SMA Newsletter

Submillimeter Array Newsletter | Number 16 | July 2013

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FROM THE DIRECTOR

Dear SMA Newsletter readers,

The SMA recently reached another scientific milestone with more than five hundred scientific papers published in refereed journals, and combined citations in excess of ten thousand. Since the inauguration of the SMA in 2004, the publication rate has risen steadily. A significant contributing factor has been the improvement in sensitivity resulting from lower-noise receivers coupled with a two-fold increase in processed bandwidth.

For the past two years, the receiver group has been working towards developing even wider bandwidth receivers at 230 and 345 GHz. Wide-band receivers at 230 GHz are available on all eight of the SMA antennas, four of which have also been equipped with wide-band 345 GHz receivers. During the coming months we expect to complete installation of the remaining receivers at 345 GHz. In addition, the SMA correlator group has been developing a second-generation spectrometer, which, when used in parallel with the existing SMA correlator, will enable another doubling of the processed bandwidth. While the second-generation spectrometer is still under development at the Cambridge labs, initial on-sky tests at reduced capacity are encouraging. We will shortly release the call for proposals for the 2013B semester (November 16 2013 – May 15 2014) in which we plan to offer shared risk observing across the full 8 GHz IF bandwidth. This will better enable wide-band spectroscopic studies, will provide a significant increase in observing speed for continuum observations, and will create an opportunity for execution of large projects at the SMA.

Ray Blundell

SUBMILLIMETER GALAXY MERGER LEADING TO MASSIVE ELLIPTICAL GALAXY FORMATION AT Z=2.3

Mark A. Gurwell, Hai Fu, Asantha Cooray

The formation and growth of the most massive elliptical galaxies that are seen today has been a puzzle. Examination of the stars in giant elliptical galaxies show that they formed rapidly, around 10 billion years ago, with star formation rates above several hundred solar masses per year ($M_{\odot}\ yr^{-1}$). These ellipticals are thought to be evolved from submillimeter galaxies (SMGs), massive star forming galaxies at redshifts (z) greater than 2. While SMGs (with mean molecular content ~$5\times10^{10}\ M_{\odot}$) are of sufficient size to form typical elliptical galaxies, they are inadequate to form ellipticals that already have stellar content greater than $2\times10^{11}\ M_{\odot}$ at z≈2. So what are their origins? One strong possibility is that these very massive ellipticals are formed through galactic merg-

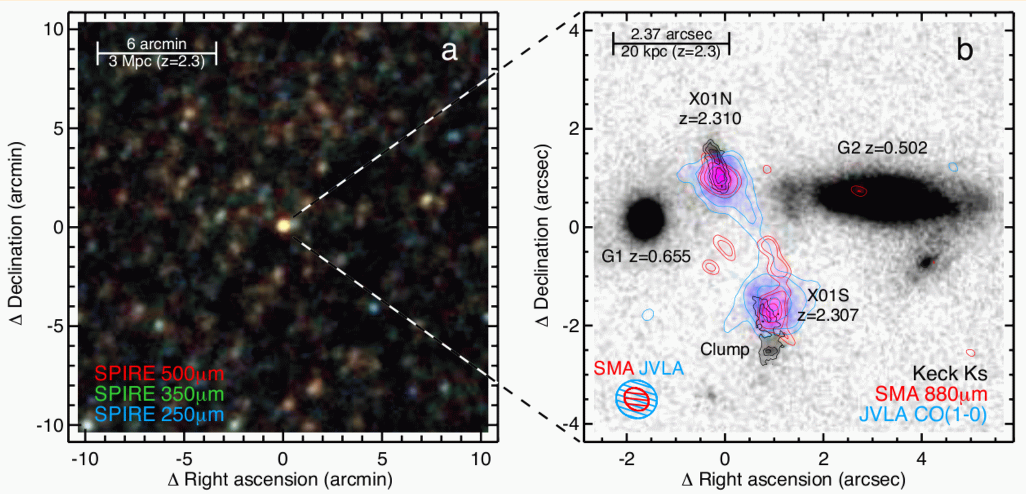


Figure 1: A multi-wavelength view of HXMM01 (Figure 1 of Fu et al, 2013). The left panel shows the Herschel Space Observatory's false three-color image combining 250 (blue), 350 (green) and 500 (red) μm SPIRE images with resolutions of 18, 25 and 36'', respectively. HXMM01 is the bright source at the center of the image. The right panel shows the high resolution images of HXMM01 taken with ground-based observatories. The background and black contours show the Keck-NIRC2 KS -band adaptive optics image. Overlain are the dust continuum emission at 880 μm from the Submillimeter Array (SMA; red contours) and the molecular CO J = 1→0 emission from the Jansky Very Large Array (JVLA; blue contours). The SMA and JVLA contours are drawn at +3, +4, +6, and +8× the rms noise (σ = 0.67 mJy beam–1 for SMA, and σ = 19 μ Jy beam–1 for JVLA), and the Keck contours are at +5, +8, +11σ, where σ is again the rms noise (3.7 × 10–3 μ Jy pixel–1). The two major components of HXMM01 (X01N and X01S) and the foreground galaxies are labeled along with their redshifts. The ellipses at the lower left show the beam full width half maximum (0.54'' ×0.44'' for the SMA and 0.83''×0.77'' for the JVLA).

ers of massive SMGs. In a new Nature paper based in part on mulitple-configuration Submillimeter Array observations, Fu et al. report multi-wavelength high resolution imaging of just such a system, HXMM01, which is a rare merger of two massive SMGs at z=2.3, which combined are forming stars at 2000 $M_{\odot}$ yr^{-1}.

HXMM01 was first identified as an unusually bright SMG in the Herschel Multi-tiered Extragalactic Survey (HerMES; Oliver et al 2012) within the XMM field, based upon SPIRE imaging at 250, 350, and 500 µm (Figure 1, left panel). High-resolution observations were then obtained at a variety of ground-based facilities to better locate the source, to better sample its spectral energy distribution, to measure its redshift, and to hopefully resolve the source. These observations include measurements in three different array configurations of the SMA at 880 µm (Figure 1, right panel), targeting dust emission, with a combined resolution of around 0.5" FWHM. The early SMA observations were the first to show that HXMM01 resolves clearly into two components of similar brightness, X01N and X01S , separated by about 3" (19 kpc at this redshift), and connected by a bridge of material potentially similar to that seen in more nearby galaxy mergers.

The HerMES survey is particularly good at locating gravitationally lensed systems, whose detection benefits from magnification of the intrinsic flux of the SMG, and often creates multiple images of the SMG. In this case, however, there were no obvious directly intervening galaxies to form a lens (the system is close to two low redshift galaxies as shown in Figure 1, but is only weakly magnified by a factor of about 1.6). Spectroscopy of the CO J=1-0, J=4-3 rotational lines and Hα all showed that the two main components were at slightly different redshifts near z=2.3, with velocity separation ~300 km s^{-1}. Furthermore, the line widths from CO J=1-0 were significantly different. Together, these points identify HXMM01 as consisting of two distinct galaxies undergoing a merger.

The SMA measures a flux density at 880 µm of 20±4 mJy (after lensing magnification correction), which places HXMM01 among the brightest SMGs known, and the source SED suggests a modified blackbody with a characteristic temperature of 55 K, much warmer than normal SF galaxies, and near the high end for starbursts. The total IR luminosity of the system is $(2.0\pm0.4)\times10^{13}$ $L_{\odot}$ and implies a prodigious star formation rate (SFR) of 2000±400 $M_{\odot}$ yr^{-1}. The total molecular gas mass of the system, evaluated from the CO(1-0) data, is found to be $(2.3\pm0.6)\times10^{11}$ $M_{\odot}$, and it is estimated that the system is still ~50% gas, implying the total mass of the system is around 4×10^{11} $M_{\odot}$. In comparison with other well-resolved SMG mergers, HXMM01 is the brightest, most luminous, and most gas-rich SMG merger known.

Using the SMA and JVLA resolved imaging, the intrinsic sizes of the gas and dust in the dusty star forming regions can be estimated (dust: 5-7 kpc^2, CO: 15-50 kpc^2), and the star formation efficiency is also very high for both components, around an order of magnitude greater than normal star forming galaxies, and similar to starbursts. These high star formation rates and efficiencies suggest that the gas content of the merging galaxies will be exhausted in just 200 million years. The end result will be the merger of the two galaxies forming a passive massive elliptical galaxy with a stellar mass of ~4×10^{11} $M_{\odot}$, comparable to the most massive elliptical galaxies at z~2.

HXMM01 shows how rapid formation of a massive elliptical galaxy can occur from mergers of massive SMGs. Similar mergers are extremely rare because they are short-lived and result from interactions of unusually massive SMGs, and are estimated to have an average surface number density of 1 per 100 square degrees. Taking these factors into account, although SMGs as luminous as HXMM01 are rare they may be sufficient to produce the space density of massive elliptical galaxies seen at z~1.1. Thus merging systems like HXMM01 could represent a short but critical transitional phase in the formation of the most massive elliptical galaxies.

The preceding is a synopsis of the article 'The rapid assembly of an elliptical galaxy of 400 billion solar masses at a redshift of 2.3' by Fu, H. et al., Nature 498, 338-341 (2013)

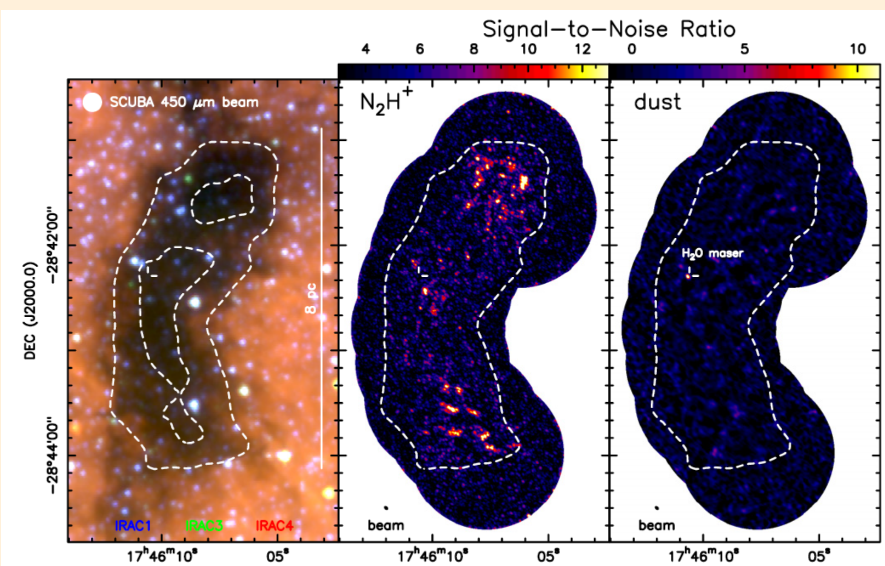
REFERENCE

- Oliver, S.J. et al. MNRAS 424, 1614-1635 (2012)

THE GALACTIC CENTER CLOUD G0.253+0.016: A DENSE CLOUD WITH LOW STAR FORMATION POTENTIAL

Jens Kauffmann, Thushara Pillai, Qizhou Zhang

The central molecular zone (CMZ), i.e. the inner ~200 pc of our galaxy, is a star–forming environment with very extreme physical properties. It produces 5 to 10% of the galaxy's infrared and Lyman continuum luminosity, and approximately 10% of its total molecular gas reside here. The molecular clouds have unusually high average densities $>10^4\,\mathrm{cm}^{-3}$, they are closely packed, and they are subject to an average pressure (from X–ray data) of order 10^6 K cm^{-3} (Morris & Serabyn 1996, for all of the above). The study of star-formation in this environment is thus crucial for two reasons: (i) by studying clouds subjected to extreme physical conditions (e.g., high pressure), we can refine theoretical models (e.g., of pressure-confined clouds); and (ii) observations of this region provide the best data on the starburst processes that take place in more distant galaxies.



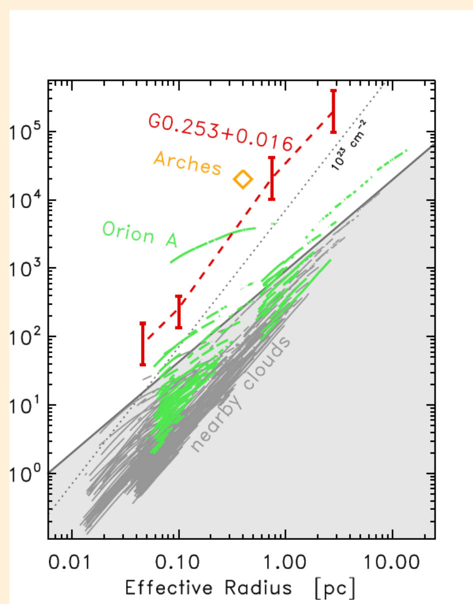


Figure 1: (left) Spitzer and SMA maps of G0.253+0.016. The left panel presents Spitzer IRAC data. Overlaid are 450 μm wavelength intensity contours at 30 and 70 Jy beam^{-1} (SCUBA Legacy Archive; Di Francesco et al. 2008). The lower contour is repeated in all maps shown. The middle and right panels present signal-to-noise maps of the N_2H^+ (3–2) and 280 GHz dust continuum probed by the SMA. The H_2O maser reported by Lis et al. (1994) is marked. **Figure 2: (right)** Density structure of G0.253+0.016 (red). Reference data on solar neighborhood clouds are taken from Kauffmann et al. (2010a; gray lines). Orion A data are generated from observations by Kainulainen et al. (2011; green lines). For reference, the dotted line highlights an H_2 column density of $10^{23}\,\mathrm{cm}^{-2}$. The gray line and shading indicate the Kauffmann & Pillai (2010b) limit for high–mass star formation.

CMZ is populated by a number of molecular clouds with very unusual properties. Among these clouds, one particular object stands out like no other: the region G0.253+0.016, informally also known as the "Lima Bean" or the "Brick". In this cloud, a mass of 2×10^5 M_{sun} is concentrated in a region of just 3 pc radius, a total mass exceeding the Orion A cloud by about a factor 2. Because of its extreme nature, G0.253+0.016 has known for three decades. Güsten et al. (1981) recorded this source under the name M0.25+0.01 in their Ammonia mapping study of the CMZ. In a series of papers written during 1994 through 2001, Lis et al. (1994, 1998, 2001) explored the properties of G0.253+0.016 in great details. This cloud also stood out as an unusually large and dark shadow in the Galactic Center images taken by the Midcourse Space Experiment (MSX). In fact, the extreme appearance of this source in the MSX images prompted researchers to search for more such shadows caused by massive and dense clouds (S. Carey, priv. com.). In this sense, G0.253+0.016 is the prototype of a cloud category that is frequently in the spotlight of today's star formation research: the Infrared Dark Clouds (IRDCs; Egan et al. 1998).

Lis et al. (2001) also established another key feature of the cloud: despite the large mass reservoir, and an average density of a few 10^4 cm^{-3}, G0.253+0.016 does not form stars at any significant rate. Specifically, infrared data from the Infrared Space Observatory (ISO) imply the presence of at most 5 embedded stars with spectral type B0. The absence of cm–continuum emission in fact rules out the presence of stars of such early type (1994; see, however, Rodríguez & Zapata 2013). The presence of a faint embedded water maser heralds, however, the presence of embedded star formation (Lis et al. 1994). None of the existing research provided a satisfying explanation for the absence of numerous massive stars. This was the motivation of our study with the SMA.

The aforementioned papers (complemented by Longmore et al. 2012) established the global properties of G0.253+0.016. But none of these studies was able to probe the substructure of the region. To remedy this problem, we used the SMA to acquire the first (sub)mm interferometric observations of G0.253+0.016 (Kauffmann et al. 2013). These data are presented in Fig 1.

The first striking result is that — despite its large average density — G0.253+0.016 is essentially devoid of detectable dust continuum emission from embedded dense cores. The only exception is detection at the location of the aforementioned water maser. The data are sensitive to H_2 column densities of order 2×10^{23} cm^{-2} at the 5σ–level, which implies masses <26 M_{sun} within a beam of 0.046 pc radius. We further find only weak emission in the J = 3–2 transition of N_2H^+, a molecular emission line that is expected to be relatively bright in cores of high gas density. These lines are modeled using the MOLLIE radiative transfer code (Keto & Rybicki 2010), a tool developed by SMA–astronomer E. Keto. The low line intensities imply H_2 densities $<3\times10^5$ cm^{-3}.

The density structure is summarized in Fig. 2, where we also compare G0.253+0.016 with the density structure of Orion A and a few other molecular clouds. Inspection of the data reveals that, for apertures with a radius of about 3 pc, G0.253+0.016 is a factor 25 more massive and dense than Orion A explored at the same spatial scale. But for apertures <0.1 pc radius, the most massive dense cores Orion A are more massive than cores in G0.253+0.016 by a factor ~4.

The SMA observations therefore explain the low star formation rate in the cloud: there is simply not enough high density gas needed to form a rich stellar group that includes high–mass stars.

This leads to the question why massive dense cores are not abundant in a cloud of high average density. We turned to the Combined Array for Research in Millimeter–wave Astronomy (CARMA) to find answers (Kauffmann et al. 2013). While the SMA is ideally suited to probe the densest gas in clouds with an angular resolution ~2", CARMA can probe the more extended gas of lower density in molecular transitions near 3 mm wavelength.

For example, the CARMA data permit to probe the global velocity field in the J = 1–0 transition of N_2H^+. The data reveal a line width of 35 km s^{-1}, when considering the entire cloud. A virial analysis reveals that such high velocity dispersions render the cloud marginally unbound. In other words, "turbulent" motions prevent the gas from clumping up significantly.

Repeating the virial analysis for smaller fragments embedded in the cloud, we find that structures at any spatial scale are about at the limit of being bound by self–gravity. More interestingly, we find that crossing times $>10^5$ yr at any spatial scale. Since random "turbulent" gas motions decay on a time scale of a few crossing times, this means that several 10^5 yr are required before the gas in G0.253+0.016 can significantly clump up and induce star formation. It has been suggested that this cloud could be a progenitor of an Arches–like stellar cluster (Lis & Menten 1998, Longmore et al. 2012). But before such a cluster can form, G0.253+0.016 might significantly interact with the violent CMZ environment. In fact, given the marginal gravitational binding, the cloud might simply dissolve. It is therefore not at all clear that G0.253+0.016 will ever evolve towards significant star formation.

Many more clouds with extreme properties reside in the CMZ. We have therefore started the Galactic Center Molecular Cloud Survey (GCMS) to systematically investigate other CMZ clouds. We have almost completed mapping of 6 CMZ clouds with the SMA, CARMA, and APEX. ALMA and VLA observations are scheduled for the middle of 2013. This fall, we will use the Green Bank Telescope to map the Ammonia emission of the entire CMZ.

REFERENCES

- Di Francesco et al. 2008, ApJS, 175, 277
- Egan et al. 1998, ApJ Letters, 494, 199
- Güsten et al. 1981, A&A, 103, 197
- Kainulainen et al. 2011, A&A, 530, A64
- Kauffmann et al. 2010a, ApJ, 716, 433
- Kauffmann & Pillai 2010b, ApJ Letters, 723, 7
- Kauffmann, Pillai & Zhang 2013, ApJ Letters, 765, 35
- Keto & Rybicki 2010, ApJ, 716, 1315
- Lada et al. 2010, ApJ, 724, 687
- Lis et al. 1994, ApJ Letters, 423, L39
- Lis & Menten 1998, ApJ, 507, 794
- Lis et al. 2001, ApJ, 550, 761
- Longmore et al. 2012, ApJ, 746, 117
- Morris & Serabyn 1996, ARA&A, 34, 645
- Rodríguez & Zapata 2013, ApJ Letters, 767, 1

DETECTION OF ROTATIONAL LINES OF TiO AND TiO_2 IN VY CMa

Nimesh A. Patel, Ken H. Young, Carl Gottlieb

Evolved stars in the Asymptotic Giant Branch (AGB) stage are well known to play an important role in the production of dust and molecules in the enrichment of the interstellar medium, with gas and dust particles. Simple molecules (with 2 or 3 atoms) which form in the photosphere of such stars levitate above the stellar surface, and take part in chemical reactions leading to more complex molecules in the cooler outer envelope. By processes as yet poorly understood, some of these chemical species lead to formation of solid particles, within a few stellar radii, which are then accelerated outwards by radiation pressure. Depending on whether the AGB star is carbon or oxygen rich, the chemical composition varies in the circumstellar envelope. Carbon rich stars produce mainly carbon dust following the formation of aromatic hyrdocarbons (Sedlmayr and Dominik 1995), whereas oxygen rich stars produce dust from inorganic molecules since most of the carbon atoms are tied up in creation of CO. However, the formation of such inorganic grains, or precursors of dust, is not yet well understood.

Spectral line surveys covering a wide frequency range (several tens of GHz) are helpful for studies of circumstellar chemistry. The SMA's wide bandwidth of 4 GHz per sideband is particularly useful for such studies. We have previously carried out a line survey of the carbon rich AGB star IRC+10216 in the 345 GHz band (Patel et al. 2011). Subsequently in 2010, we completed a spectral-line survey of the oxygen rich supergiant star VY CMa, and the Mira variable IK Tau, covering a frequency range of 279-355 GHz. About 220 lines from 20 molecules were detected (Kaminski et al. 2013a; submitted to ApJS). One of the key discoveries from this line survey is the detection of 6 rotational lines of TiO and 26 rotational lines of TiO_2 in VY CMa. (These lines were not detected in IK Tau, observed in the same survey). To confirm our identifications of these molecules in the SMA survey, in October 2012 we made additional observations of two lines in TiO and three lines in TiO_2 in the 220 GHz band with the IRAM Plateau de Bure interferometer.

Refractory molecules such as TiO and TiO_2 are expected to be the first species in the chain of reactions producing titanium oxide clusters, as the first step in the formation of dust (Gail & Sedlmayr 1998; Jeong et al. 2003). In oxygen-rich stars, TiO is also shown to be a dominant source of opacity. The cyclic formation of TiO, as a function of varying temperature as the star pulsates, is shown to be the cause of the dramatic visual luminosity changes exceeding 8 magnitudes (Reid and Goldston 2002). TiO is known to exist in these circumstellar shells from optical spectroscopy (E.g., Merril et al. 1962; Morgan & Keenan 1973; Branbaum et al. 1996; Kaminski et al. 2010) but so far it has never been observed in radio frequencies despite extensive searches (Churchwell et al. 1980; Millar et al. 1987; Bruenken et al. 2008). TiO_2 has never been observed before in an astronomical object at any wavelength.

Figure 1 shows the TiO lines observed in the SMA survey, along with the PdBI detections, at angular resolutions of about 1" and 4", respectively. Figure 2 shows the TiO_2 spectra. The combined spectrum of TiO lines (averaging all the lines weighted by the rms^{-2}, and scaled inversely by the integrated flux), is shown in Figure 3. Most of the emission covers a velocity range of 3 to 32 km s^{-1}. A Gaussian fit to the line profile has a central velocity of 20±2 km s^{-1} and a FWHM of 18 ± 2 km s^{-1}. A weak red-shifted emission component is also seen in the averaged spectrum. Figure 3 also compares the TiO and TiO_2 lines with two other species: NaCl and SO2. Maps of TiO and TiO_2 lines show very compact emission, centered close to the continuum emission peak, with an offset of about -0.2" in RA. We measured a continuum flux density of 0.6 Jy at 320 GHz, which is consistent with models of spectral energy distribution of VY CMa (Harwit et al. 2001). The continuum emission most likely represents emission from reprocessed dust and not direct photospheric flux. The molecular line emission maps vary significantly in spatial distribution over several arcseconds scale in VY CMa, with SO2 lines showing the most complex distribution (Kaminski et al. 2013a; Fu et al. 2012). But many lines from molecules such as NaCl and H_2O (particularly, highly excited states with energies > 2900 K), also peak at a consistent position, slightly shifted from the continuum peak. These peaks probably correspond to the position of the star since the excitation of such lines requires that the gas be close to the excitation source.

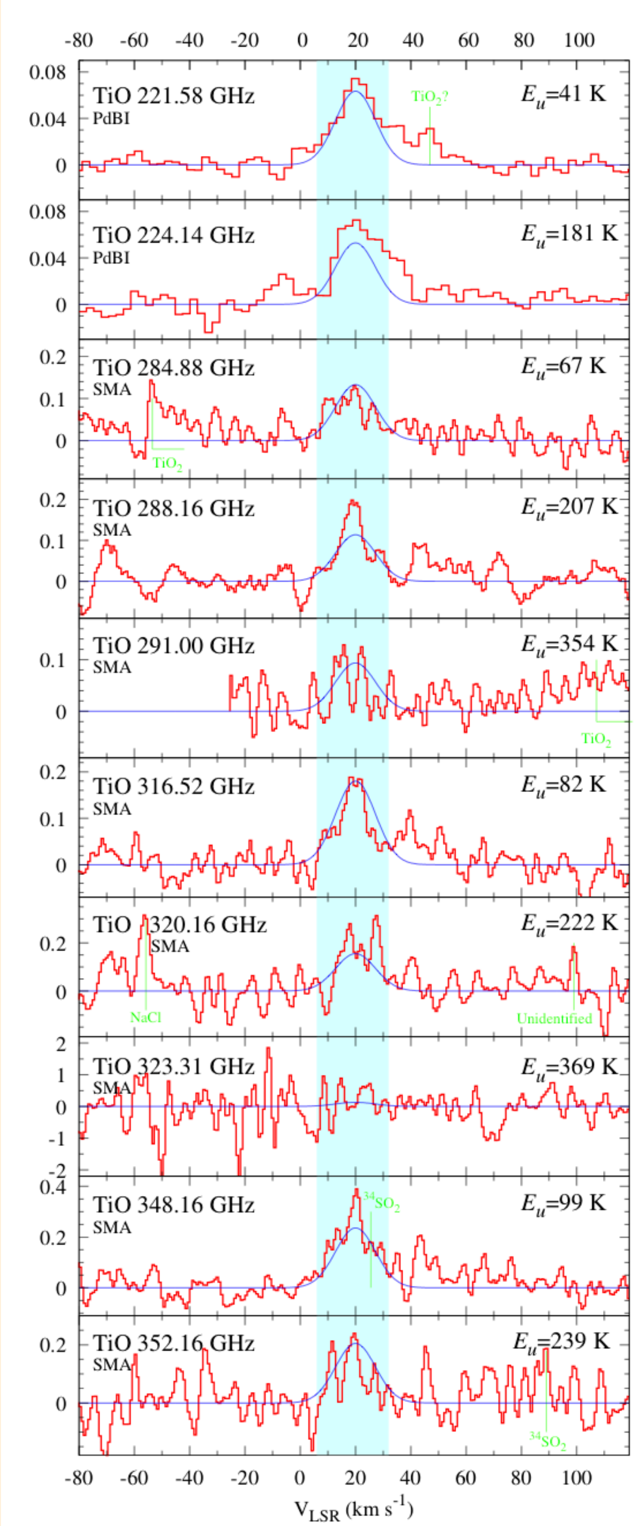


Figure 1: Spectra of all transitions of TiO covered in the SMA survey and the PdBI spectrum. The shaded area is the range over which the spectra were integrated (see Figure 4. of Kaminski et al. 2013b). The blue overlaid curves are theoretical Gaussian profiles plotted on the assumption of LTE at 1000 K. The ordinate is flux density in Jy..

TiO_2 emission appears to have reached the terminal velocity of the gas around VY CMa (V_infinity=40-45 km s^{-1}, Humphreys et al. 2005) but the TiO lines are too weak to determine whether TiO is also reaching terminal velocity. The FWHM of the main Gaussian component of TiO lines shows that TiO is formed in the inner outflow since the lines are much narrower than 2xV_∞. The observed line width of 40±5 km s^{-1} implies that the TiO emission region extends out to r=28±10 R_* (R_*=2000 $R_\odot$) (0.18" at 1.2 kpc), and the emission corresponding to the broad pedestal is located at even larger distances from the star. We have used the semi-empircal wind acceleration model in VY CMa (Richards et al. 1998), which assumes a linear wind acceleration within 75-440 mas of the star and assumes a homogeneous wind. This spatial location of TiO near 28 R_* is inconsistent with predictions of Gail & Sedlmayr (1998) that TiO should primarily be inside the dust formation zone of 6-15 R_* (Monnier et al. 2000; Le Sidaner & Le Bertre 1996). We estimate a rotation temperature of 1010±870 K (see section 3.1 of Kaminski et al. 2013b) which is too uncertain to test the prediction of T > 1100 K for TiO, by Gail & Sedlmayer, but the relatively large observed line widths of TiO are inconsistent with this model. TiO likely does not originate inside the dust formation zone, but in a more extended region. Conclusions for TiO_2 are similar. The rotation temperature of 250 K is much cooler by about a factor of 5 compared to predictions, and again the size of emission is much larger. Simple equilibrium-chemistry models cannot explain these observations, and more complex models do not yet exist.

Future observations of TiO and TiO_2 in other oxygen rich stars, and searches for other small transition-metal bearing molecules require higher sensitivity. Such observations will be made possible with ALMA, which will allow us to spatially resolve the emission and improve our understanding of the circumstellar chemistry and formation of the first solid particles in AGB envelopes.

REFERENCES

- Barnbaum, C., Omont, A., & Morris, M., 1996, A&A, 310, 259
- Bruenken, S., Muller, H., Menten, K., et al., 2008, ApJ, 676, 1367
- Churchwell, E., Hocking, W., Merer, A., & Gerry, M., 1980, AJ, 85, 1382
- Fu, R., Moullet, A., Patel, N., et al., 2012, ApJ, 746, 42
- Gail, H., & Sedlmayr, E., 1998, Faraday Discussions, 109, 303
- Harwit, M., Malfait, K, Decin, L., et al. 2001, ApJ, 557, 844
- Jeong, K., Winters, J., & Sedlmayr, E., 2003, A&A, 407, 191
- Kaminski, T., Schmidt, M., & Tylenda, R., 2010, A&A, 522, A75
- Kaminski, T., Gottlieb, C., Young, K., et al. 2013a, ApJS, submitted
- Kaminski, T., Gottlieb, C., Menten, K., et al. 2013b, A&A, 551, A113
- Le Sidaner, P. & Le Bertre, T. 1996, A&A, 314, 896
- Merril, P. W., Deutsch, A. & Keenan, P., 1962, ApJ, 136, 21
- Millar, T., Ellder, J., Hjalmarson, A., & Olofsson, H., 1987, A&A, 182, 143
- Monnier, J., Danchi, W., Hale, D., et al., 2000, ApJ, 543, 868
- Morgan, W., & Keenan, P., 1973, ARA&A, 11, 29
- Patel, N., Young, K., Gottlieb, C, et al. 2011, ApJS, 193, 17
- Reid, M. & Goldston, J., 2002, ApJ, 568, 931
- Sedlmayr, E. & Dominik, C., 1995, Space, Sci. Rev., 73, 211

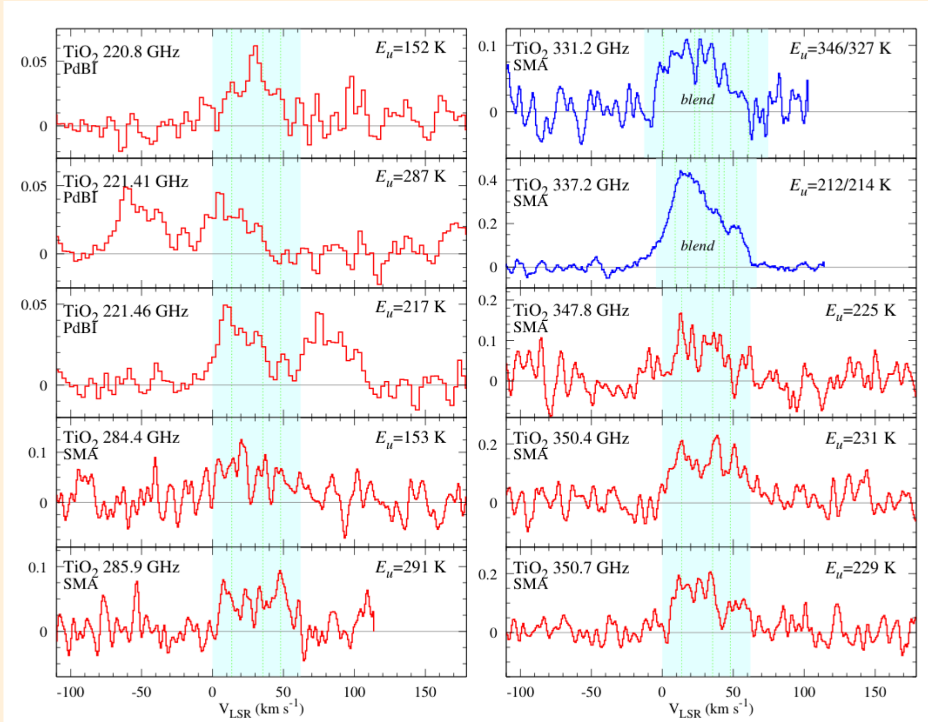


Figure 2: Spectra of unblended lines of TiO_2 with the highest S/N, and two blended lines (blue). The dotted green vertical lines mark the position of the three main components of the TiO_2 emission identified in the combined profile (see Figure 3). The ordinate is flux density in Jy.

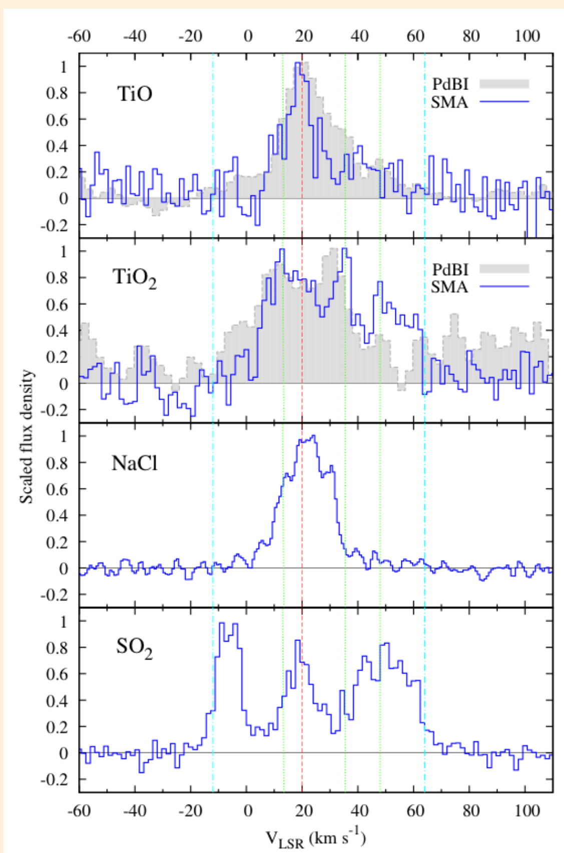


Figure 3: Two top panels: spectra of TiO and TiO_2 obtained by combining several lines from the SMA survey (blue line) or PdBI observations (filled gray histogram). They are compared to a combined profile of the NaCl emission **(third panel)** and a strong line of SO_2 ($16_{0,16}$ - $15_{1,15}$) from the SMA survey **(bottom panel)**. Spectra were smoothed and the peak flux density of each was normalized to 1.0. The dashed (red) vertical line marks the line center of TiO at V_{LSR} =20 km s^{-1}, and the dotted (green) vertical lines mark 14, 35.5, and 48.0 km s^{-1} identified as peaks of velocity components in the SMA combined profile of TiO2. The outermost dash-dotted lines (cyan) show the full velocity range of the TiO2 emission.

DIGITAL BACK END (DBE): SMA PHASE AGILE ANTENNA SIMULATOR

Jonathan Weintroub and John Test

A milestone for the new digital back end was realized on 16 May 2013. 6-baseline sky detections were obtained with the new SMA Wideband Astronomical ROACH2 Machine (SWARM) digital back end on both Uranus and the quasar BL Lac. The fringes verify the design of the wideband packetized corner turner, using FPGA logic designed by Dave MacMahon and integrated with Rurik Primiani's correlator bit code. Single baseline correlator operation had already been verified in the sky tests which were reported in the February 2013 SMA newsletter. The corner turn was accomplished using a direct connect configuration with no network switch. The next step is to arrange for data packets to be be processed through an Arista 10 Gb/s network switch.

Test and development in Cambridge was enabled by a four channel phase agile laboratory antenna simulator which allowed us to verify the correlator design under controlled conditions in the lab, with quadrature Walshing and fringe tracking active, before attempting a sky test. The antenna simulator generates four independent, phase programmable IF blocks to provide wideband signals for the Analog to Digital Converter (ADC) inputs of the new digital backend.

The block outputs from the antenna simulator are broadband noise which can be configured in bandwidths of either 1 or 2 GHz. The phases of the four blocks are programmed by an AD9959, a four channel 500 MSPS Direct Digital Synthesizer (DDS). The four DDS cores can be independently controlled in phase, frequency and amplitude. The DDS outputs are mixed with a 3.9 GHz local oscillator which in turn is mixed with a broadband noise source, or a broadband noise source combined with a tone, to generate the four block outputs.

A Digi International RCM4200 microcontroller is used to program the phase and frequency of the DDS. The controller receives 2 external signals, the start-of-Walsh and heartbeat. The start-of-walsh Interrupt Service Routine (ISR) tells the microcontroller to load four programmed phase values representing the walsh patterns from four antennas at the receipt of each heartbeat. The heartbeat ISR synchronously loads the four phase registers of the DDS, then programs the next phase values from the Walsh pattern array into the phase registers to be loaded by the next heartbeat.

PROCESSING SMA DATA WITH THE NRAO CASA PROGRAM

Ken H. Young

The SMA has long supported two ways to calibrate our data. Calibration may be done with the MIR/IDL package (*https://www.cfa.harvard.edu/~cqi/mircook.html*) and both calibration and imaging may be done with the Miriad software suite (*http://www.cfa.harvard.edu/sma/miriad/*). Recently, many of our observers have expressed interest in processing SMA data using the NRAO CASA package (*http://casa.nrao.edu/*), and in the era of ALMA we expect an ever increasing fraction of our observers will feel more familiar with CASA than with any other data reduction package. With that in mind, a pair of Python scripts have been written that will produce a CASA Measurement Set (MS) directly from raw SMA data.

The first script, **sma2casa.py**, converts the raw SMA data into a set of FITS-IDI files. By default, one such file is produced for each sideband of each correlator chunk, as well as the pseudo-continuum channel which is the vector sum of all "usable" channels in all correlator chunks. This script uses the system temperature to convert the visibility amplitudes from raw correlation coefficients to "pseudo-Janskys". The system temperature is also used to calculate the visibility weights. sma2casa.py contains command line options to select a single sideband, or a limited set of correlator chunks, etc. This script processes the visibilities by mapping the entire visibility data file into the computer's RAM, so it will run slowly on machines which have less RAM than the size of the sch_read file. At this time the size of sch_read rarely exceeds 3 GBytes, but once our new correlator comes online, the size will typically be 20 GBytes.

Once **sma2casa.py** has been run, the second script **smaImportFix.py** can be run within the CASA ipython interpreter. This second script reads each FITS-IDI file into a separate MS. It then performs certain calculations to make the data appear as a more standard CASA MS (for example, scan numbers are calculated which increment whenever the FIELD_ID value changes). Finally, the script concatenates all the single-chunk MSs for each sideband into a single large MS.

These two scripts can be obtained from github, by executing the command

```
> git clone https://github.com/kenyoung/sma2casa.git
```

Documentation is available here:

Importing SMA data into CASA

These scripts are new, and they are apt to change frequently as new bugs are found and fixed, so users are encouraged to check the git repository each time they wish to use them. Please send any comments or bug reports to *kyoung@cfa.harvard.edu.* If you wish to be added to an email list for discussing processing SMA data with CASA, please send a request to the same address.

POSTDOCTORAL OPPORTUNITIES AT THE SMA

Applications are now being accepted for SMA Postdoctoral Fellowships starting 2014. These positions are aimed chiefly at research in submillimeter astronomy, and successful candidates will participate either in observations with the SMA,research in their interpretation, or instrument development.

While the SMA fellowships are intended primarily for research associated with the SMA, fellows enjoy extraordinary freedom in structuring their research activities.

The CfA has a dynamic scientific environment where fellows have the opportunity to interact with world-class scientists and use the CfA's many observing facilities on a competitive basis.

Fellows may choose to be based either at the Center for Astrophysics in Cambridge, MA or at the SMA office in Hilo, HI.

Online applications are due **October 1, 2013**.

http://www.cfa.harvard.edu/opportunities/fellowships/sma/

CALL FOR SMA SCIENCE OBSERVING PROPOSALS

The joint CfA-ASIAA SMA Time Allocation Committee (TAC) solicits proposals for observations for the period 2013 Nov 16 - 2014 May 14 (2013B semester). The deadline for submitting proposals is **2013 August 08** (20:00 GMT = 16:00 EDT = 10:00 HST). For more information please see link below.

http://sma1.sma.hawaii.edu/proposing.html

The deadline for the following semester (2014B: 16 May 2014 - 15 Nov 2014) is expected to be on **February 13, 2014**.

PROPOSAL STATISTICS 2013A (16 MAY 2013 – 15 NOV 2013)

The SMA received a total of 88 proposals (SAO 84, UH: 4) requesting observing time in the 2013A semester. The proposals received by the joint SAO and ASIAA Time Allocation Committee are divided among science categories as follows:

Category	Proposals
high mass (OB) star formation, cores	26
low/intermediate mass star formation, cores	18
protoplanetary, transition, debris disks	10
submm/hi-z galaxies	7
evolved stars, AGB, PPN	6
galactic center	5
local galaxies, starbursts, AGN	5
GRB, SN, high energy	3
solar system	2
other	2

NOTE: University of Hawaii received 4 proposals.

TRACK ALLOCATIONS BY WEATHER REQUIREMENT (ALL PARTNERS):

PWV[1]	SAO+ASIAA	UH[2]
< 4.0mm	14A + 27B	4
< 2.5mm	36A + 42B	2
< 1.0mm	4A + 4B	2
Total	**54A + 73B**	**8**

(1) Precipitable water vapor required for the observations.

(2) UH does not list As and Bs.

TOP-RANKED SAO AND ASIAA PROPOSALS - 2013A SEMESTER

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.

EVOLVED STARS, AGB, PPN

Felipe Alves, Argelander-Institut für Astronomie
The role of magnetic fields on the mass-loss process of AGB stars

GALACTIC CENTER

Dan Marrone, University of Arizona
Capitalizing on the G2 Cloud Impact: Understanding Sgr A Accretion with SMA, CARMA, and ATCA*

HIGH MASS (OB) STAR FORMATION, CORES

Claudia Cyganowski, SAO/CfA
Completing an SMA Survey of Protocluster Evolution

Siyi Feng, Max-Planck-Institute for Astronomy
Fragmentation and dynamical collapse of high-mass starless gas clumps

Stefan Kraus, University of Exeter
Zooming in on high-mass star formation with VLTI infrared and SMA sub-millimeter interferometry

Todd Hunter, NRAO
G11.92-0.61--MM2: A Bonafide Massive Prestellar Core?

LOW/INTERMEDIATE MASS STAR FORMATION, CORES

Anaelle Maury, CfA
On the role of magnetic braking to solve the angular momentum problem in low-mass star formation

Hsien Shang, ASIAA
Resolving SiO Knots in the Class 0 Source IRAS04166

John Tobin, National Radio Astronomy Observatory
A Keplerian Disk Around the Class 0 Protostar L1448 IRS2?

Lars Kristensen, Harvard-Smithsonian Center for Astrophysics
Connecting the kinematics of global filament collapse to core accretion in Serpens South: what sets the star formation efficiency?

Luis Zapata, CRyA-UNAM
Resolving the disk-jet connection in rotating molecular outflows with the SMA

OTHER

Michael McCollough, Smithsonian Astrophysical Observatory
Monitoring A Major Cygnus X-3 Flare

PROTOPLANETARY, TRANSITION, DEBRIS DISKS

Joanna Brown, Cfa
Determining the origin of warm water vapour around young stellar objects

Meredith Hughes, Wesleyan University
Understanding Variations in Turbulent Linewidth Between Sources

Meredith MacGregor, Harvard University
Structure of the HD 15115 Debris Disk

SUBMM/HI-Z GALAXIES

David Clements, Imperial College London
High z Dusty Galaxy Candidates in HeLMS

Lin Yan, Infrared Processing and Analysis Center, California Institute of Technology
An extraordinary group of 3.4micron sources with extended, bright far-IR emission

Scott Chapman, IoA, Cambridge
SMA 870μm continuum map in H1700, a z=2.30 highly overdense galaxy cluster

Shane Bussmann, CfA
Continuing An SMA Pilot Project for a Thousand-Lens Cosmological Survey

Wei-Hao Wang, ASIAA
SMA Identification of SCUBA-2 Sources in the ECDFS

ALL SAO PROPOSALS - 2012B SEMESTER

The following is the listing of all proposals observed in the 2012B semester (16 November 2012 - 15 May 2013)

Juan Carlos Algaba, ASIAA
Testing Sub–mm Fluxes of Highest Apparent Size SMBHs

Sean Andrews, CfA
A Snapshot SMA Survey to Complete the Disk Mass Census in Taurus

Sean Andrews, CfA
Additional Snapshot Observations of Disks around Taurus M Dwarfs

Keiichi Asada, ASIAA
Constraining the Mass Accretion rate onto the Supermassive Black Hole in M 87

Joanna Brown, CfA
Resolving the dust ring in the disk around weakline T Tauri star PDS 70

Joanna Brown, CfA
A survey of forgotten Herbig Ae/Be disks to probe intermediate mass disk evolution

Shane Bussmann, CfA
An SMA Pilot Project for a Thousand-Lens Cosmological Survey

Sayan Chakraborti, ITC, Harvard University
The SMA Rapid Transient (SMART) Legacy Program

Scott Chapman, IoA, University of Cambridge
SMA 890um continuum map in the most overdense galaxy cluster known at z > 2

Rosie Chen, Max Planck Institute for Radio Astronomy
The Birth Environment of Super-Star Clusters at Low-Metallicity

Vivien Huei-Ru Chen, National Tsing Hua University
Resolving the Magnetic Field Structures in the W3(H2O) Hot Core

David Clements, Imperial College London
A z=5.29 lensed or highly luminous submm galaxy

David Clements, Imperial College London
H-ATLAS: A z=3.26 Starbursting Galaxy Cluster found by Planck and Herschel

David Clements, Imperial College London
HerMES Selected High z Dusty Galaxies

Yu (Sophia) Dai, CfA
Mapping the dust in extremely luminous AGNs ù approaching the z >1 universe with the SMA conti-3 (2012A-S103)

Kalliopi Dasyra, Observatoire de Paris
The gas excitation in radio-loud AGN with massive molecular outflows

Sheperd Doeleman, MIT Haystack Observatory
Polarization Emission on Event Horizon Scales

Eiichi Egami, University of Arizona
SMA Observations of an Exceptionally Bright and Extended Gravitationally-Lensed Submillimeter Galaxy

Michel Guelin, IRAM
Small scale structure of the outer CO shells of IRC+10216 (II)

Mark Gurwell, CfA
CO on Pluto: Confirmation (or not) of JCMT Detection

Mark Gurwell, CfA
Testing Black Hole Accretion: GRS1915+105

Jun Hashimoto, NAOJ
Probing Gap Formation Mechanism of Pre-transitional Disk around PDS 70

Edmund Hodges-Kluck, University of Michigan
Mapping Clouds on "Forbidden" Orbits in the Inner Galaxy

Tien Hao Hsieh, National Tsing Hua University, Taiwan
Study the Jets and Chemical Properties of DCE185 - The Only VeLLO with H_3 *Jets Detection*

Meredith Hughes, Wesleyan University
Understanding Variations in Turbulent Linewidth Between Sources

Ho Seong Hwang, CfA
A Submillimeter Array Survey for 870 micron Dust Continuum Emission in local Dust-Obscured Galaxies

Soh Ikarashi, University of Tokyo
Identification of a highest redshift SMG candidate in the Subaru Deep Field; pinpointing accurate position and redshift by [CII] emission line

Eric Keto, CfA
H2D+ in the L1544 starless core (2010B-S057)

Hyosun Kim, ASIAA
Binary characteristics imprinted in the observed circumstellar pattern of an AGB star, CIT 6

Stefan Kraus, University of Exeter
Studying the gap-clearing mechanism in a pre-transitional disk using infrared + SMA sub-millimeter interferometry

Lars Kristensen, CfA
Small-scale irradiated shocks in a low-mass protostar: are they there?

Cheng-Yu Kuo, ASIAA
Constraining the Mass Accretion Rate onto the Supermassive Black Hole in M60 and M84 --- Measuring Submm Fluxes from the Accretion Disks

Chin-Fei Lee, ASIAA
Mapping the B-fields in Protostellar Jets

Hua-bai Li, MPIA
Can galactic magnetic fields resist cloud rotation during the formation processes?

Xing Lu, CfA
Gas Kinematics and Condensations in Filamentary Infrared Dark Clouds

Xing Lu, CfA
Revealing the initial conditions of high-mass star formation: The intriguing case of IRDC G028.23-00.19.

Rita Mann, Herzberg Institute of Astrophysics - National Research Council
A Submillimeter Array Survey of Protoplanetary Disks in the NGC 1333 Rich Cluster

Dan Marrone, University of Arizona
Capitalizing on the G2 Cloud Impact: Understanding Sgr A Accretion with SMA+CARMA*

Sergio Martin Ruiz, European Southern Observatory
Studying the effects of fueling and star formation feedback on the ISM through high-resolution/fidelity chemical imaging.

James Moran, CfA
G2 Impact - Short Time-Scale Monitoring

Justin Neill, University of Michigan
The distribution of deuterated organics within Orion KL

Karin Oberg, University of Virgnia
The HCN/HNC chemistry in a protoplanetary disk

Nimesh Patel, CfA
Disk or Outflow? Probing the molecular region in the AGB star Y Gem. (2011A-S103)

Nimesh Patel, CfA
Investigating Circumstellar Gravel: Dusty Disks with Large Grains in Dying Stars

Nimesh Patel, CfA
Small scale structure of the outer CO shells of IRC+10216 (III)

Jaime Pineda, ESO ALMA Fellow/University of Manchester
Fragmentation in the isothermal filament embedded in the Barnard 5 dense core

Charlie Qi, CfA
A Search for (CO-)Gas in Edge-on Circumstellar Disks

Keping Qiu, School of Astronomy and Space Science, Nanjing University
A Toroidal Magnetic Field in the Brightest YSO Radio Jet in our Galaxy?

Ramprasad Rao, ASIAA
Are Magnetic Fields important for Low Mass Star Formation?

Kazimierz Sliwa, McMaster University
Exploring the Dense Molecular Gas of Arp 299

Shigehisa Takakuwa, ASIAA
Investigation of the Keplerian Disk Formation in the Infalling Envelope around L1551 IRS 5

An-Li Tsai, NCU
Looking for the Submm Counterpart of Fermi Sources 2FGL J1823.8+4312 at 230GHz

Yuji Urata, NCU/ASIAA
Constrain Reverse and Forward shock Emissions of GRB Afterglows

Wei-Hao Wang, ASIAA
SMA Identification of SCUBA-2 Sources in the GOODS-N

Linda Watson, CfA
The Resolved Vertical Structure of Molecular Gas in Edge-on Disk Galaxies

Sarah Willis, Iowa State University / CfA
Exposing an embedded massive young cluster in NGC 6334

Steven Willner, CfA
Confirmation of a Strongly-Lensed Submillimeter Galaxy

David Wilner, CfA
Subcompact Look at the HD 92945 Debris DIsk

Hsi-Wei Yen, ASIAA
Toward the Unified Understanding of Formation of Circumstellar Disks around Low-mass Protostars

Hsi-Wei Yen, ASIAA
Unveiling the Kinematics of the Common Envelope around the Widely-Separated Protostellar Binary IRAS 04325+2402

Qizhou Zhang, CfA
Massive protostellar disk candidates

Qizhou Zhang, CfA
Star Formation in the Central Molecular Zone

RECENT PUBLICATIONS

Title: Unveiling the Evolutionary Sequence from Infalling Envelopes to Keplerian Disks around Low-Mass Protostars
Authors: Yen, Hsi-Wei; Takakuwa, Shigehisa; Ohashi, Nagayoshi; Ho, Paul T. P.
Publication: *eprint arXiv:1305.6877*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.6877Y

Title: Millimetric and sub-millimetric observations of IRAS 05327+3404 "Holoea" in M36
Authors: Morata, O.; Kuan, Y. J.; Ho, P. T. P.; Huang, H. C.; Magnier, E. A.; Zhao-Geisler, R.
Publication: *eprint arXiv:1305.6550*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.6550M

Title: DR 21(OH): a highly fragmented, magnetized, turbulent dense core
Authors: Girart, J. M.; Frau, P.; Zhang, Q.; Koch, P. M.; Qiu, K.; Tang, Y.-W.; Lai, S.-P.; Ho, P. T. P.
Publication: *eprint arXiv:1305.6509*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.6509G

Title: The Mass Dependence Between Protoplanetary Disks and their Stellar Hosts
Authors: Andrews, Sean M.; Rosenfeld, Katherine A.; Kraus, Adam L.; Wilner, David J.
Publication: *eprint arXiv:1305.5262*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.5262A

Title: The rapid assembly of an elliptical galaxy of 400 billion solar masses at a redshift of 2.3
Authors: Fu, Hai; Cooray, Asantha; Feruglio, C.; Ivison, R. J.; Riechers, D. A.; Gurwell, M.; Bussmann, R. S.; Harris, A. I.; Altieri, B.; Aussel, H.; Baker, A. J.; Bock, J.; Boylan-Kolchin, M.; Bridge, C.; Calanog, J. A.; Casey, C. M.; Cava, A.; Chapman, S. C.; Clements, D. L.; Conley, A.; Cox, P.; Farrah, D.; Frayer, D.; Hopwood, R.; Jia, J.; Magdis, G.; Marsden, G.; Martínez-Navajas, P.; Negrello, M.; Neri, R.; Oliver, S. J.; Omont, A.; Page, M. J.; Pérez-Fournon, I.; Schulz, B.; Scott, D.; Smith, A.; Vaccari, M.; Valtchanov, I.; Vieira, J. D.; Viero, M.; Wang, L.; Wardlow, J. L.; Zemcov, M.
Publication: *Nature, Volume 498, Issue 7454, pp. 338-341 (2013).*
Publication Date: 06/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.4930F

Title: Gas Kinematics and the Dragged Magnetic Field in the High-mass Molecular Outflow Source G192.16–3.84: An SMA View
Authors: Liu, Hauyu Baobab; Qiu, Keping; Zhang, Qizhou; Girart, Josep M.; Ho, Paul T. P.
Publication: *The Astrophysical Journal, Volume 771, Issue 1, article id. 71, 8 pp. (2013).*
Publication Date: 07/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.3681L

Title: Modeling the Resolved Disk around the Class 0 Protostar L1527
Authors: Tobin, John J.; Hartmann, Lee; Chiang, Hsin-Fang; Wilner, David J.; Looney, Leslie W.; Loinard, Laurent; Calvet, Nuria; D'Alessio, Paola
Publication: *The Astrophysical Journal, Volume 771, Issue 1, article id. 48, 19 pp. (2013).*
Publication Date: 07/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.3604T

Title: Fine-scale structure of the quasar 3C 279 Measured with 1.3 mm very long baseline interferometry
Authors: Lu, Ru-Sen; Fish, Vincent L.; Akiyama, Kazunori; Doeleman, Sheperd S.; Algaba, Juan C.; Bower, Geoffrey C.; Brinkerink, Christiaan; Chamberlin, Richard; Crew, Geoffrey; Cappallo, Roger J.; Dexter, Matt; Freund, Robert; Friberg, Per; Gurwell, Mark A.; Ho, Paul T. P.; Honma, Mareki; Inoue, Makoto; Jorstad, Svetlana G.; Krichbaum, Thomas P.; Loinard, Laurent; MacMahon, David; Marrone, Daniel P.; Marscher, Alan P.; Moran, James M.; Plambeck, Richard; Pradel, Nicolas; Primiani, Rurik; Tilanus, Remo P. J.; Titus, Michael; Weintroub, Jonathan; Wright, Melvyn; Young, Ken H.; Ziurys, Lucy M.
Publication: *eprint arXiv:1305.3359*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.3359L

Title: The Spatial Distribution of Organics toward the High-Mass YSO NGC 7538 IRS9
Authors: Oberg, Karin I.; Dufie Boamah, Mavis; Fayolle, Edith C.; Garrod, Robin T.; Cyganowski, Claudia; van der Tak, Floris
Publication: *eprint arXiv:1305.3151*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.3151O

Title: The Rotating Outflow, Envelope and Disk in Class-0/I protostar [BHB2007] 11 in the Pipe Nebula
Authors: Hara, C.; Shimajiri, Y.; Tsukagoshi, T.; Kurono, Y.; Saigo, K.; Nakamura, F.; Saito, M.; Wilner, D.; Kawabe, R.
Publication: *eprint arXiv:1305.2668*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.2668H

Title: Mapping the Central Region of the PPN CRL 618 at Subarcsecond Resolution at 350 GHz
Authors: Lee, Chin-Fei; Yang, Chun-Hui; Sahai, Raghvendra; Sánchez Contreras, Carmen
Publication: *The Astrophysical Journal, Volume 770, Issue 2, article id. 153, 17 pp. (2013).*
Publication Date: 06/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1305.1731L

Title: Interstellar Medium Processing in the Inner 20 pc in Galactic Center
Authors: Liu, Hauyu Baobab; Ho, Paul T. P.; Wright, Melvyn C. H.; Su, Yu-Nung; Hsieh, Pei-Ying; Sun, Ai-Lei; Kim, Sungsoo S.; Minh, Young Chol
Publication: *The Astrophysical Journal, Volume 770, Issue 1, article id. 44, 15 pp. (2013).*
Publication Date: 06/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1304.7573L

Title: Evidence of a SiO collimated outflow from a massive YSO in IRAS 17233-3606
Authors: Leurini, S.; Codella, C.; Gusdorf, A.; Zapata, L.; Gómez-Ruiz, A.; Testi, L.; Pillai, T.
Publication: *Astronomy & Astrophysics, Volume 554, id.A35, 11 pp.*
Publication Date: 06/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1304.4401L

Title: Dust-obscured massive maximum-starburst galaxy at a redshift of 6.34
Authors: Riechers, Dominik A.; Bradford, C. M.; Clements, D. L.; Dowell, C. D.; Pérez-Fournon, I.; Ivison, R. J.; Bridge, C.; Conley, A.; Fu, Hai; Vieira, J. D.; Wardlow, J.; Calanog, J.; Cooray, A.; Hurley, P.; Neri, R.; Kamenetzky, J.; Aguirre, J. E.; Altieri, B.; Arumugam, V.; Benford, D. J.; Béthermin, M.; Bock, J.; Burgarella, D.; Cabrera-Lavers, A.; Chapman, S. C.; Cox, P.; Dunlop, J. S.; Earle, L.; Farrah, D.; Ferrero, P.; Franceschini, A.; Gavazzi, R.; Glenn, J.; Solares, E. A. Gonzalez; Gurwell, M. A.; Halpern, M.; Hatziminaoglou, E.; Hyde, A.; Ibar, E.; Kovács, A.; Krips, M.;

Lupu, R. E.; Maloney, P. R.; Martinez-Navajas, P.; Matsuhara, H.; Murphy, E. J.; Naylor, B. J.; Nguyen, H. T.; Oliver, S. J.; Omont, A.; Page, M. J.; Petitpas, G.; Rangwala, N.; Roseboom, I. G.; Scott, D.; Smith, A. J.; Staguhn, J. G.; Streblyanska, A.; Thomson, A. P.; Valtchanov, I.; Viero, M.; Wang, L.; Zemcov, M.; Zmuidzinas, J.
Publication: *Nature, Volume 496, Issue 7445, pp. 329-333 (2013).*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013Natur.496..329R

Title: SMA Observations of Class 0 Protostars: A High Angular Resolution Survey of Protostellar Binary Systems
Authors: Chen, Xuepeng; Arce, Héctor G.; Zhang, Qizhou; Bourke, Tyler L.; Launhardt, Ralf; Jørgensen, Jes K.; Lee, Chin-Fei; Foster, Jonathan B.; Dunham, Michael M.; Pineda, Jaime E.; Henning, Thomas
Publication: *The Astrophysical Journal, Volume 768, Issue 2, article id. 110, 31 pp. (2013).*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...768..110C

Title: Formation of Dense Molecular Gas and Stars at the Circumnuclear Starburst Ring in the Barred Galaxy NGC 7552
Authors: Pan, Hsi-An; Lim, Jeremy; Matsushita, Satoki; Wong, Tony; Ryder, Stuart
Publication: *The Astrophysical Journal, Volume 768, Issue 1, article id. 57, 22 pp. (2013).*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...768...57P

Title: Probing the Earliest Stage of Protostellar Evolution—Barnard 1-bN and Barnard 1-bS
Authors: Huang, Yun-Hsin; Hirano, Naomi
Publication: *The Astrophysical Journal, Volume 766, Issue 2, article id. 131, 9 pp. (2013).*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...766..131H

Title: Deciphering the Ionized Gas Content in the Massive Star-forming Complex G75.78+0.34
Authors: Sánchez-Monge, Álvaro; Kurtz, Stan; Palau, Aina; Estalella, Robert; Shepherd, Debra; Lizano, Susana; Franco, José; Garay, Guido
Publication: *The Astrophysical Journal, Volume 766, Issue 2, article id. 114, 13 pp. (2013).*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...766..114S

Title: Mapping H-band Scattered Light Emission in the Mysterious SR21 Transitional Disk
Authors: Follette, Katherine B.; Tamura, Motohide; Hashimoto, Jun; Whitney, Barbara; Grady, Carol; Close, Laird; Andrews, Sean M.; Kwon, Jungmi; Wisniewski, John; Brandt, Timothy D.; Mayama, Satoshi; Kandori, Ryo; Dong, Ruobing; Abe, Lyu; Brandner, Wolfgang; Carson, Joseph; Currie, Thayne; Egner, Sebastian E.; Feldt, Markus; Goto, Miwa; Guyon, Olivier; Hayano, Yutaka; Hayashi, Masahiko; Hayashi, Saeko; Henning, Thomas; Hodapp, Klaus; Ishii, Miki; Iye, Masanori; Janson, Markus; Knapp, Gillian R.; Kudo, Tomoyuki; Kusakabe, Nobuhiko; Kuzuhara, Masayuki; McElwain, Michael W.; Matsuo, Taro; Miyama, Shoken; Morino, Jun-Ichi; Moro-Martin, Amaya; Nishimura, Tetsuo; Pyo, Tae-Soo; Serabyn, Eugene; Suto, Hiroshi; Suzuki, Ryuji; Takami, Michihiro; Takato, Naruhisa; Terada, Hiroshi; Thalmann, Christian; Tomono, Daigo; Turner, Edwin L.; Watanabe, Makoto; Yamada, Toru; Takami, Hideki; Usuda, Tomonori
Publication: *The Astrophysical Journal, Volume 767, Issue 1, article id. 10, 26 pp. (2013).*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...767...10F

Title: Interferometric Upper Limits on Millimeter Polarization of the Disks around DG Tau, GM Aur, and MWC 480
Authors: Hughes, A. Meredith; Hull, Charles L. H.; Wilner, David J.; Plambeck, Richard L.
Publication: *The Astronomical Journal, Volume 145, Issue 4, article id. 115, 7 pp. (2013)*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013AJ....145..115H

Title: Kinematics and chemistry of the hot core in G20.08-0.14N
Authors: Xu, Jin-Long; Wang, Jun-Jie
Publication: *Monthly Notices of the Royal Astronomical Society, Volume 431, Issue 3, p.2385-2396*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/doi/10.1093/mnras/stt331

Title: Long-term monitoring of PKS 0537-441 with Fermi-LAT and multiwavelength observations
Authors: D'Ammando, F.; Antolini, E.; Tosti, G.; Finke, J.; Ciprini, S.; Larsson, S.; Ajello, M.; Covino, S.; Gasparrini, D.; Gurwell, M.; Hauser, M.; Romano, P.; Schinzel, F.; Wagner, S. J.; Impiombato, D.; Perri, M.; Persic, M.; Pian, E.; Polenta, G.; Sbarufatti, B.; Treves, A.; Vercellone, S.; Wehrle, A.; Zook, A.
Publication: *Monthly Notices of the Royal Astronomical Society, Volume 431, Issue 3, p.2481-2492*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/doi/10.1093/mnras/stt344

Title: Properties of free-free, dust and CO emissions in the starbursts of blue compact dwarf galaxies
Authors: Hirashita, Hiroyuki
Publication: *Monthly Notices of the Royal Astronomical Society, Volume 429, Issue 4, p.3390-3401*
Publication Date: 03/2013
Abstract: http://adsabs.harvard.edu/abs/2013MNRAS.429.3390H

Title: Vertical settling and radial segregation of large dust grains in the circumstellar disk of the Butterfly Star
Authors: Gräfe, C.; Wolf, S.; Guilloteau, S.; Dutrey, A.; Stapelfeldt, K. R.; Pontoppidan, K. M.; Sauter, J.
Publication: *Astronomy & Astrophysics, Volume 553, id.A69, 17 pp.*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1303.6499G

Title: Formation of Dense Molecular Gas and Stars at the Circumnuclear Starburst Ring in the Barred Galaxy NGC 7552
Authors: Pan, Hsi-An; Lim, Jeremy; Matsushita, Satoki; Wong, Tony; Ryder, Stuart
Publication: *The Astrophysical Journal, Volume 768, Issue 1, article id. 57, 22 pp. (2013).*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1303.2758P

Title: ALMA Redshifts of Millimeter-selected Galaxies from the SPT Survey: The Redshift Distribution of Dusty Star-forming Galaxies
Authors: Weiß, A.; De Breuck, C.; Marrone, D. P.; Vieira, J. D.; Aguirre, J. E.; Aird, K. A.; Aravena, M.; Ashby, M. L. N.; Bayliss, M.; Benson, B. A.; Béthermin, M.; Biggs, A. D.; Bleem, L. E.; Bock, J. J.; Bothwell, M.; Bradford, C. M.; Brodwin, M.; Carlstrom, J. E.; Chang, C. L.; Chapman, S. C.; Crawford, T. M.; Crites, A. T.; de Haan, T.; Dobbs, M. A.; Downes, T. P.; Fassnacht, C. D.; George, E. M.; Gladders, M. D.; Gonzalez, A. H.; Greve, T. R.; Halverson, N. W.; Hezaveh, Y. D.; High, F. W.; Holder, G. P.; Holzapfel, W. L.; Hoover, S.; Hrubes, J. D.; Husband, K.; Keisler, R.; Lee, A. T.; Leitch, E. M.; Lueker, M.; Luong-Van, D.; Malkan, M.; McIntyre, V.; McMahon, J. J.; Mehl, J.; Menten, K. M.; Meyer, S. S.; Murphy, E. J.; Padin, S.; Plagge, T.; Reichardt, C. L.; Rest, A.; Rosenman, M.; Ruel, J.; Ruhl, J. E.; Schaffer, K. K.; Shirokoff, E.; Spilker, J. S.; Stalder, B.; Staniszewski, Z.; Stark, A. A.; Story, K.; Vanderlinde, K.; Welikala, N.; Williamson, R.
Publication: *The Astrophysical Journal, Volume 767, Issue 1, article id. 88, 16 pp. (2013).*
Publication Date: 04/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...767...88W

Title: The NGC 1614 interacting galaxy. Molecular gas feeding a "ring of fire"
Authors: König, S.; Aalto, S.; Muller, S.; Beswick, R. J.; Gallagher, J. S.
Publication: *Astronomy & Astrophysics, Volume 553, id.A72, 11 pp.*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1303.1012K

Title: CO J = 2-1 Emission from Evolved Stars in the Galactic Bulge
Authors: Sargent, Benjamin A.; Patel, N. A.; Meixner, M.; Otsuka, M.; Riebel, D.; Srinivasan, S.
Publication: *The Astrophysical Journal, Volume 765, Issue 1, article id. 20, 12 pp. (2013).*
Publication Date: 03/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...765...20S

Title: Herschel-ATLAS: a binary HyLIRG pinpointing a cluster of starbursting proto-ellipticals
Authors: Ivison, R. J.; Swinbank, A. M.; Smail, Ian; Harris, A. I.; Bussmann, R. S.; Cooray, A.; Cox, P.; Fu, Hai; Kovacs, A.; Krips, M.; Narayanan, D.; Negrello, M.; Neri, R.; Penarrubia, J.; Richard, J.; Riechers, D. A.; Rowlands, K.; Staguhn, J. G.; Targett, T. A.; Amber, S.; Baker, A. J.; Bourne, N.; Bertoldi, F.; Bremer, M.; Calanog, J. A.; Clements, D. L.; Dannerbauer, H.; Dariush, A.; De Zotti, G.; Dunne, L.; Eales, S. A.; Farrah, D.; Fleuren, S.; Franceschini, A.; Geach, J. E.; George, R. D.; Helly, J. C.; Hopwood, R.; Ibar, E.; Jarvis, M. J.; Kneib, J.-P.; Maddox, S.; Omont, A.; Scott, D.; Serjeant, S.; Smith, M. W. L.; Thompson, M. A.; Valiante, E.; Valtchanov, I.; Vieira, J.; van der Werf, P.
Publication: *eprint arXiv:1302.4436*
Publication Date: 02/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1302.4436I

Title: Vibrationally Excited HCN around AFGL 2591: A Probe of Protostellar Structure
Authors: Veach, Todd J.; Groppi, Christopher E.; Hedden, Abigail
Publication: *The Astrophysical Journal Letters, Volume 765, Issue 2, article id. L34, 6 pp. (2013).*
Publication Date: 03/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1302.2099V

Title: A 10,000 Year Old Explosion in DR21
Authors: Zapata, Luis A.; Schmid-Burgk, Johannes; Pérez-Goytia, Nadia; Ho, Paul T. P.; Rodríguez, Luis F.; Loinard, Laurent; Cruz-González, Irene
Publication: *The Astrophysical Journal Letters, Volume 765, Issue 2, article id. L29, 4 pp. (2013).*
Publication Date: 03/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1302.0208Z

Title: Submm/mm galaxy counterpart identification using a characteristic density distribution
Authors: Alberts, Stacey; Wilson, Grant W.; Lu, Yu; Johnson, Seth; Yun, Min S.; Scott, Kimberly S.; Pope, Alexandra; Aretxaga, Itziar; Ezawa, Hajime; Hughes, David H.; Kawabe, Ryohei; Kim, Sungeun; Kohno, Kotaro; Oshima, Tai
Publication: *Monthly Notices of the Royal Astronomical Society, Volume 431, Issue 1, p.194-209*
Publication Date: 05/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1301.6171A

Title: Disentangling the Entangled: Observations and Analysis of the Triple Non-coeval Protostellar System VLA1623
Authors: Murillo, Nadia M.; Lai, Shih-Ping
Publication: *The Astrophysical Journal Letters, Volume 764, Issue 1, article id. L15, 7 pp. (2013).*
Publication Date: 02/2013
Abstract: http://adsabs.harvard.edu/abs/2013ApJ...764L..15M

Title: Pure rotational spectra of TiO and TiO2 in VY Canis Majoris
Authors: Kamiński, T.; Gottlieb, C. A.; Menten, K. M.; Patel, N. A.; Young, K. H.; Brünken, S.; Müller, H. S. P.; McCarthy, M. C.; Winters, J. M.; Decin, L.
Publication: *Astronomy & Astrophysics, Volume 551, id.A113, 13 pp.*
Publication Date: 03/2013
Abstract: http://adsabs.harvard.edu/abs/2013arXiv1301.4344K

Title: Water deuterium fractionation in the high-mass hot core G34.26+0.15
Authors: Liu, F.-C.; Parise, B.; Wyrowski, F.; Zhang, Q.; Güsten, R.
Publication: *Astronomy & Astrophysics, Volume 550, id.A37, 15 pp.*
Publication Date: 02/2013
Abstract: http://adsabs.harvard.edu/abs/2013A%26A...550A..37L

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