le Gal, R., Yamato, Y., Zhang, K., Guzmán, V. V., Hernández-Vera, C., Cleeves, L. I., Guidi, G., Booth, A. S.
PUBLICATION: *The Astrophysical Journal, 985, 84*
PUBLICATION DATE: 05/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...985...84L*
DOI: 10.3847/1538-4357/adc304

TITLE: The 4–400 GHz Survey for the 32 Class II Disks in the Taurus Molecular Cloud
AUTHOR(S): Chung, C.-Y., Tsai, A.-L., Wright, M., Xu, W., Long, F., Gurwell, M. A., Liu, H. B.
PUBLICATION: *The Astrophysical Journal Supplement Series, 277, 45*
PUBLICATION DATE: 04/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJS..277...45C*
DOI: 10.3847/1538-4365/adb717

TITLE: X-Ray Polarization of the High-synchrotron-peak BL Lacertae Object 1ES 1959+650 during Intermediate and High X-Ray Flux States
AUTHOR(S): Pacciani, L., Kim, D. E., Middei, R., Marshall, H. L., Marscher, A. P., Liodakis, I., Agudo, I., Jorstad, S. G., Poutanen, J., Errando, M., Di Gesu, L., Negro, M., Tavecchio, F., Wu, K., Chen, C.-T., Muleri, F., Antonelli, L. A., Donnarumma, I., Ehlert, S. R., Massaro, F., O'Dell, S. L., Perri, M., Puccetti, S., Aceituno, F. J., Bonnoli, G., Casanova, V., Escudero, J., Agís-González, B., Husillos, C., Morcuende, D., Otero-Santos, J., Sota, A., Kouch, P. M., Lindfors, E., Borman, G. A., Gómez, J. L., Kopatskaya, E. N., Larionova, E. G., Morozova, D. A., Savchenko, S. S., Vasilyev, A. A., Zhovtan, A. V., Blinov, D., Gourni, A., Kiehlmann, S., Kourtidis, A., Mandarakas, N., Palaiologou, E., Triantafyllou, N., Vervelaki, A., Myserlis, I., Gurwell, M., Keating, G., Rao, R., Angelakis, E., Kraus, A., Bachetti, M., Baldini, L., Baumgartner, W. H., Bellazzini, R., Bianchi, S., Bongiorno, S. D., Bonino, R., Brez, A., Bucciantini, N., Capitanio, F., Castellano, S., Cavazzuti, E., Ciprini, S., Costa, E., De Rosa, A., Del Monte, E., Di Lalla, N., Di Marco, A., Doroshenko, V., Dovčiak, M., Enoto, T., Evangelista, Y., Fabiani, S., Ferrazzoli, R., Garcia, J. A., Gunji, S., Hayashida, K., Heyl, J., Iwakiri, W., Kaaret, P., Karas, V., Kislat, F., Kitaguchi, T., Kolodziejczak, J. J., Krawczynski, H., La Monaca, F., Latronico, L., Maldera, S., Manfreda, A., Marin, F., Marinucci, A., Matt, G., Mitsuishi, I., Mizuno, T., Ng, C.-Y., Omodei, N., Oppedisano, C., Papitto, A., Pavlov, G. G., Peirson, A. L., Pesce-Rollins, M., Petrucci, P.-O., Pilia, M., Possenti, A., Ramsey, B. D., Rankin, J., Ratheesh, A., Roberts, O. J., Romani, R. W., Sgró, C., Slane, P., Soffitta, P., Spandre, G., Swartz, D. A., Tamagawa, T., Taverna, R., Tawara, Y., Tennant, A. F., Thomas, N. E., Tombesi, F., Trois, A., Tsygankov, S. S., Turolla, R., Vink, J., Weisskopf, M. C., Xie, F., Zane, S.
PUBLICATION: *The Astrophysical Journal, 983, 78*
PUBLICATION DATE: 04/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...983...78P*
DOI: 10.3847/1538-4357/adbbe2

TITLE: First Frequency Phase Transfer from the 3 mm to the 1 mm Band on an Earth-sized Baseline
AUTHOR(S): Issaoun, S., Pesce, D. W., Rioja, M. J., Dodson, R., Blackburn, L., Keating, G. K., Doeleman, S. S., Sohn, B. W., Jiang, W., Hoak, D., Yu, W., Torne, P., Rao, R., Tilanus, R. P. J., Martí-Vidal, I., Jung, T., Fitzpatrick, G., Sánchez-Portal, M., Sánchez, S., Weintroub, J., Gurwell, M., Kramer, C., Durán, C., John, D., Santaren, J. L., Kubo, D., Han, C.-C., Rottmann, H., SooHoo, J., Fish, V. L., Zhao, G.-Y., Algaba, J. C., Lu, R.-S., Cho, I., Matsushita, S., Schuster, K.-F.
PUBLICATION: *The Astronomical Journal, 169, 229*
PUBLICATION DATE: 04/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025AJ....169..229I*
DOI: 10.3847/1538-3881/adbb55

TITLE: From filament to clumps and cores: A multiscale study of fragmentation and the role of the magnetic field and gas velocity in the infrared dark cloud SDC18.624-0.070
AUTHOR(S): Lee, H.-T., Tang, Y.-W., Koch, P. M., Wang, J.-W., Clarke, S., Fuller, G. A., Peretto, N., Kim, W.-J., Yen, H.-W.
PUBLICATION: *Astronomy and Astrophysics, 696, A163*
PUBLICATION DATE: 04/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025A&A...696A.163L*
DOI: 10.1051/0004-6361/202452974

TITLE: Relationship between the γ-ray variability and the parsec-scale jet in the blazar 3C 454.3
AUTHOR(S): Palafox, E., Patiño-Álvarez, V. M., Chavushyan, V., Lobanov, A., Dzib, S. A., Zensus, A.
PUBLICATION: *Astronomy and Astrophysics, 696, A70*
PUBLICATION DATE: 04/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025A&A...696A..70P*
DOI: 10.1051/0004-6361/202452255

TITLE: Application of Resolved Low-J Multi-CO Line Modeling with RADEX to Constrain the Molecular Gas Properties in the Starburst M82
AUTHOR(S): Zhang, V., den Brok, J., Zhang, Q., Teng, Y.-H., Jiménez-Donaire, M. J., Koch, E. W., Usero, A., Walter, F., Boogaard, L., Yanitski, C., Eibensteiner, C., Bešlic, I., Verbena, J. L.
PUBLICATION: *The Astrophysical Journal, 982, 21*
PUBLICATION DATE: 03/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...982...21Z*
DOI: 10.3847/1538-4357/adb579

TITLE: The Structure of the Molecular Envelope of the Ring Nebula (NGC 6720)
AUTHOR(S): Kastner, J. H., Wilner, D. J., Ryder, D., Moraga Baez, P., De Marco, O., Sahai, R., Wootten, A., Zijlstra, A.
PUBLICATION: *The Astrophysical Journal, 981, 46*
PUBLICATION DATE: 03/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...981...46K*
DOI: 10.3847/1538-4357/adace1

TITLE: Relationship between the $γ-$ray variability and the pc-scale jet in the blazar 3C 454.3
AUTHOR(S): Palafox, E., Patiño-Álvarez, V. M., Chavushyan, V., Dzib, S. A., Lobanov, A., Zensus, J. A.
PUBLICATION: *arXiv e-prints, arXiv:2502.17689*
PUBLICATION DATE: 02/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250217689P*
DOI: 10.48550/arXiv.2502.17689

TITLE: Polarized dust emission in Arp220: magnetic fields in the core of an ultraluminous infrared Galaxy
AUTHOR(S): Clements, D. L., Zhang, Q., Pattle, K., Petitpas, G., Ding, Y., Cairns, J.
PUBLICATION: *Monthly Notices of the Royal Astronomical Society, 537, L67-L71*
PUBLICATION DATE: 02/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025MNRAS.537L..67C*
DOI: 10.1093/mnrasl/slae107

TITLE: Multiwavelength Variability Analysis of the Blazar PKS 0727-11: An ~ 168 day Quasiperiodic Oscillation in the γ-Ray
AUTHOR(S): Shen, Y., Yi, T., Dhiman, V., Mao, L., Dong, L.
PUBLICATION: *The Astrophysical Journal, 980, 153*
PUBLICATION DATE: 02/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...980..153S*
DOI: 10.3847/1538-4357/ada775

TITLE: Differential virial analysis: a new technique to determine the dynamical state of molecular clouds
AUTHOR(S): Krumholz, M. R., Lada, C. J., Forbrich, J.
PUBLICATION: *arXiv e-prints, arXiv:2501.16474*
PUBLICATION DATE: 01/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025arXiv250116474K*
DOI: 10.48550/arXiv.2501.16474

TITLE: Spectral Energy Distribution Modeling of BL Lacertae during a Large Submillimeter Outburst and Low X-Ray Polarization State
AUTHOR(S): Mondal, A., Sar, A., Kundu, M., Chatterjee, R., Majumdar, P.
PUBLICATION: *The Astrophysical Journal, 978, 43*
PUBLICATION DATE: 01/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025ApJ...978...43M*
DOI: 10.3847/1538-4357/ad9603

TITLE: The persistent shadow of the supermassive black hole of M87: II. Model comparisons and theoretical interpretations
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PUBLICATION: *Astronomy and Astrophysics, 693, A265*
PUBLICATION DATE: 01/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025A&A...693A.265E*
DOI: 10.1051/0004-6361/202451296

TITLE: REsolved ALMA and SMA Observations of Nearby Stars (REASONS): A population of 74 resolved planetesimal belts at millimetre wavelengths
AUTHOR(S): Matrà, L., Marino, S., Wilner, D. J., Kennedy, G. M., Booth, M., Krivov, A. V., Williams, J. P., Hughes, A. M., del Burgo, C., Carpenter, J., Davies, C. L., Ertel, S., Kral, Q., Lestrade, J.-F., Marshall, J. P., Milli, J., Öberg, K. I., Pawellek, N., Sepulveda, A. G., Wyatt, M. C., Matthews, B. C., MacGregor, M.
PUBLICATION: *Astronomy and Astrophysics, 693, A151*
PUBLICATION DATE: 01/2025
ABSTRACT: *https://ui.adsabs.harvard.edu/abs/2025A&A...693A.151M*
DOI: 10.1051/0004-6361/202451397

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