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Submillimeter Array Newsletter

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CONTENTS

FROM THE DIRECTOR

In November 2020, the SMA hosted an internal operations review with the main goals of:

- Improving array reliability by understanding and reducing time lost events, and by improving automation.
- Improving SMA user support by increasing the consistency of array performance, and by improving data reduction pathways
- Solidifying the medium-term (three years) goals for the observatory: including establishing priorities for the formal deployment and merging of the wSMA into SMA operations

The review, which was organized by SMA Project Scientist Garrett Keating and Senior Software Engineer Chris Moriarty, took place over three days, and was scheduled to enable full participation by SMA staff in different time zones. Presentations were made by more than twenty staff members, both at SAO and at ASIAA, and an anonymous survey, which was completed by 2/3 of SMA staff, gathered feedback and ideas on how to best improve SMA operations and scientific return.

The results of the operations review and survey will be posted shortly on the SMA website. Here I share the most significant:

- Further develop plans to field receivers with expanded IF, 16 GHz per sideband, from 0.1 to 16 GHz. To this end, the first such receiver is ready to ship to Maunakea, and we expect to demonstrate three-baseline interferometry with the new low frequency IF channels this summer.
- Work towards providing SMA users with publishable data products from a standard data reduction pipeline to better enable non-expert users to take advantage of SMA data.

Best wishes for a safe and successful 2021,

Raymond Blundell

CMZOOM II: CATALOG OF COMPACT SUBMILLIMETER DUST CONTINUUM SOURCES IN THE MILKY WAY'S CENTRAL MOLECULAR ZONE

Newsletter article by H Perry Hatchfield, based on the publication from:
H Perry Hatchfield[1], Cara Battersby[1,2], Eric Keto[2], Daniel Walker[1,3,4], Ashley Barnes[5], Daniel Callanan[2,6], Adam Ginsburg[7], Jonathan Henshaw[8], Jens Kauffman[9], J. M. Diederik Kruijssen[10], Steven N. Longmore[6], Xing Lu[4], Elisabeth A. C. Mills[11], Thushara Pillai[12], Qizhou Zhang[2], John Bally[13], Natalie Butterfield[14], Yanett A. Contreras[15], Luis C. Ho[16,17], Jürgen Ott[18], Nimesh Patel[2], Volker Tolls[2]

Background

Within the Milky Way's innermost ~500 pc, there lies a vast complex of ~ 3×10^7 $M_\odot$ of molecular gas known as the Central Molecular Zone, or the CMZ (Morris et al. 1996, Dahmen et al. 1998, Pierce-price et al. 2000), where star formation can be studied in an environment substantially different from those in the Galactic disk (e.g. Yusef-zadeh et al. 2008, Longmore et al. 2012, Longmore et al. 2013, Kauffmann et al. 2013, 2017a, b, Lu et al. 2015, 2019a, b). The molecular gas in this environment exhibits high densities (e.g. Rathborne et al. 2014) and temperatures (e.g. Mills and Morris 2013, Ginsburg et al. 2016), with intense pressures (e.g. Walker et al. 2018), magnetic fields (e.g. Pillai et al. 2015) and turbulence (e.g. Henshaw et al. 2016, Federrath et al. 2016), as well as high cosmic ray ionization rates (Goto et al. 2013, Harada et al. 2015, Le Petit et al. 2016, Oka et. al. 2019) and UV background radiation (e.g. Lis et al. 2001). The CMZ is a unique laboratory for studying star formation, as it is our best local analog to the conditions at the peak of cosmic star formation, providing us with an indirect glimpse into the cosmic history of star formation (Kruijssen & Longmore 2013) for which comparably detailed extragalactic observations are not possible.

The concentration of dense gas in the CMZ is much greater than is observed in the Galactic disc, leading conventional theories of star formation to predict a correspondingly high Star Formation Rate (SFR, Lada et al. 2012, Longmore et al. 2013, Barnes et al. 2017). However, this elevated rate of star formation is not observed, and in fact the CMZ's SFR is observed to be 10-100 times lower than predicted by current theories of star formation relative to the dense gas content (Immer et al. 2012, Koepferl et al. 2015, Longmore et al. 2013, Kruijssen & Longmore 2014, Barnes et al. 2017). Despite this dearth of star formation, there are many well studied stellar nurseries forming stars in the CMZ, including the cloud complexes Sagittarius B2 (Sgr B2), Sgr C, and the Dust Ridge (Gordon et al. 1993, Yusef-zadeh et al. 2008, 2009, Schmiede-

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ke et al. 2016, Ginsburg et al. 2018, Walker et al. 2018, Barnes et al. 2019, Lu et al. 2019a,b).

In order to effectively test theoretical explanations for this present lack of star formation, the *CMZoom* team has carried out a Submillimeter Array (SMA) large survey of all high density (N > 10^{23} cm^{-2}) material in the Galactic Center. In this work we use the 1.3 mm dust continuum from *CMZoom* to generate a catalog of all potential sites of massive star formation at sufficient resolution to resolve and characterize compact substructure. The *CMZoom* survey overview paper, Battersby et al. (2020), describes the survey strategy and imaging details, and reveals an overall lack of compact substructure within the dense gas of the CMZ, which further challenges theories of a universal density threshold for star formation. An article in the July 2020 issue of the SMA Newsletter provides a more complete summary of the survey overview[1].

Cataloging Procedure and Properties of Compact Submillimeter Sources

The *CMZoom* survey maps out all material in the CMZ above a column density of 10^{23} cm^{-2}, and in this work we catalog the compact substructure within the surveyed region. We construct a catalog from the 1.3 mm dust continuum using a pruned dendrogram algorithm, a hierarchical clustering method which produces a "tree" of related sources, with the highest level emission being the "leaves". We form an initial catalog of these leaves, which are then "pruned" such that only those with peak flux 6σ above the local RMS noise and with a mean flux 2σ above the local RMS noise remain in the final catalog. This two-fold thresholding ensures that the catalog is robust, while remaining consistent across the wide range of intensities and noise levels in the survey region. A second version of the catalog is constructed to relax the

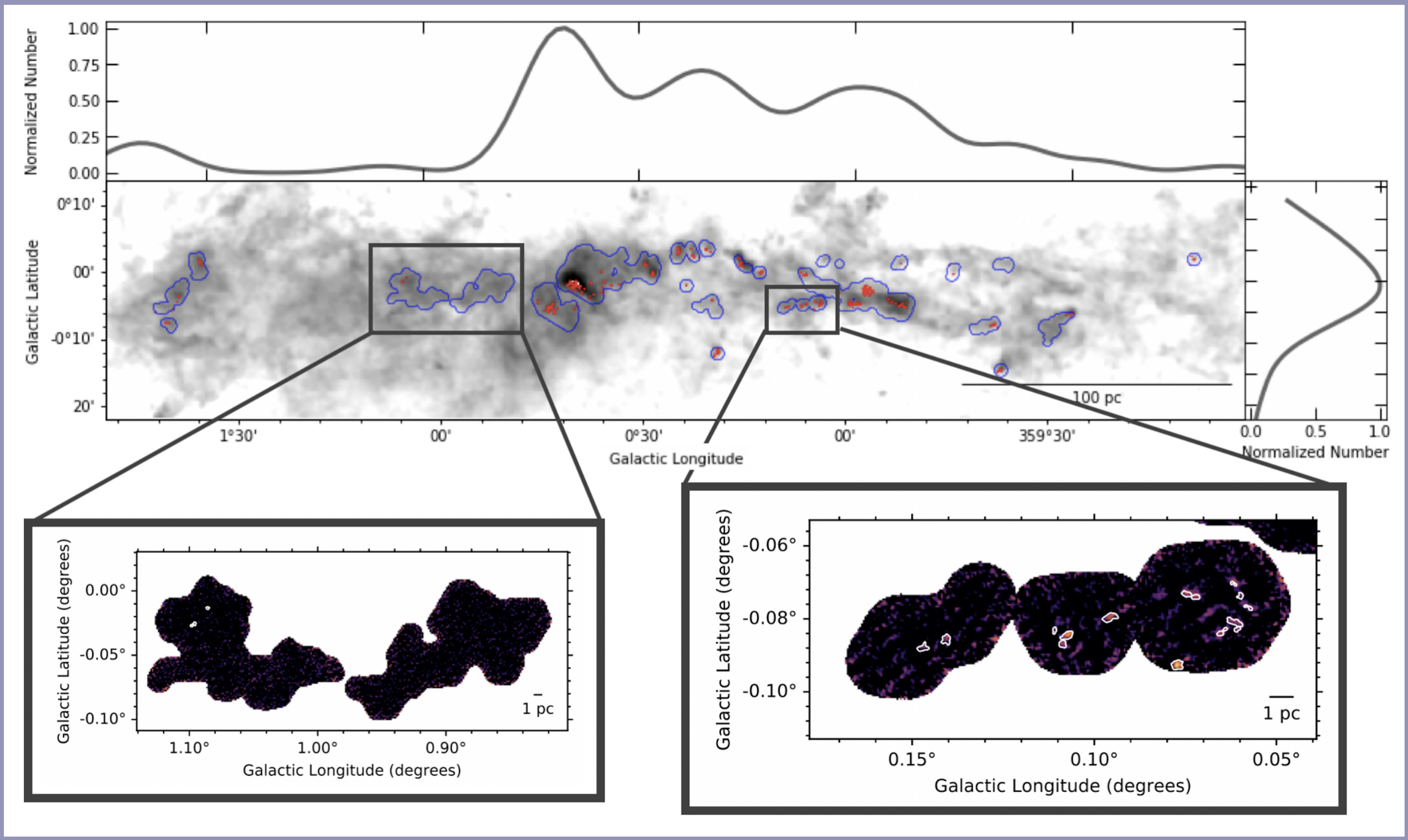

Figure 1: A column density map from Herschel with overlaid blue contours representing the *CMZoom* SMA footprint, and identified sources overplotted in red. A kernel density estimation is shown for the galactic longitude and latitude, representing the normalized distribution of the robust catalog's sources. The highest concentration of sources is in the Sgr B2 complex, the Dust Ridge, and the 50 km s^{-1} cloud, while many regions are devoid of compact substructure despite their high column densities. The two zoom-in panels show the 1.1 Degree Cloud Complex (left), which displays very little substructure, and the Three Little Pigs (right), which are named for their seemingly sequential increase in substructure complexity. The catalog sources are shown as white contours on top of the SMA 1.3mm dust continuum.

[1] https://www.cfa.harvard.edu/sma/Newsletters/SMA_NewsJuly2020.pdf

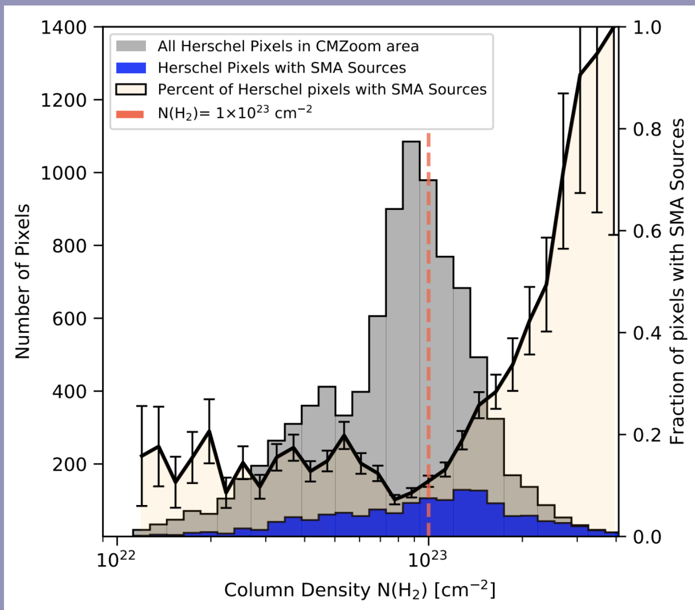

Figure 2: The column density distribution of the CMZoom robust catalog, derived from Herschel on 1.5 pc scales. The grey histogram displays the column density of all Herschel pixels within the CMZoom footprint, and the blue histogram represents the subset of these which house a robust catalog source. The black line is the fraction of Herschel pixels at each column density bin which have CMZoom sources. This fraction increases sharply past a column density threshold of 1-2×10^{23} cm-2, suggesting that compact substructure is more readily able to condense and persist at these high column densities.

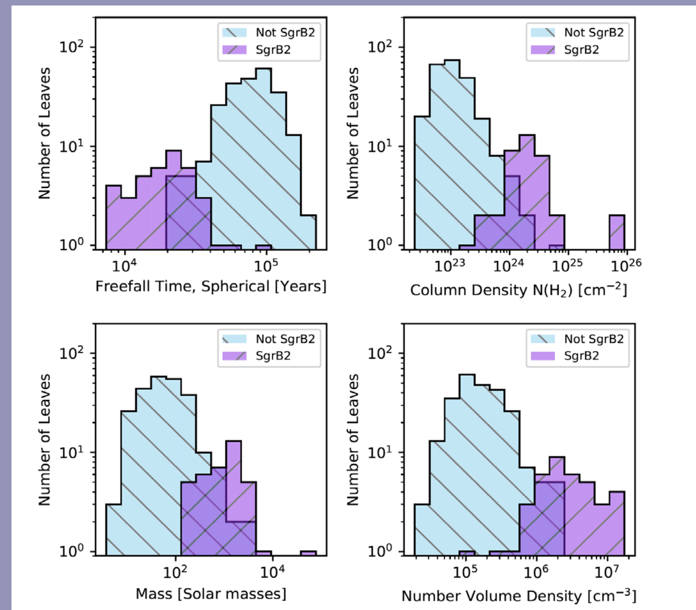

Figure 3: Histograms of the freefall time, column density, mass, and number density of all objects in the robust version of the catalog. The sources are separated by association with the Sgr B2 complex, where source properties are measured to be much more extreme than the rest of the CMZ. The SgrB2 distribution is substantially different from the rest of the catalog, which supports the idea that the SgrB2 complex may have significant line-of-sight complexity.

pruning threshold and increase completeness, and both versions of the catalog have been released along with the publication for use by the community. Figure 1 shows the distributions of these dendrogram leaves from the robust version of the catalog, along with zoom-ins of two sample regions. Figure 2 shows a histogram of the Herschel column densities at which SMA sources are found, a distribution with a sharp uptick around 1-2×10^{23} cm^{-2}. This sudden increase in compact structure may support the existence of an environmentally variable density threshold for gravitational collapse and star formation.

The sources in this catalog are intermediate to the canonical scales of clumps (~1pc) and cores (~0.1pc), given the typical spatial resolution of the CMZoom survey is ~0.1pc. From comparisons with overlapping Atacama Large Millimeter/submillimeter Array (ALMA) studies in the Dust Ridge (Barnes et al. 2019) and Sgr B2 (Ginsburg et al. 2018), it is clear that many of these compact sources have substructure on scales smaller than those resolved in these SMA observations. We test the completeness of these catalogs using simulated observations, mimicking the interferometric effects and noise of the SMA in its recovering of point-like sources. We find a 95% completeness limit for sources more massive than ~80 $M_{\odot}$ for the robust catalog, and 60 $M_{\odot}$ for the high completeness catalog. Both of these completeness estimates assume a dust temperature of the source of 20K, a typical value in this environment (Marsh et al. 2017). In regions with higher dust temperatures, these 95% completeness masses will decrease. Overall, we identify 285 compact sources in the robust catalog, with a median mass of ~86$M_{\odot}$, and 816 sources in the high completeness catalog with median mass ~33$M_{\odot}$, as it contains many more low mass source candidates.

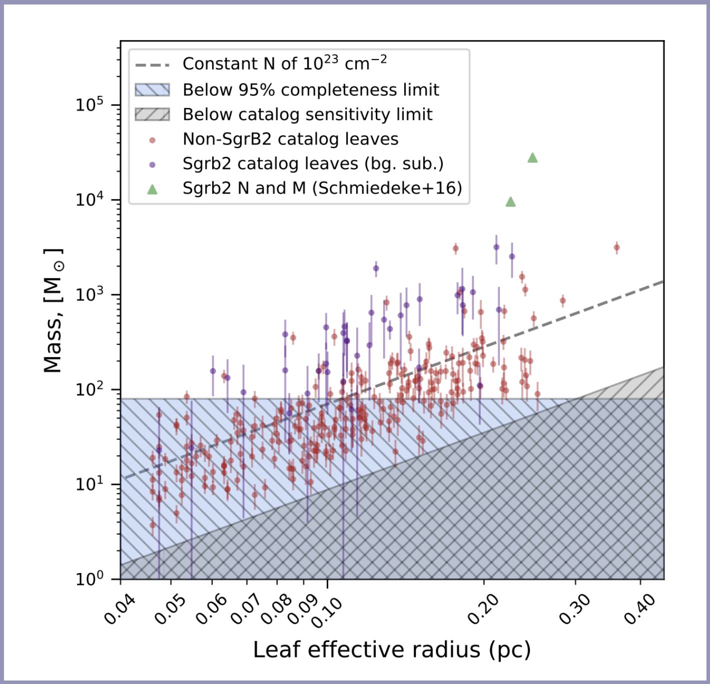

Figure 4: The mass-radius distribution for sources in the *CMZoom* robust catalog. A line of constant column density 10^{23} cm^{-2} is shown for reference, along with the 95% completeness mass and the catalog sensitivity limit. The sources for the Sgr B2 region are plotted using their background subtracted masses, which helps to address the line-of-sight complexity which might bias measurements of fluxes in this region. Additionally, we use the masses from Schmiedeke et al. (2016) to replace the source masses for Sgr B2 North and Main, for which the dust continuum is highly contaminated with free-free emission (Ginsburg et al. 2018).

Sagittarius B2: The Elephant in the Room

The well known star forming complex Sagittarius B2 (Sgr B2) dominates the high mass component of the catalog. These high mass Sgr B2 sources lie apart from the rest of the catalog, suggesting that they are either systematically different from the rest of the CMZ, or their fluxes are being interpreted incorrectly. Figure 3 shows how the populations of physical properties differ between Sgr B2 and the rest of the CMZ. A combination of high local dust temperatures, line-of-sight envelope overlap, and non-continuum contamination can readily explain the apparent divergence of these sources from the more general distribution of CMZ compact structures in mass-radius space. Figure 4 shows how the line of sight complexity can be partially mitigated by considering the background subtracted masses, in which the flux contained in lower components of the dendrogram hierarchy is subtracted away from the source flux. This interpretation is appropriate given the literature surrounding Sgr B2 suggests that this region is composed of clustered star forming structures with overlapping envelopes (e.g. Schmiedeke et al 2016).

High Mass Star Formation Completeness and the Star Formation Potential of the CMZ

The robust catalog produced in this work identifies nearly all sites of ongoing or potential future massive star formation in the CMZ. Because the mapping strategy for *CMZoom* was designed to be an unbiased map of all high column density material in the Galactic Center, we can use the completeness of this catalog to estimate our completeness to all possible sites of high mass star formation. By interpreting the catalog's completeness as a suggestion of the expected number of missing sources, and assuming a star formation efficiency along with a stellar initial mass function (IMF, e.g. Kroupa et al. 2001) for those expected missing sources, we find that the catalog is complete to >99% of possible sites of massive ($M > 8M_\odot$) star formation within the CMZ.

Given the completeness of this sample, we can estimate the maximum possible star formation potential of the CMZ. To accomplish this, we suppose that every source in the catalog forms stars with some star formation efficiency ε, and that these sources will collapse to form stars in a freefall time, thus producing the maximum number of stars possible for the region's distribution of dense gas. Under the assumption that few, if any, stars are forming outside of the high column density material which we completely survey, we find that the Galactic Center is currently unable to form more than 0.08-2.2 $M_\odot$ yr^{-1}, for ε ranging between 0.1 and 0.75. The variation quoted in this number is from differences in the assumed star formation efficiency for each source, and whether we use individual freefall times for each source or a global timescale for star formation characteristic to our sample. This star formation potential implies maximum star formation rates ranging between values similar to recent measurements of the CMZ's SFR, and the SFR of the entire Galaxy depending on the efficiency assumed. A large part of this star formation potential is localized to the Sgr B2 complex, the star formation properties of which have been studied extensively and characterized more accurately with ALMA (e.g. Ginsburg et al. 2018). Removing the star formation contribution due to

Sgr B2, we find the remaining star formation potential of the rest of the CMZ to be 0.04-0.47$M_{\odot}$ yr^{-1}.

Future Work

The *CMZoom* catalog provides a complete groundwork for more detailed surveys studying high mass star formation by identifying and characterizing nearly all possible sites of high mass star formation in the Milky Way's Galactic Center. The catalog presented here considers only the 1.3 mm dust continuum, and upcoming work will study the wealth of spectral line data available for each of the cataloged sources, exploring the complexity of the velocity structure for CMZ clouds in a variety of chemical species, as well as correlating the properties of cataloged sources with tracers of active and recent star formation. The full versions of both catalogs as well as the dust continuum maps are available on the *CMZoom* Dataverse[2], where the spectral cubes will be released along with an upcoming release paper (Callanan et al. in prep.).

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OBSERVATIONAL CORRELATION BETWEEN MAGNETIC FIELD, ANGULAR MOMENTUM, AND FRAGMENTATION IN THE ENVELOPES OF CLASS 0 PROTOSTARS?

Maud Galametz[1], Anaëlle Maury[1,2], Josep M. Girart[3,4], Ramprasad Rao[2], Qizhou Zhang[2], Mathilde Gaudel[5], Valeska Valdivia[1], Patrick Hennebelle[1], Victoria Cabedo-Soto[1], Eric Keto[2], Shih-Ping Lai[6]

Magnetic fields (hereafter B) are ubiquitous in the Universe (Vallee et al. 2004), and have been observed to permeate the interstellar material deep down into star-forming cores and protostellar environments (Girart et al. 2006, Hull et al. 2019). From a theoretical point of view, the presence of B in star-forming cores has been shown to significantly alter the dynamics of the gas participating in the building of stars during the accretion phase, and hence influence the resulting properties of these stars and associated circumstellar disks (Wurster et al. 2018, Hennebelle & Inutsuka et al. 2019). One of the main predictions of magnetized models is that the formation of large circumstellar disks may depend on the initial alignment of B compared to the rotational axis (Galli et al. 2006, Hennebelle & Fromang 2008, Masson et al. 2016, Hirano et al. 2019). Another prediction is that a strong, organized B-field partly alters the ability of a single core to fragment, suggesting the B-field is one of the regulating agents driving the birth of the multiple stellar systems commonly observed in the Galaxy (Hennebelle & Teyssier 2008).

Observationally, the influence of B-fields during the star-formation process is still poorly quantified. Very few studies attempted to test the predicted relationship linking the B-field orientation in protostellar cores to the angular momentum of the gas responsible for disk properties and the formation of multiple stellar systems. We used the Submillimeter Array to carry out observations of the dust polarized emission at 0.87 mm in the envelopes of a large sample of 20 Class 0 protostars (Figure 1). A part of the sample is presented in Galametz et al. (2018). The polarization angles were rotated by 90° to obtain the magnetic field direction. The mean magnetic field orientation is then estimated over the central 1000 au to characterize the orientation of the main component of the organized magnetic field at the envelope scales in these embedded protostars. This direction is compared to that of the protostellar outflow in order to study the relation of their misalignment and the kinematics of the circumstellar gas.

To trace the gas kinematics, we are using estimates of the velocity gradient at envelope scales that are constrained using interferometric observations of molecular line emission (mainly N_2H^+). Such observations have been routinely used to trace the organized gas motions across the core, whether this gas falls and/or rotates down to the protostellar central regions. The larger the gas velocity gradient, the larger the angular momentum of the collapsing-rotating circumstellar material which flows in, throughout the protostellar envelope towards the stellar embryo. For our sample, the measured velocity gradients range between ~1 and 20 km s^{-1} pc^{-1}, values consistent with the typical orders of magnitude reported in the literature for cores forming young solar analogues (Yen et al. 2015, Pineda et al. 2019, Gaudel et al. 2020). Figure 2

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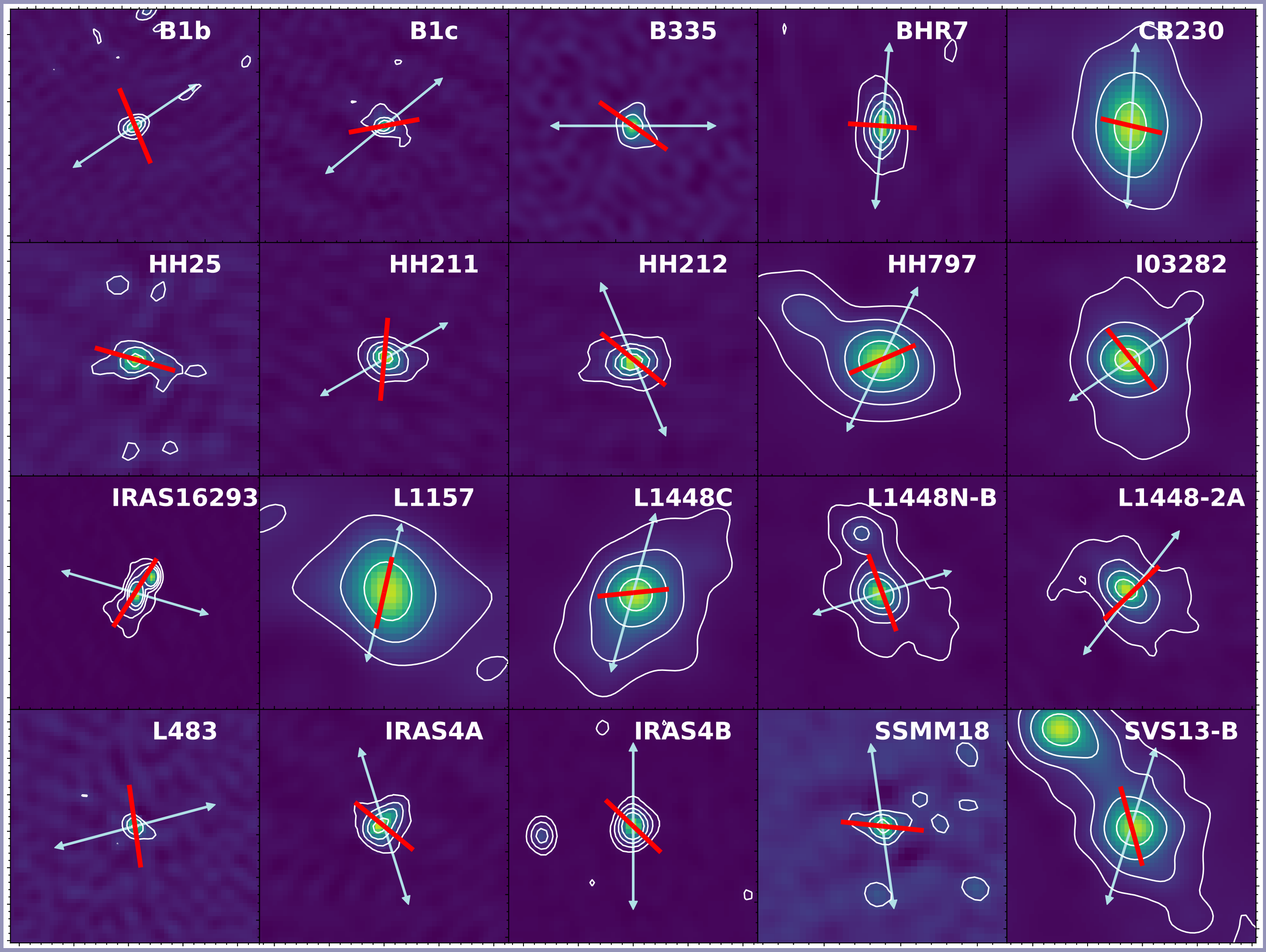

Figure 1: Mean magnetic field orientation in the 20 Class 0 protostellar envelopes (red segments) observed with the SMA, overlaid on the dust emission maps (contour and color maps). Contours are indicated for detections at 5, 20, 50, and 100 σ. The common physical scale of each map is 8000 × 8000 au. We indicate the outflow axis for each source with cyan arrows.

shows how the misalignment of B with respect to the outflow axis relates to the gas dynamics in the collapsing-rotating star-forming cores of the sample. Colors will be discussed later.

We report, for the first time, a positive correlation between the misalignment of B and the strength of the velocity gradient (Galametz et al. 2020, https://arxiv.org/abs/2010.12466). This observational correlation between B-field orientation and angular momentum of the star-forming gas in cores can have various interpretations.

One of them is that protostellar cores with large initial angular momentum develop a twisting of the B-field lines at the envelope scale when the gas collapses, generating a misalignment in the case of weak B-fields, while cores with stronger B-fields would remain organized despite the angular momentum of the gas. In such case, the organized motions of the gas in the envelope would drive the misalignment of B we observe at envelope scales, and we would expect a relation between the B-field and the velocity gradient position angles. However, such a relation between the B position angles and the velocity gradient angles is not observed in our sample.

Another interpretation is that configurations of initially aligned stronger B-field allow less angular momentum to be transported inside the core, as gas flows in. We favor this interpretation for two main reasons. First, the lack of relationship between the direction of the gas velocity gradient and the B-field configuration suggests the B-field observed

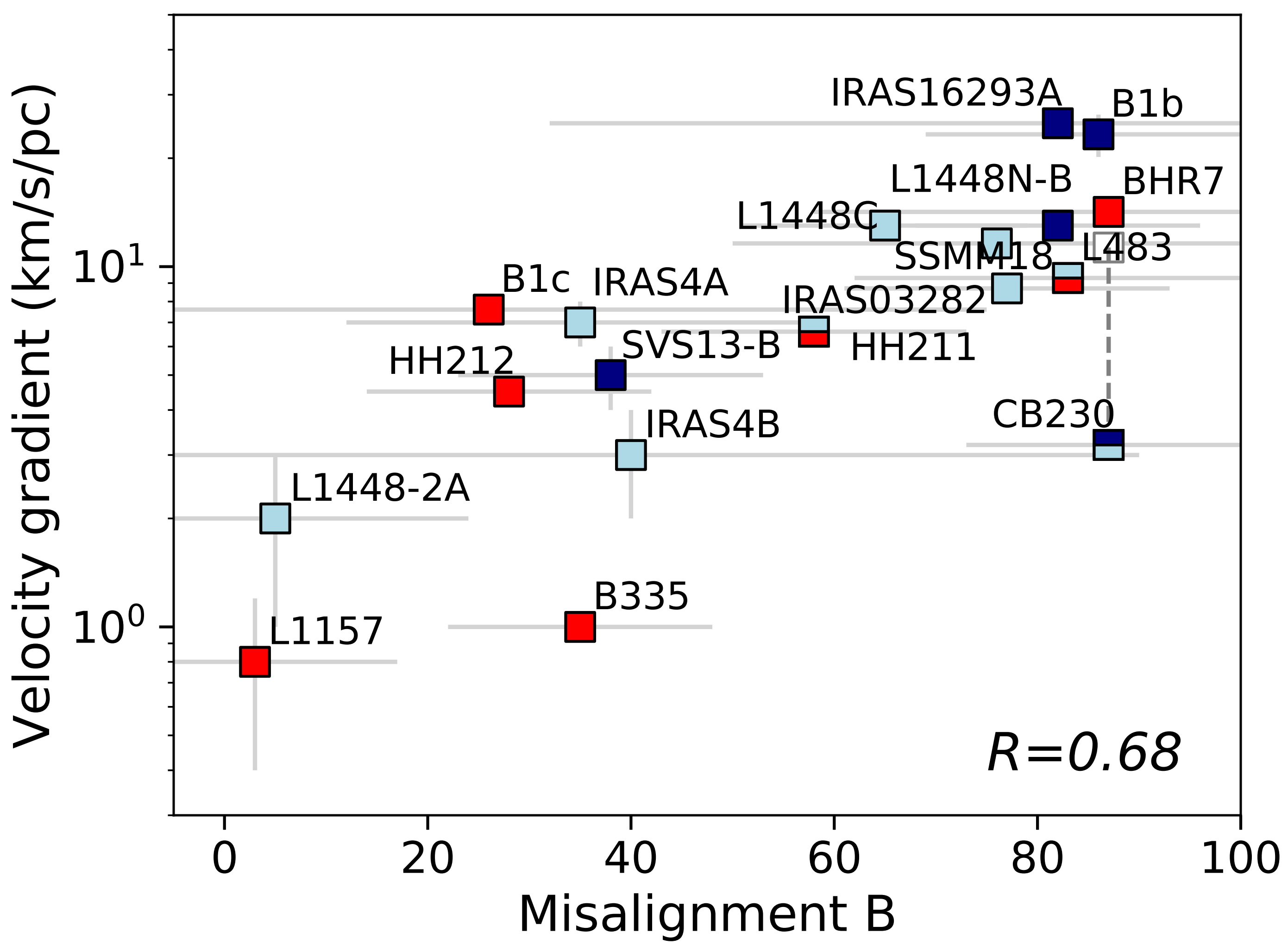

Figure 2: Projected angle between the mean magnetic field within the 1000 au central region and the outflow direction as a function of the velocity gradient of the source estimated from line measurements. Sources are color-coded as a function of their fragmentation below 5000 au scales (with red, light blue, and dark blue for sources with a detection of a single, double, and 3-4 dust peaks).

at core scales is a good representation of the initial large-scale field orientation in the core compared to, for instance, B-fields observed at smaller scales that have shown signatures of strong gravitational pull and significant line pinching (Girart et al. 2006, Maury et al. 2019, Le Gouellec et al. 2019). Second, the tight relationship we find between the orientation of the B-field at the envelope scale and the amount of organized angular momentum at these scales can be easily explained by magnetic braking. Non-ideal magneto-hydrodynamical protostellar formation models indeed suggest that the alignment of the B-field with the core rotation axis could influence the properties of the pristine protoplanetary disks because it regulates the angular momentum of the gas transferred inwards during the mass accretion of the forming star.

Magnetized models also predict that the ability of a given core to undergo global fragmentation, (and form the future binary / multiple stellar systems observed in our Galaxy) depends on the magnetic field misalignment in strong B-field configurations (Hennebelle & Teyssier 2008, Joos et al. 2012). In order to investigate the effect of the magnetic field on the envelope fragmentation, we color-code the sources of Fig. 2 depending on whether they are fragmented below 5000 au scales. We indicate in particular whether the source hosts a single, double, triple, or quadruple dust peak (using submillimeter direct imaging). Uncertainties remain on the nature of potential companions detected in HH211 and L483. We observe that sources that stand as single objects mostly reside in environments with weak velocity gradients and/or with rather well-aligned B-field orientations. 2D Kolmogorov-Smirnov tests return a low p-value of 0.13, indicating that the single and multiple source populations likely do not belong to the same population. We thus find tantalizing evidence that the initial alignment or misalignment of the B-field, still imprinted at envelope scales, correlates with the stellar multiplicity developing in the pristine envelopes forming the very first stars and disks. Observational studies have suggested that the magnetic field might affect the fragmentation rate at molecular clouds or filaments scales (e.g., Teixeira et al. 2016; Koch et al. 2018). Our analysis at protostellar envelope scales appears to support the theoretical predictions that the magnetic field orientation in the envelope also plays a role in favoring or inhibiting the fragmentation processes of a dense protostellar core into multiple stellar systems.

Our analysis of the B-field topology in 20 of the youngest protostars with the SMA has revealed a striking correlation between the misalignment of the magnetic field orientation at core scales and the angular momentum of the gas involved in the star formation process at similar scales. Comparing the trend with the presence of multiple stellar systems, we show that sources that stand as single objects mostly reside in environments with weak velocity gradient and/or rather aligned B-field orientation compared to the outflow axis. All together, our observations yield for the first time towards a coherent picture for the role of magnetic fields in forming stars and their protoplanetary disks: they suggest that a strong B-field in an aligned configuration may be more efficient in regulating both the gas kinematics and the level of fragmentation into multiple stellar systems during the star formation process. Our findings are in line with the theoretical expectation from state-of-the art magnetized models of star formation, which predict a reduced angular momentum at smaller scales due to magnetic braking. These conclusions will have to be confirmed with observational studies of larger samples. However, taken at face value, they may stand as the first strong observational confirmation of the cornerstone role of B-fields to regulate the formation of stellar systems and settle the primordial conditions from which the future disk, star and planets will form.

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AN ARCHIVAL ANALYSIS OF M87* SHOWS SMA AS ESSENTIAL TO THE DEVELOPMENT OF THE EHT

Jonathan Weintroub (CfA) and Maciek Wielgus (CfA)

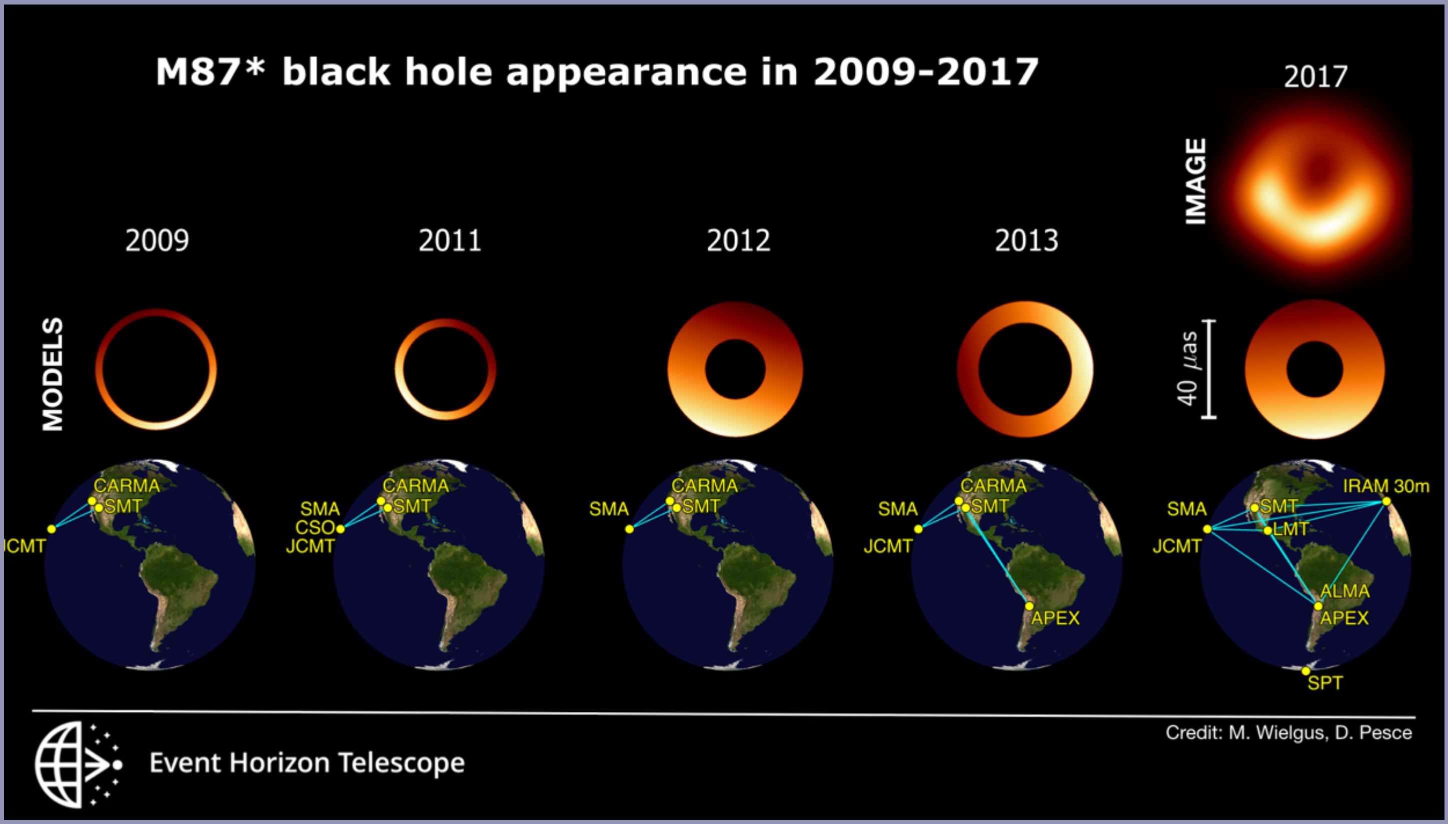


Figure 1: Snapshots of the M87* black hole obtained through imaging and geometric modeling, and the EHT array map in 2009-2017. The mean diameters of all rings agree within ~10%, and all measurements are consistent with the 42 micro-arcsecond diameter reported by the EHT last year. However, the location of the bright side varies significantly, which is challenging for some of the theoretical models of the accretion flow. Credit: Maciek Wielgus and Dom Pesce (CfA) & The Event Horizon Telescope Collaboration.

The iconic ring image of the M87 black hole released by the EHTC in April 2019 used data from a global eight station EHT array, including the SMA and the JCMT on Maunakea. This array observed M87* for four nights in 2017. In a decade prior to that groundbreaking observation, starting with the first transpacific fringe detection on Sgr A* in 2007, a smaller "proto-EHT array" made pathfinding observations mostly with just three geographic locations, Hawai'i, California and Arizona. The M87* data taken during campaigns in 2009, 2011, 2012, 2013 all used Maunakea telescopes. In 2011, 2012 and 2013 the SMA also contributed phased array collecting area to the EHT. In 2009 JCMT supported by SMA's maser and referencing system was the Maunakea station. The 2013 campaign included APEX in Chile as well.

SWARM, the new generation SMA correlator, had not been built yet, so the the phased array was a retrofit to the SMA's then ASIC correlator, which had been built without VLBI features. We called this pathfinding 1 GHz bandwidth (4 Gbps) beamformer system the "Phased Array Recording Instrument for Galactic Event Horizon Studies", or "PhRInGES".

In a retrospective analysis of archival data, Wielgus et al. have performed geometric modeling of the 2009 to 2017 EHT observations of M87*. A simple asymmetric ring model is motivated by EHT imaging and modeling using the 2017 data. Further confidence in the model results from the stability of fits across the proto-EHT observations. The estimated ring diameter is stable throughout, favoring its association with the shadow of a supermassive black hole. Modest intrinsic variability is seen in the total flux density of the ring and in its position angle. Looking forward, continued full EHT observations have the potential to confirm the variation of the estimated position angle and allow discrimination between viable models. These observations will also further improve estimates of the physical parameters of M87*.

This article refers to the following science paper:

Maciek Wielgus and the Event Horizon Telescope Collaboration
Monitoring the Morphology of M87* in 2009–2017 with the Event Horizon Telescope
The Astrophysical Journal, 901:67, 2020 September 20
https://doi.org/10.3847/1538-4357/abac0d

MIR: STATUS UPDATES AND FUTURE DEVELOPMENTS

Charlie Qi (CfA) and Mark Gurwell (CfA)

Introduction:

MIR, the Millimeter Interferometer Reduction package, is an IDL-based offline data reduction software package for the SMA. The MIR software is highly flexible and adapts to SMA's fast-changing hardware and data format upgrades. MIR has recently undergone several new developments, including faster, memory-saving data loading, new spectral brightness models for solar system calibration sources, and new versions of data support (designated v2 and v3 data formats). We are currently focusing upgrades of MIR capability to fully incorporate and utilize the scanning spectrometer data, allow cloud-based scripting calibration, and to provide better data translation to and calibration integration with CASA.

ABOUT THE MIR PACKAGE

The MIR package was originally developed using IDL for calibration of data from the Owens Valley Radio Observatory (OVRO) millimeter array, and was based upon the OVRO in-house calibration package MMA. Since the early 2000's, it has been adapted to and developed for calibration of SMA data, and today remains the primary interactive calibration package for the SMA. With MIR, the SMA data are loaded into IDL for calibration, and the results can then be output to MIRIAD or UVFITS files for imaging or UV analysis. The MIR package is extremely flexible and easily updated; this flexibility makes it ideal to adapt to the fast-changing nature of the SMA hardware developments. The package is the simplest of those in use at radio interferometers — only about 1.5 MB in size, easy to maintain and develop, the calibration process is fast, and it is backward compatible with all the previous versions of the SMA data. The primary limitations are that since it is written in IDL, it (1) requires IDL licenses to work, and (2) all the data to be calibrated must be entirely loaded into memory for processing. This worked well when SMA data sets were 100's of MB to a couple GB total, but as the SMA SWARM correlator has expanded, our data sizes routinely exceed several 10's of GB, requiring processing machines with 100+GB of memory. However, there are several methods in place to reduce the data size through preprocessing, depending on the needs of the user. Please refer to the CfA's Radio Telescope Data Center (RTDC) and the MIR cookbook websites for the details of the SMA data calibration.

LINKS:

A more formal introduction to MIR:
https://www.cfa.harvard.edu/rtdc/SMAdata/process/mir/

The MIR Cookbook for use cases:
http://www.cfa.harvard.edu/~cqi/mircook.html

RECENT UPDATES

Here we highlight a few recent developments of MIR:

Data loading, implemented in the task 'readdata'. A new way of loading the raw SMA data into memory has been implemented, reducing the memory needed by a factor of two. Depending on the available virtual memory and the swap space usage, the speed of data loading increases by a factor of 1.2-2.

Brightness temperature models. The flux standard brightness temperature models from CASA (current version from CASA 5.6.0) are now available for MIR calibration by default. The available sources are "primary" sources including Uranus, Mars, Callisto, Ganymede, and Titan, and "secondary" sources including Vesta and Pallas. The time variable flux density models are available for Ceres, Lutetia, Mars, Pallas, and Vesta.

New data versions. MIR data forms v2 and v3 are fully supported. MIR v2 data, spanning between 2019 October 3 and

2020 July 1, includes correct normalization of the SWARM correlation coefficients, and spectral spike marking. MIR v3 data, starting after 2020 July 1, adds support for the spectral continuum band, with each channel of the continuum band generated from the vector average over each 2 GHz SWARM segment. The current six-segment SWARM coverage for each receiver+sideband combination (covering 12 GHz) is now associated with a 6-channel spectral band with 2 GHz channels. The averaged frequency, bandwidth and weights information of the entire 12 GHz IF band are now stored using the new baseline (bl) headers fave, bwave, and wtave.

FUTURE DEVELOPMENTS

Future MIR developments will focus on (1) utilizing the scanning spectrometer data for spectral weights/noise estimates of individual visibilities[1], (2) testing cloud-based scripting calibrations to support calibration including dual receiver full polarization calibration for the future wSMA upgrades[2], and (3) enhancing the translation of SMA data into a useful format for CASA, by placing the SMA UVFITS output in the topocentric velocity reference frame.

MIR UPDATE: MIR FIX FOR THE OFF-BY-ONE CHANNEL ERROR

During the transition of replacing the ASIC correlator with the SWARM correlator, SMA had a hybrid data mode which included both ASIC and SWARM chunks in the data. In order to differentiate an ASIC chunk from a SWARM chunk, a header variable in the sp_read structure was used as a flag, i.e. 1 for SWARM and 0 for ASIC, starting on 2016 June 3rd. Unfortunately the same header variable was also used in the MIR package as a channel number incrementing index for a temporary function, and the variable was not reset when the function became obsolete. This led to what was recently discovered to be an off-by-one channel error, in which SWARM data taken after 2016 June 3rd were loaded in MIR by effectively skipping the first channel of each correlator segment, resulting in an offset, by one channel, relative to the design expectation. Since the first and last channel are well within the segment guard band and typically discarded, the channel skip itself did not result in important data loss.

The SMA correlator coverage uses an alternating channel-vs-frequency direction for adjacent 2 GHz segments. This 'off-by-one channel' error therefore would have caused a two channel relative shift in the overlap region between adjacent segments. However, possibly due to comparison of SWARM and ASIC data at the start of the SWARM era, the reported frequencies in the data were adjusted by one native channel resolution element, or +/-139.648 kHz, to make them agree. In effect, a correction was applied in the data recording software to fix the undiscovered 'off-by-one' error in the MIR readdata task. This means that data analyzed at the native resolution provided by SWARM were properly aligned in frequency space throughout the past 4 years.

However, data processed by the rebinning program SMARechunker were affected by a frequency offset. For a rebinning factor of n, the frequency offset would be equal to +/-(n-1) x 139.648 kHz. SMA staff discovered the off-by-one data error serendipitously when testing the new per-segment continuum data product. The MIR readdata program was corrected to no longer skip the first channel of each segment, while at the same time adjusting the frequency and velocity headers for each SWARM segment by +/- 139.648 kHz, to correct the introduced frequency offset in the data recording program. This solution means the data recording has not changed, and all data from the SWARM era can be read into MIR using the same procedure. After testing, this correction has been implemented in MIR starting on 2020 October 2nd.

In summary, rebinned SWARM data loaded into MIR before 2020 October have an incorrect frequency header with frequency change about one rebinned channel width. Native resolution SWARM data loaded into MIR during that period are not affected.

[1] Currently MIR is able to handle system temperature data on a per-segment basis for calibration usage.
[2] Limited testing has been run through the Amazon Web Service (AWS).

2021 SUBMILLIMETER ARRAY INTERFEROMETRY SCHOOL

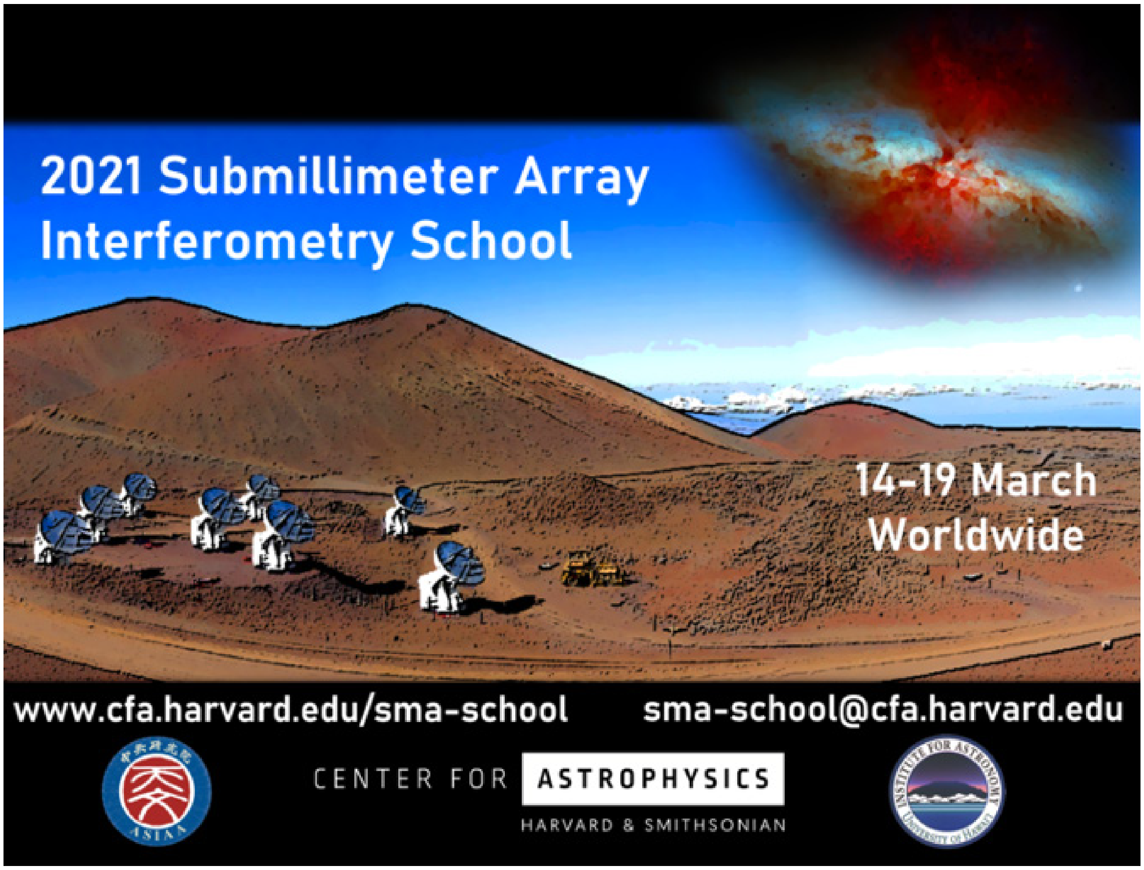
The Center for Astrophysics, in conjunction with the Academia Sinica Institute of Astronomy and Astrophysics and the University of Hawaii, is organizing the second Submillimeter Array Interferometry School.

The school will be held virtually between March 14–19th 2021. The main goals of the school are to provide graduate students, postdocs and scientists with a broad knowledge of interferometry and data reduction techniques at (sub)millimeter wavelengths.

The workshop will provide a series of online lectures on the fundamentals of radio interferometry with a special emphasis on observations at (sub)millimeter wavelengths along with data reduction tutorials with SMA observations. The school will extensively utilize the Submillimeter Array (SMA) on Mauna Kea, Hawaii and its new capabilities, providing hands-on experience of data reduction for projects proposed by school participants. Multiple sessions will be organized daily to accommodate participants from all time zones.

Website: www.cfa.harvard.edu/sma-school

Contact: sma-school@cfa.harvard.edu



CALL FOR STANDARD OBSERVING PROPOSALS - 2021A SEMESTER

We wish to draw your attention to the next Call for Standard Observing Proposals for observations with the Submillimeter Array (SMA). This call is for the 2021A semester with observing period **16 May 2021 - 15 Nov 2021.**

Standard Observing Proposals Submission deadline: **Thursday, 4 March 2021 21:00 GMT**

The full Call for Proposals, with details on time available and the proposal process, will be available by January 30 at the SMA Observer Center (SMAOC) at **http://sma1.sma.hawaii.edu/call.html.**

Details on the SMA capabilities and status can be found at **http://sma1.sma.hawaii.edu/status.html;** proposal creation and submission is also done through the SMAOC at **http://sma1.sma.hawaii.edu/proposing.html.** We are happy to answer and questions and provide assistance in proposal submission, simply email sma-propose@cfa.harvard.edu with any inquiries.

Sincerely,

Mark Gurwell
SAO Chair, SMA TAC

Hau-Yu (Baobab) Liu
ASIAA Chair, SMA TAC

STAFF CHANGES IN HILO

MAC COOPER RETIRES AFTER 20 YEARS AT SMA

Mac Cooper retired at the end of January, just over twenty years after he joined the SMA in Hilo. Previously, Mac worked at the CSO for a decade, where he supported the CSO–JCMT interferometry experiments. At the SMA, Mac tirelessly supported crucial systems as the telescope progressed from initial testing with three antennas into full operations. He kept the complex, heterogeneous, distributed IT infrastructure running despite a seemingly continuous stream of external interruptions and unexpected outages. To support additional capabilities, such as high speed networking, a new correlator, and greatly expanded data volumes, he made major upgrades, integrating new technologies and methods while maintaining the original legacy systems that are the foundation for SMA operations.

Thank you, Mac, for your contributions to the SMA over all these years. Smooth Sailing and Happy Retirement!

Michael Flower, IT Specialist, joined SAO in January, reporting to Simon Radford. A veteran of the US Air Force, he has worked for the US Army Corps of Engineers and other DoD agencies.

Austin Jennings, Astrophysicist (Telescope Operator), joined SAO in August, reporting to Ram Rao. He recently earned his bachelor's degree in astronomy at the University of Hawaiʻi at Hilo.

RECEIVER LAB TALKS

We have resumed the Receiver Lab Talk on Wednesdays after a short summer break in August. During the last 4 months of 2020, we had a total of 11 talks, which focused mainly on instrumentation for radio-astronomy. Most of the speakers are from within the CfA and they range from graduate students to senior scientists. The audience includes current staff members of the CfA, veterans of the CfA, colleagues from MIT Haystack, and even colleagues from India. The attendance has been overwhelming, and we invite all to join us. If you would like to consider presenting a talk for the 2021 season, which will begin in mid-January of 2021, please contact Edward Tong **(etong@cfa.harvard.edu)**.

https://www.cfa.harvard.edu/sma/Projects/LabTalks/

PROPOSAL STATISTICS 2020B (16 NOV 2020 – 15 MAY 2021)

The SMA partner institutions received a total of 68 proposals (SAO 52, ASIAA 12, UHawaii 4) requesting observing time in the 2020B semester. The 64 proposals reviewed by the joint SAO and ASIAA Time Allocation Committee are divided among science categories as follows:

CATEGORY	PROPOSALS
submm/hi-z galaxies	13
low/intermediate mass star formation, cores	11
high mass (OB) star formation, cores	10
protoplanetary, transition, debris disks	10
local galaxies, starbursts, AGN	8
GRB, SN, high energy	7
evolved stars, AGB, PPN	2
other	1
solar system	1
Galactic center	1

TRACK ALLOCATIONS BY WEATHER REQUIREMENT (ALL PARTNERS):

PWV[1]	SAO	ASIAA	UH[2]
< 4.0mm	22A + 44B	1A + 17B	0
< 2.5mm	4A + 33B	2A + 2B	21
< 1.0mm	2A + 1B	5A + 0B	0
Total	**28A + 78B**	**8A + 19B**	**21**

(1) Precipitable water vapor required for the observations.

(2) UH does not list As and Bs.

TOP-RANKED 2020B SEMESTER PROPOSALS

The following is the listing of all SAO and ASIAA proposals with at least a partial A ranking with the names and affiliations of the principal investigators.

GALACTIC CENTER

Garrett "Karto" Keating, CfA
Polarimetric VLBI with the Event Horizon Telescope

GRB, SN, HIGH ENERGY

Anna Ho, UC Berkeley
Long-lived, luminous millimeter transients from engine-powered stellar explosions in dense environments

Deanne Coppejans, Northwestern University
Constraining the Nature and Progenitors of the Fast Blue Optical Transients

Yuji Urata, NCU
Electro-magnetic wave candidate of IceCube Neutrino event

LOCAL GALAXIES, STARBURSTS, AGN

Maria Jesus Jimenez-Donaire, CfA
Searching for Embedded Super Star Clusters in M82

Steven Willner, CfA
Disentangling radiating particle properties and jet physics from M87 multi-wavelength variability

LOW/INTERMEDIATE MASS STAR FORMATION, CORES

Naomi Hirano, ASIAA
Variability and proper motion of the L1448C(N) protostellar jet

PROTOPLANETARY, TRANSITION, DEBRIS DISKS

Romane Le Gal, CfA
Sulfur Chemistry in Planet-forming Disks

SOLAR SYSTEM

Mark Gurwell, CfA
Dance of the Trojans: Thermal Light Curve of the Patroclus-Menoetius Binary

SUBMM/HI-Z GALAXIES

David Clements, Imperial College London
Extreme Starbursts - the most rapidly star-forming galaxies in the universe (copied from 2019A-S003) (copied from 2019B-S003) (copied from 2020A-S005)

Kirsten Hall, Atomic and Molecular Physics Division, Center for Astrophysics | Harvard & Smithsonian
Constraining dust spectra and detecting hot quasar winds via the thermal Sunyaev-Zel'dovich Effect, Part 2

Rohit Kondapally, University of Edinburgh
Revealing the nature of the most extreme, dusty, LOFAR-identified galaxies at 3

Wei-Hao Wang, ASIAA
SMA STUDIES II: Unidentified SCUBA-2 Sources

STANDARD AND LARGE SCALE PROJECTS OBSERVED DURING 2020A

SMA Semester 2020A encompassed the period 16 May 2020 - 15 Nov 2020. However, the cessation of observational operations in response to the pandemic and then the initial recovery (spanning 17 March 2020 - 10 June 2020) adversely affected both the 2019B and 2020A semesters. Upon reinstating science operations, several projects from 2019B were moved into 2020A in order for them to be completed. Additionally, an SAO large scale program was allocated significant time in September and October. Listed below are all SMA standard and large scale projects that were at least partially completed during the SMA Semester 2020A.

2019B

Manar el Akel, Observatory of Paris, LERMA
The Rosetta stone to sulfur: H2S from laboratory to observations

Mislav Balokovic, CfA
High-frequency Radio Spectra Revealing Coronae of Nearby Radio-quiet Seyfert Nuclei

Giuliana Cosentino, ESO & University College of London
G034.77-00.55 and the first fully resolved CJ-type interstellar shock.

Garrett Karto Keating, CfA
Untangling the Molecular Mystery of An Unusual High-Redshift Galaxy

Junhao Liu, CfA
A pilot dust polarization survey of massive dense cores in Cygnus-X

2020A

Mojegan Azadi, CfA
The Non-Thermal Contribution from Radio Structures at Sub-mm Wavelengths

Chian-Chou Chen, ASIAA
Pinpointing the dusty star-forming galaxies around the Slug ELAN

Deanne Coppejans, Northwestern University
Diagnosing the Heart of an Old Supernova

Lennox Cowie, Institute for astronomy
SMA identification of submm sources behind A3290

Kirsten Hall, CfA
Constraining dust spectra and detecting hot quasar winds via the thermal Sunyaev-Zel'dovich Effect

Kevin Harrington, Argelander Institute for Astronomy
Rest-frame 775 - 1730 GHz ISM Diagnostics of the Most IR Luminous, Lensed Planck Starburst at z = 3

Anna Ho, UC Berkeley
A new class of energetic stellar explosions in a dense medium

Kuiyun Huang, CYCU
Multi-frequency follow-ups of Short GRBs

Romane Le Gal, CfA
Sulfur Chemistry in Planet-forming Disks

Romane Le Gal, CfA
First unbiased interferometric molecular survey of PDRs: NGC 7023 NW and 2023 S

Hau-Yu Baobab Liu, ASIAA
Millimeter Flux Variability/Stability of FU Orionis Objects and EXors

Feng Long, CfA
Testing Binary Formation with Disk Alignment

Jamila Pegues, CfA
SMA Survey of Chemistry in Herbig Ae/Be Protoplanetary Disks

Charlie Qi, CfA
Imaging of Comet C/2019 Y4(ATLAS)

Keping Qiu, Nanjing University
Catching the missing in CENSUS: mapping coldest condensations around worm to hot cores in Cygnus-X

William Schap, University of Florida
Characterizing the disk fraction of M dwarfs

Antony Stark, CfA
First Radio Observations of the Brightest Known Object at z > 5

Richard Teague, CfA
A 3D Exploration of an Edge-On Self-Gravitating Disk

LARGE SCALE PROJECT

Jan Forbrich, University of Hertfordshire
SMA Survey of Resolved Dust and Simultaneous CO Observations of GMCs in M31

RECENT PUBLICATIONS

TITLE: The Relativistic Jet Orientation and Host Galaxy of the Peculiar Blazar PKS 1413+135
AUTHOR: Readhead, A. C. S.; Ravi, V.; Liodakis, I.; Lister, M. L.; Singh, V.; Aller, M. F.; Blandford, R. D.; Browne, I. W. A.; Gorjian, V.; Grainge, K. J. B.; Gurwell, M. A.; Hodges, M. W.; Hovatta, T.; Kiehlmann, S.; Lähteenmäki, A.; McAloone, T.; Max-Moerbeck, W.; Pavlidou, V.; Pearson, T. J.; Peirson, A. L. Perlman, E. S.; Reeves, R. A.; Soifer, B. T.; Taylor, G. B.; Tornikoski, M.; Vedantham, H. K.; Werner, M.; Wilkinson, P. N.; Zensus, J. A.
PUBLICATION: *eprint arXiv:2012.04045*
PUB DATE: December 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020arXiv201204045R/abstract

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TITLE: Rapid Variability of Sgr A* across the Electromagnetic Spectrum
AUTHOR: Witzel, G.; Martinez, G.; Willner, S. P.; Becklin, E. E.; Boyce, 4 H.; Do, T.; Eckart, A.; Fazio, G. G.; Ghez, A.; Gurwell, M. A.; Haggard, D.; Herrero-Illana, R.; Hora, J. L.; Li, Z.; Liu, J.; Marchili, N.; Morris, Mark R.; Smith, Howard A.; Subroweit, M.; Zensus, J. A.
PUBLICATION: *eprint arXiv:2011.09582*
PUBLICATION DATE: November 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020arXiv201109582W/abstract

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TITLE: Multi-epoch SMA observations of the L1448C(N) protostellar SiO jet
AUTHOR: Yoshida, Tomohiro; Hsieh, Tien-Hao; Hirano, Naomi; Aso, Yusuke
PUBLICATION: *eprint arXiv:2011.04882*
PUBLICATION DATE: November 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020arXiv201104882Y/abstract

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TITLE: A Dust Trap in the Young Multiple System HD 34700
AUTHOR: Benac, Peyton; Matra, Luca; Wilner, David J.; Jimenez-Donaire, Maria J.; Monnier, John D.; Rich, Evan A.; Harries, Tim J.; Laws, Anna; Zhang, Qizhou
PUBLICATION: *eprint arXiv:2011.03489*
PUBLICATION DATE: November 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020arXiv201103489B/abstract

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TITLE: Multiwavelength analysis and the difference in the behavior of the spectral features during the 2010 and 2014 flaring periods of the blazar 3C 454.3
AUTHOR: Amaya-Almazán, Raúl Antonio; Chavushyan, Vahram; Patiño-Álvarez, Victor Manuel
PUBLICATION: *eprint arXiv:2010.13224*
PUBLICATION DATE: October 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020arXiv201013224A/abstract

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TITLE: An observational correlation between magnetic field, angular momentum and fragmentation in the envelopes of Class 0 protostars?
AUTHOR: Galametz, Maud; Maury, Anaëlle; Girart, Josep M.; Rao, Ramprasad; Zhang, Qizhou; Gaudel, Mathilde; Valdivia, Valeska; Hennebelle, Patrick; Cabedo-Soto, Victoria; Keto, Eric; Lai, Shih-Ping
PUBLICATION: *Astronomy & Astrophysics, Volume 644, id.A47, 19 pp.*
PUBLICATION DATE: December 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020A%26A...644A..47G/abstract

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TITLE: Rotational Spectra of Vibrationally Excited AlO and TiO in Oxygen-rich Stars
AUTHOR: Danilovich, T.; Gottlieb, C. A.; Decin, L.; Richards, A. M. S.; Lee, K. L. K.; Kamiński, T.; Patel, N. A.; Young, K. H.; Menten, K. M.
PUBLICATION: *The Astrophysical Journal, Volume 904, Issue 2, id.110, 21 pp.*
PUBLICATION DATE: December 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJ...904..110D/abstract

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TITLE: Constraining the Chemical Signatures and the Outburst Mechanism of the Class 0 Protostar HOPS 383
AUTHOR: Sharma, Rajeeb; Tobin, John J.; Sheehan, Patrick D.; Megeath, S. Thomas; Fischer, William J.; Jørgensen, Jes K.; Safron, Emily J.; Nagy, Zsofia
PUBLICATION: *The Astrophysical Journal, Volume 904, Issue 1, id.78, 16 pp.*
PUBLICATION DATE: November 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJ...904...78S/abstract

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TITLE: Hints for Icy Pebble Migration Feeding an Oxygen-rich Chemistry in the Inner Planet-forming Region of Disks
AUTHOR: Banzatti, Andrea; Pascucci, Ilaria; Bosman, Arthur D.; Pinilla, Paola; Salyk, Colette; Herczeg, Gregory J.; Pontoppidan, Klaus M.; Vazquez, Ivan; Watkins, Andrew; Krijt, Sebastiaan; Hendler, Nathan; Long, Feng
PUBLICATION: *The Astrophysical Journal, Volume 903, Issue 2, id.124, 18 pp.*
PUBLICATION DATE: November 2020
ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJ...903..124B/abstract

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TITLE: Monitoring the Morphology of M87* in 2009-2017 with the Event Horizon Telescope
AUTHOR: Wielgus, Maciek; Akiyama, Kazunori; Blackburn, Lindy; Chan, Chi-kwan; Dexter, Jason; Doeleman, Sheperd S.; Fish, Vincent L.; Issaoun, Sara; Johnson, Michael D.; Krichbaum, Thomas P.; Lu, Ru-Sen; Pesce, Dominic W.; Wong, George N.; Bower, Geoffrey C.; Broderick, Avery E.; Chael, Andrew; Chatterjee, Koushik; Gammie, Charles F.; Georgiev, Boris; Hada, Kazuhiro Loinard, Laurent; Markoff, Sera; Marrone, Daniel P.; Plambeck, Richard; Weintroub, Jonathan; Dexter, Matthew; MacMahon, David H. E.; Wright, Melvyn; Alberdi, Antxon; Alef, Walter; Asada, Keiichi; Azulay, Rebecca; Baczko, Anne-Kathrin; Ball, David; Baloković, Mislav; Barausse, Enrico; Barrett, John; Bintley, Dan; Boland, Wilfred; Bouman, Katherine L.; Bremer, Michael; Brinkerink, Christiaan D.; Brissenden, Roger; Britzen, Silke; Broguiere, Dominique; Bronzwaer, Thomas; Byun, Do-Young; Carlstrom, John E.; Chatterjee, Shami; Chen, Ming-Tang; Chen, Yongjun; Cho, Ilje; Christian, Pierre; Conway, John E.; Cordes, James M.; Crew, Geoffrey B.; Cui, Yuzhu; Davelaar, Jordy; De Laurentis, Mariafeliciae; Deane, Roger; Dempsey, Jessica; Desvignes, Gregory; Dzib, Sergio A.; Eatough, Ralph P.; Falcke, Heino; Fomalont, Ed; Fraga-Encinas, Raquel; Friberg, Per; Fromm, Christian M.; Galison, Peter; García, Roberto; Gentaz, Olivier; Goddi, Ciriaco; Gold, Roman; Gómez, José L.; Gómez-Ruiz, Arturo I.; Gu, Minfeng; Gurwell, Mark; Hecht, Michael H.; Hesper, Ronald; Ho, Luis C.; Ho, Paul; Honma, Mareki; Huang, Chih-Wei L.; Huang, Lei; Hughes, David H.; Inoue, Makoto; James, David J.; Jannuzi, Buell T.; Janssen, Michael; Jeter, Britton; Jiang, Wu; Jimenez-Rosales, Alejandra; Jorstad, Svetlana; Jung, Taehyun; Karami, Mansour; Karuppusamy, Ramesh; Kawashima, Tomohisa; Keating, Garrett K.; Kettenis, Mark; Kim, Jae-Young; Kim, Junhan; Kim, Jongsoo; Kino, Motoki; Koay, Jun Yi; Koch, Patrick M.; Koyama, Shoko; Kramer, Michael; Kramer, Carsten; Kuo, Cheng-Yu; Lauer, Tod R.; Lee, Sang-Sung; Li, Yan-Rong; Li, Zhiyuan; Lindqvist, Michael; Lico, Rocco; Liu, Kuo; Liuzzo, Elisabetta; Lo, Wen-Ping; Lobanov, Andrei P.; Lonsdale, Colin; MacDonald, Nicholas R.; Mao, Jirong; Marchili, Nicola; Marscher, Alan P.; Martí-Vidal, Iván; Matsushita, Satoki; Matthews, Lynn D.; Medeiros, Lia; Menten, Karl M.; Mizuno, Yosuke; Mizuno, Izumi; Moran, James M.; Moriyama, Kotaro; Moscibrodzka, Monika; Müller, Cornelia; Musoke, Gibwa; Nagai, Hiroshi; Nagar, Neil M.; Nakamura, Masanori; Narayan,

Ramesh; Narayanan, Gopal; Natarajan, Iniyan; Nathanail, Antonios; Neri, Roberto; Ni, Chunchong; Noutsos, Aristeidis; Okino, Hiroki; Olivares, Héctor; Ortiz-León, Gisela N.; Oyama, Tomoaki; Özel, Feryal; Palumbo, Daniel C. M.; Park, Jongho; Patel, Nimesh; Pen, Ue-Li; Piétu, Vincent; PopStefanija, Aleksandar; Porth, Oliver; Prather, Ben; Preciado-López, Jorge A.; Psaltis, Dimitrios; Pu, Hung-Yi; Ramakrishnan, Venkatessh; Rao, Ramprasad; Rawlings, Mark G.; Raymond, Alexander W.; Rezzolla, Luciano; Ripperda, Bart; Roelofs, Freek; Rogers, Alan; Ros, Eduardo; Rose, Mel; Roshanineshat, Arash; Rottmann, Helge; Roy, Alan L.; Ruszczyk, Chet; Ryan, Benjamin R.; Rygl, Kazi L. J.; Sánchez, Salvador; Sánchez-Arguelles, David; Sasada, Mahito; Savolainen, Tuomas; Schloerb, F. Peter; Schuster, Karl-Friedrich; Shao, Lijing; Shen, Zhiqiang; Small, Des; Sohn, Bong Won; SooHoo, Jason; Tazaki, Fumie; Tiede, Paul; Tilanus, Remo P. J.; Titus, Michael; Toma, Kenji; Torne, Pablo; Trent, Tyler; Traianou, Efthalia; Trippe, Sascha; Tsuda, Shuichiro; van Bemmel, Ilse; van Langevelde, Huib Jan; van Rossum, Daniel R.; Wagner, Jan; Wardle, John; Ward-Thompson, Derek; Wex, Norbert; Wharton, Robert; Wu, Qingwen; Yoon, Doosoo; Young, André; Young, Ken; Younsi, Ziri; Yuan, Feng; Yuan, Ye-Fei; Zensus, J. Anton; Zhao, Guangyao; Zhao, Shan-Shan; Zhu, Ziyan

PUBLICATION: *The Astrophysical Journal, Volume 901, Issue 1, id.67, 28 pp.*

PUBLICATION DATE: September 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJ...901...67W/abstract

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TITLE: CMZoom. II. Catalog of Compact Submillimeter Dust Continuum Sources in the Milky Way's Central Molecular Zone

AUTHOR: Hatchfield, H. Perry; Battersby, Cara; Keto, Eric; Walker, Daniel; Barnes, Ashley; Callanan, Daniel; Ginsburg, Adam; Henshaw, Jonathan D.; Kauffmann, Jens; Kruijssen, J. M. Diederik; Longmore, Steve N.; Lu, Xing; Mills, Elisabeth A. C.; Pillai, Thushara; Zhang, Qizhou; Bally, John; Butterfield, Natalie; Contreras, Yanett A.; Ho, Luis C.; Ott, Jürgen Patel, Nimesh; Tolls, Volker

PUBLICATION: *The Astrophysical Journal Supplement Series, Volume 251, Issue 1, id.14, 29 pp.*

PUBLICATION DATE: November 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJS..251...14H/abstract

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TITLE: Gravitational Test Beyond the First Post-Newtonian Order with the Shadow of the M87 Black Hole

AUTHOR: Psaltis, Dimitrios; Medeiros, Lia; Christian, Pierre; Özel, Feryal; Akiyama, Kazunori; Alberdi, Antxon; Alef, Walter; Asada, Keiichi; Azulay, Rebecca; Ball, David; Baloković, Mislav; Barrett, John; Bintley, Dan; Blackburn, Lindy; Boland, Wilfred; Bower, Geoffrey C.; Bremer, Michael; Brinkerink, Christiaan D.; Brissenden, Roger; Britzen, Silke Broguiere, Dominique; Bronzwaer, Thomas; Byun, Do-Young; Carlstrom, John E.; Chael, Andrew; Chan, Chi-kwan; Chatterjee, Shami; Chatterjee, Koushik; Chen, Ming-Tang; Chen, Yongjun; Cho, Ilje; Conway, John E.; Cordes, James M.; Crew, Geoffrey B.; Cui, Yuzhu; Davelaar, Jordy; De Laurentis, Mariafelicia; Deane, Roger; Dempsey, Jessica; Desvignes, Gregory; Dexter, Jason; Eatough, Ralph P.; Falcke, Heino; Fish, Vincent L.; Fomalont, Ed; Fraga-Encinas, Raquel; Friberg, Per; Fromm, Christian M.; Gammie, Charles F.; García, Roberto; Gentaz, Olivier; Goddi, Ciriaco; Gómez, José L.; Gu, Minfeng; Gurwell, Mark; Hada, Kazuhiro; Hesper, Ronald; Ho, Luis C.; Ho, Paul; Honma, Mareki; Huang, Chih-Wei L.; Huang, Lei; Hughes, David H.; Inoue, Makoto; Issaoun, Sara; James, David J.; Jannuzi, Buell T.; Janssen, Michael; Jiang, Wu; Jimenez-Rosales, Alejandra; Johnson, Michael D.; Jorstad, Svetlana; Jung, Taehyun; Karami, Mansour; Karuppusamy, Ramesh; Kawashima, Tomohisa; Keating, Garrett K.; Kettenis, Mark; Kim, Jae-Young; Kim, Junhan; Kim, Jongsoo; Kino, Motoki; Koay, Jun Yi; Koch, Patrick M.; Koyama, Shoko; Kramer, Michael; Kramer, Carsten; Krichbaum, Thomas P.; Kuo, Cheng-Yu; Lauer, Tod R.; Lee, Sang-Sung; Li, Yan-Rong; Li, Zhiyuan; Lindqvist, Michael; Lico, Rocco; Liu, Jun; Liu, Kuo; Liuzzo, Elisabetta; Lo, Wen-Ping; Lobanov, Andrei P.; Lonsdale, Colin; Lu, Ru-Sen; Mao, Jirong; Markoff, Sera; Marrone, Daniel P.; Marscher, Alan P.; Martí-Vidal, Iván; Matsushita, Satoki; Mizuno, Yosuke; Mizuno, Izumi; Moran, James M.; Moriyama, Kotaro; Moscibrodzka, Monika; Müller, Cornelia; Musoke, Gibwa; Mus Mejías, Alejandro; Nagai, Hiroshi; Nagar, Neil M.; Narayan, Ramesh; Narayanan, Gopal; Natarajan, Iniyan; Neri, Roberto; Noutsos, Aristeidis; Okino, Hiroki; Olivares, Héctor; Oyama, Tomoaki; Palumbo, Daniel C. M.; Park, Jongho; Patel, Nimesh; Pen, Ue-Li; Piétu, Vincent; Plambeck, Richard; PopStefanija, Aleksandar; Prather, Ben; Preciado-López, Jorge A.; Ramakrishnan, Venkatessh; Rao, Ramprasad; Rawlings, Mark G.; Raymond, Alexander W.; Ripperda, Bart; Roelofs, Freek; Rogers, Alan; Ros, Eduardo; Rose, Mel; Roshanineshat, Arash; Rottmann, Helge; Roy, Alan L.; Ruszczyk, Chet; Ryan, Benjamin R.; Rygl, Kazi L. J.; Sánchez, Salvador; Sánchez-Arguelles, David; Sasada, Mahito; Savolainen, Tuomas; Schloerb, F. Peter; Schuster, Karl-Friedrich; Shao, Lijing; Shen, Zhiqiang; Small, Des; Sohn, Bong Won; SooHoo, Jason; Tazaki, Fumie; Tilanus, Remo P. J.; Titus, Michael; Torne, Pablo; Trent, Tyler; Traianou, Efthalia; Trippe, Sascha; van Bemmel, Ilse; van Langevelde, Huib Jan; van Rossum, Daniel R.; Wagner, Jan; Wardle, John; Ward-Thompson, Derek; Weintroub, Jonathan; Wex, Norbert;

Wharton, Robert; Wielgus, Maciek; Wong, George N.; Wu, Qingwen; Yoon, Doosoo; Young, André; Young, Ken; Younsi, Ziri; Yuan, Feng; Yuan, Ye-Fei; Zhao, Shan-Shan; EHT Collaboration

PUBLICATION: *Physical Review Letters, Volume 125, Issue 14, article id.141104*

PUBLICATION DATE: October 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020PhRvL.125n1104P/abstract

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TITLE: Interferometric Monitoring of Gamma-Ray Bright AGNs: OJ 287

AUTHOR: Lee, Jee Won; Lee, Sang-Sung; Algaba, Juan-Carlos; Hodgson, Jeffrey; Kim, Jae-Young; Park, Jongho; Kino, Motoki; Kim, Dae-Won; Kang, Sincheol; Yoo, Sungmin; Kim, Sang Hyun; Gurwell, Mark

PUBLICATION: *The Astrophysical Journal, Volume 902, Issue 2, id.104, 17 pp.*

PUBLICATION DATE: October 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020ApJ...902..104L/abstract

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TITLE: Linking ice and gas in the Serpens low-mass star-forming region

AUTHOR: Perotti, G.; Rocha, W. R. M.; Jørgensen, J. K.; Kristensen, L. E.; Fraser, H. J.; Pontoppidan, K. M.

PUBLICATION: *Astronomy & Astrophysics, Volume 643, id.A48, 23 pp.*

PUBLICATION DATE: November 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020A%26A...643A..48P/abstract

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TITLE: Event Horizon Telescope imaging of the archetypal blazar 3C 279 at an extreme 20 microarcsecond resolution

AUTHOR: Kim, Jae-Young; Krichbaum, Thomas P.; Broderick, Avery E.; Wielgus, Maciek; Blackburn, Lindy; Gómez, José L.; Johnson, Michael D.; Bouman, Katherine L.; Chael, Andrew; Akiyama, Kazunori; Jorstad, Svetlana; Marscher, Alan P.; Issaoun, Sara; Janssen, Michael; Chan, Chi-kwan; Savolainen, Tuomas; Pesce, Dominic W.; Özel, Feryal; Alberdi, Antxon; Alef, Walter Asada, Keiichi; Azulay, Rebecca; Baczko, Anne-Kathrin; Ball, David; Baloković, Mislav; Barrett, John; Bintley, Dan; Boland, Wilfred; Bower, Geoffrey C.; Bremer, Michael; Brinkerink, Christiaan D.; Brissenden, Roger; Britzen, Silke; Broguiere, Dominique; Bronzwaer, Thomas; Byun, Do-Young; Carlstrom, John E.; Chatterjee, Shami; Chatterjee, Koushik; Chen, Ming-Tang; Chen, Yongjun; Cho, Ilje; Christian, Pierre; Conway, John E.; Cordes, James M.; Crew, Geoffrey B.; Cui, Yuzhu; Davelaar, Jordy; De Laurentis, Mariafelicia; Deane, Roger; Dempsey, Jessica; Desvignes, Gregory; Dexter, Jason; Doeleman, Sheperd S.; Eatough, Ralph P.; Falcke, Heino; Fish, Vincent L.; Fomalont, Ed; Fraga-Encinas, Raquel; Friberg, Per; Fromm, Christian M.; Galison, Peter; Gammie, Charles F.; García, Roberto; Gentaz, Olivier; Georgiev, Boris; Goddi, Ciriaco; Gold, Roman; Gómez-Ruiz, Arturo I.; Gu, Minfeng; Gurwell, Mark; Hada, Kazuhiro; Hecht, Michael H.; Hesper, Ronald; Ho, Luis C.; Ho, Paul; Honma, Mareki; Huang, Chih-Wei L.; Huang, Lei; Hughes, David H.; Ikeda, Shiro; Inoue, Makoto; James, David J.; Jannuzi, Buell T.; Jeter, Britton; Jiang, Wu; Jimenez-Rosales, Alejandra; Jung, Taehyun; Karami, Mansour; Karuppusamy, Ramesh; Kawashima, Tomohisa; Keating, Garrett K.; Kettenis, Mark; Kim, Junhan; Kim, Jongsoo; Kino, Motoki; Koay, Jun Yi; Koch, Patrick M.; Koyama, Shoko; Kramer, Michael; Kramer, Carsten; Kuo, Cheng-Yu; Lauer, Tod R.; Lee, Sang-Sung; Li, Yan-Rong; Li, Zhiyuan; Lindqvist, Michael; Lico, Rocco; Liu, Kuo; Liuzzo, Elisabetta; Lo, Wen-Ping; Lobanov, Andrei P.; Loinard, Laurent; Lonsdale, Colin; Lu, Ru-Sen; MacDonald, Nicholas R.; Mao, Jirong; Markoff, Sera; Marrone, Daniel P.; Martí-Vidal, Iván; Matsushita, Satoki; Matthews, Lynn D.; Medeiros, Lia; Menten, Karl M.; Mizuno, Yosuke; Mizuno, Izumi; Moran, James M.; Moriyama, Kotaro; Moscibrodzka, Monika; Musoke, Gibwa; Müller, Cornelia; Nagai, Hiroshi; Nagar, Neil M.; Nakamura, Masanori; Narayan, Ramesh; Narayanan, Gopal; Natarajan, Iniyan; Neri, Roberto; Ni, Chunchong; Noutsos, Aristeidis; Okino, Hiroki; Olivares, Héctor; Ortiz-León, Gisela N.; Oyama, Tomoaki; Palumbo, Daniel C. 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M.; Jiang, Homin; John, David; Kamble, Atish; Keisler, Ryan; Kimura, Kimihiro; Kono, Yusuke; Kubo, Derek; Kuroda, John; Lacasse, Richard; Laing, Robert A.; Leitch, Erik M.; Li, Chao-Te; Lin, Lupin C. -C.; Liu, Ching-Tang; Liu, Kuan-Yu; Lu, Li-Ming; Marson, Ralph G.; Martin-Cocher, Pierre L.; Massingill, Kyle D.; Matulonis, Callie; McColl, Martin P.; McWhirter, Stephen R.; Messias, Hugo; Meyer-Zhao, Zheng; Michalik, Daniel; Montaña, Alfredo; Montgomerie, William; Mora-Klein, Matias; Muders, Dirk; Nadolski, Andrew; Navarro, Santiago; Neilsen, Joseph; Nguyen, Chi H.; Nishioka, Hiroaki; Norton, Timothy; Nowak, Michael A.; Nystrom, George; Ogawa, Hideo; Oshiro, Peter; Oyama, Tomoaki; Parsons, Harriet; Peñalver, Juan; Phillips, Neil M.; Poirier, Michael; Pradel, Nicolas; Primiani, Rurik A.; Raffin, Philippe A.; Rahlin, Alexandra S.; Reiland, George; Risacher, Christopher; Ruiz, Ignacio; Sáez-Madaín, Alejandro F.; Sassella, Remi; Schellart, Pim; Shaw, Paul; Silva, Kevin M.; Shiokawa, Hotaka; Smith, David R.; Snow, William; Souccar, Kamal; Sousa, Don; Sridharan, Tirupati K.; Srinivasan, Ranjani; Stahm, William; Stark, Antony A.; Story, Kyle; Timmer, Sjoerd T.; Vertatschitsch, Laura; Walther, Craig; Wei, Ta-Shun; Whitehorn, Nathan; Whitney, Alan R.; Woody, David P.; Wouterloot, Jan G. A.; Wright, Melvin; Yamaguchi, Paul; Yu, Chen-Yu; Zeballos, Milagros; Zhang, Shuo; Ziurys, Lucy; Event Horizon Telescope Collaboration

PUBLICATION: *Astronomy & Astrophysics, Volume 640, id.A69, 21 pp.*

PUBLICATION DATE: August 2020

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2020A%26A...640A..69K/abstract

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TITLE: Mass Assembly of Stellar Systems and Their Evolution with the SMA (MASSES)—Full Data Release

AUTHOR: Stephens, Ian W.; Bourke, Tyler L.; Dunham, Michael M.; Myers, Philip C.; Pokhrel, Riwaj; Tobin, John J.; Arce, Héctor G.; Sadavoy, Sarah I.; Vorobyov, Eduard I.; Pineda, Jaime E.; Offner, Stella S. R.; Lee, Katherine I.; Kristensen, Lars E.; Jørgensen, Jes K.; Gurwell, Mark A.; Goodman, Alyssa A.

PUBLICATION: *The Astrophysical Journal Supplement Series, Volume 245, Issue 2, article id. 21, 35 pp. (2019).*

PUBLICATION DATE: December 2019

ABSTRACT: https://ui.adsabs.harvard.edu/abs/2019ApJS..245...21S/abstract

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The Submillimeter Array (SMA) is a pioneering radio-interferometer dedicated to a broad range of astronomical studies including finding protostellar disks and outflows; evolved stars; the Galactic Center and AGN; normal and luminous galaxies; and the solar system. Located on Maunakea, Hawaii, the SMA is a collaboration between the Smithsonian Astrophysical Observatory and the Academia Sinica Institute of Astronomy and Astrophysics.

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