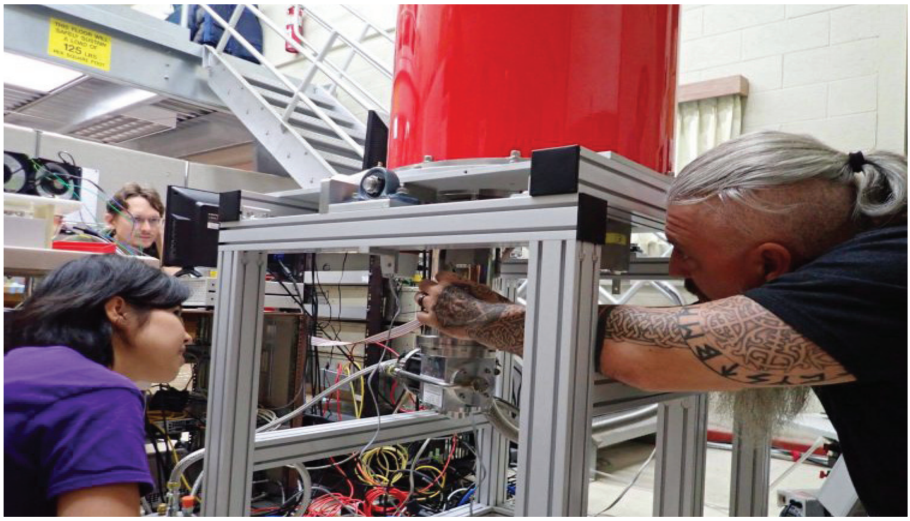
East Asian Observatory News

James Clerk Maxwell Telescope
East Asian Observatory



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In this Issue:

East Asian Observatory

660 North A'Ohōkū Place
Hilo, Hawai'i, 96720
USA

www.eaobservatory.org
helpdesk@eaobservatory.org

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This copy of the East Asian Observatory News was produced and edited by Callie Matulonis and Harriet Parsons with additional editorial assistance from Maren Purves.

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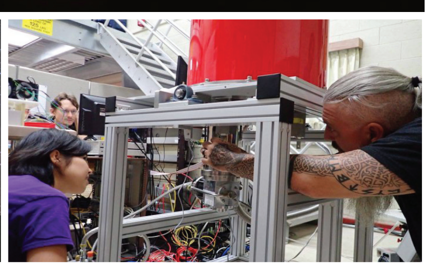


From the front cover.

Top: Event Horizon Telescope, image of the black hole in the M87 galaxy, Pōwehi. (Story on Page 4)

Bottom Left: The JCMT at night captured by Telescope System Specialist, Kevin Silva.

Bottom Right: EAO staff Izumi Mizuno, Ryan Berthold, and Jason Fleck testing the instrument Nāmakanui instrument. (Story on Page 18)

Director's Corner

Paul Ho, Director General of EAO

The EAO is now in the final year of her first 5-year operations of the JCMT. During this past year, the JCMT produced many exciting scientific results. These include SCUBA-2 observations of a protocluster of galaxies and the associated Enormous Lyman-alpha Nebulae (ELANe), in ELAN MAMMOTH-1 at a redshift of 2.3, the detection of the brightest quasar at a redshift of 6.5 due to lensing by a foreground galaxy, and the report of the detection of the most luminous flare from a young stellar object in Orion with ten billion times the energy as compared to standard solar flares.

On April 10, 2019, the JCMT was part of the exciting report from the eight-telescope Event Horizon Telescope, on the first direct image of a black hole in the M87 galaxy. This seminal result received worldwide attention. In Hawai'i, Dr. Larry Kimura, Hawaiian language expert and cultural practitioner at the University of Hawai'i at Hilo, bestowed the Hawaiian name of Pōwehi on the M87 black hole. Governor Ige in Hawai'i, subsequently declared April 10, 2019 as Pōwehi Day. All of these exciting scientific results demonstrate the continued position of JCMT at the forefront of sub-mm wave astronomy.

On the instrumentation front, a new receiver named Nāmakanui, with three receiver inserts at 86, 230, and 345GHz, was delivered to the JCMT in July 2019. It is currently undergoing commissioning tests. Nāmakanui is a spare receiver system for the Greenland Telescope provided to the JCMT by ASIAA and replaces the decommissioned 230GHz RxA, providing much higher sensitivity. Nāmakanui will also provide VLBI capabilities at 86 and 345GHz.

HARP has gotten a number of upgrades including replacing the old mixers in order to improve performance. The new mixers were made by the Superconductor Device Laboratory at ASIAA. HARP will be cooled down shortly followed by a thorough functional checkout and evaluation of the mixer performances before we restart science observations.

In May 2019, an international workshop on EAO Sub-mm Futures was held at the Purple Mountain Observatory in China. The focus was on the development of the next generation 850μm camera for JCMT. This new camera will replace the current SCUBA-2 TES detectors with MKID detector arrays that have dual polarization at every pixel. An international team, including all the JCMT regional partners, are driving the development and construction of this new camera. This new 850μm camera is projected to have an increase in speed by about a factor of 20 over POL-2. In other news, due to pressure from TMT funding requirements, Japan has reduced its participation in the EAO/JCMT project beginning with 2019.

EAO now has four regions that are on observer status. These are Vietnam, Thailand, Malaysia and Indonesia. We welcome them into our EAO family, and look forward to their becoming partners in EAO, and to expand the funding base and scientific community for EAO.

In the later part of 2019, the JCMT was shut down for about one month due to the protests against the TMT construction on Maunakea. After regular safe access to the mountain was secured, all of the Maunakea Observatories returned to operations in August.

The JCMT is also moving towards full remote operations by the end of 2019. We thank the JCMT users community for their patience and understanding as we move to the new modes of operations.

Finally, in 2020, we will begin our next 5-year operations for JCMT. We look forward to a new era of much higher sensitivity and greater science for our users community.

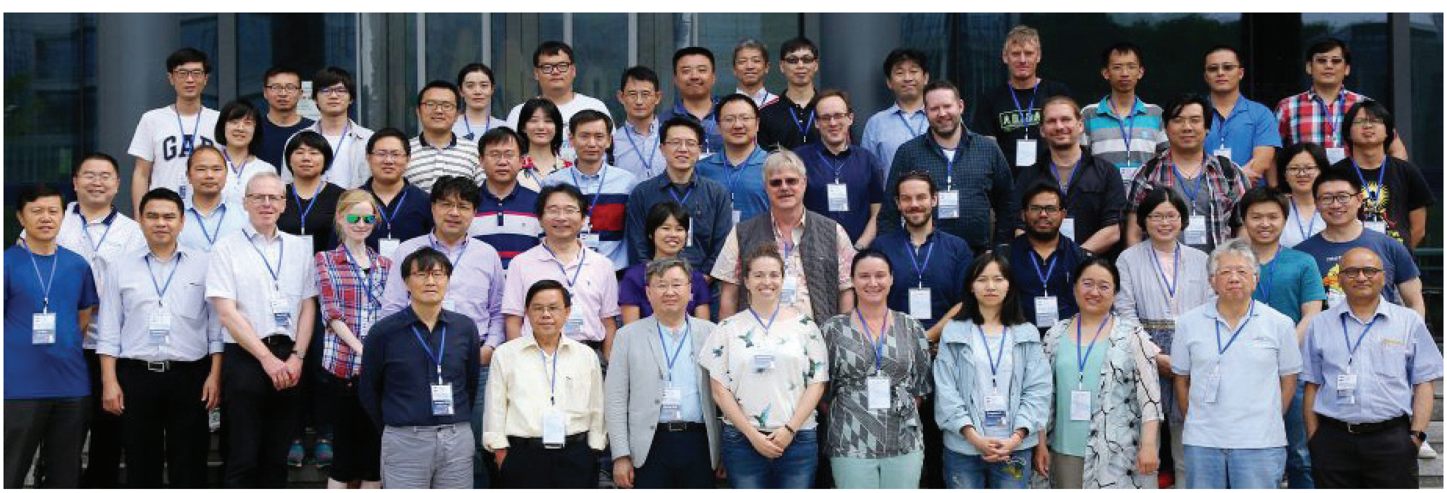


Figure 1: Attendees of the International Workshop on EAO Futures: Future Science and Instrumentation that was held in Nanjing, China from May 20th through May 23rd, 2019.

Finding Pōwehi

Jessica Dempsey, Deputy Director of EAO

By now you will all have seen this remarkable image. The startling, tangible evidence of black holes produced by the Event Horizon Telescope was announced across the world on April 10th, 2019. The six papers describing the result are a testament to the vast (300+ strong) team, and intensive work required to bring this experiment to fruition. Here in Hawai'i, JCMT and SMA anchored the western-point of the world-spanning experiment, and our incredibly committed team will forever be a part of this amazing work. Other articles (wow, how the world's attention was captured by this image!) describe in detail how it all came together, and the implications from the image – the mass, the spin, the nearly-but-not-quite confirmation of Einstein's predictions. Here I want to highlight the long, diligent work of JCMT's scientists over decades, which laid the foundation for the image we now have in our hands.

Figure 2: Top Left: Deputy Director of EAO, Jessica Dempsey; UHH Hawaiian Language Professor, Larry Kimura; and Chief Scientist for Hawai'i Operations, ASIAA, Geoff Bower in front of JCMT antenna. Top Right: Pōwehi. Bottom: Some of the staff in Hilo who were involved in the EHT collaboration.

The most remarkable thing to me is the worldwide collaboration and coordination required to achieve this goal. An achievement that has been recognized by the 2020 Breakthrough Prize in Fundamental Physics, an award that is being shared by all the members of the EHTC.

Here in Hawai'i, where we now face challenging times in our community, with ramifications for the future of Maunakea astronomy that have yet to be fully realized, it was remarkable to see that put aside as the community embraced the achievement. I was privileged to work with Professor Larry Kimura, of the University of Hawai'i, Hilo School of Hawaiian Language, who leads the A Hua He Inoa program, aimed to give Hawaiian names to astronomical objects discovered from the Maunakea telescopes. We described the discovery, and we watched his eyes light up as he explained that it sounded exactly like the descriptions of the darkness of creation in the Kumulipo. He offered the name Pōwehi almost instantly. In Professor Kimura's words: "Pō, profound dark source of unending creation, is a concept emphasized and repeated over and over in the Kumulipo, the primordial creation chant of the Hawaiian universe. It links the Hawaiian genealogy back into a pō of ceaseless creation. The words kumu and lipo, literally mean, source of deep darkness, accentuating the fathomless power of pō. Wehi, or wehiwehi, honored with embellishments, is one of the many descriptions of pō found in the Kumulipo and so the name Pōwehi."

The Governor of Hawai'i has now offered up April 10th, in perpetuity, as Pōwehi Day in the State of Hawai'i. It sparked remarkable conversations here in Hawai'i and around the world regarding indigenous cultural practice and how it could relate and contribute to astronomy. Hawai'i could lead the world in finding ways to interweave indigenous cultural practice, language and identity with modern scientific methods. In the divisive and polarized conflicts we are now experiencing here in Hawai'i, the finding of Pōwehi, and the potential of such a path forward, gives me hope that we can not just move past the challenges we now face, but create something more enduring and remarkable beyond it, both to heal our community, and to bring these collective efforts to the world. Together.

BISTRO explores the turbulent magnetic field of the Barnard 1 star-forming region

Simon Coudé, Research Associate at the Stratospheric Observatory for Infrared Astronomy (SOFIA), on behalf of the JCMT BISTRO Survey Team

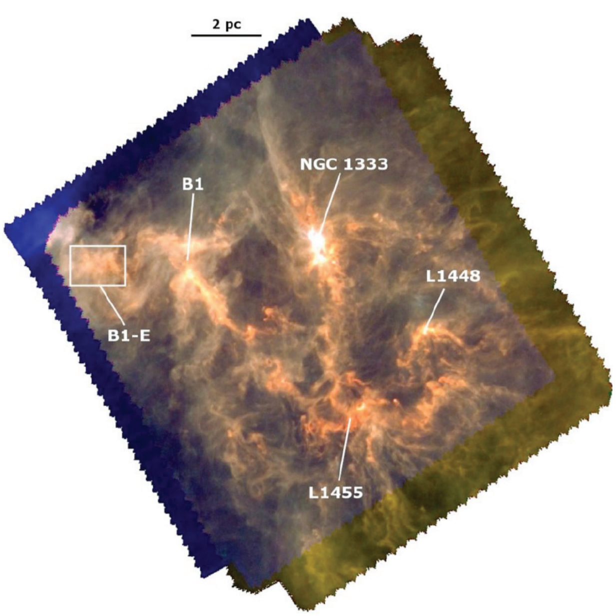
The magnetic field of the Barnard 1 molecular cloud has been mapped with unprecedented sensitivity by the B-Fields in Star-Forming Region Observations (BISTRO) survey using the SCUBA-2 camera and its polarimeter, POL-2, at the JCMT. Located at a distance of approximately 300 pc in the Perseus molecular cloud complex (see left panel of Figure 3), Barnard 1 is a relatively evolved low-mass star-forming region containing several young stellar objects at different evolutionary stages, from prestellar cores to young stars with disks. This interstellar cloud is therefore an ideal laboratory to study the role of magnetic fields and turbulence on the physical processes leading to the birth of low-mass stars.

Specifically, both magnetic fields and turbulent motions are expected to slow the gravitational collapse of the dense gas fueling star formation deep within molecular clouds. However, interstellar magnetic fields are still notoriously difficult to detect even with today's instrumentation, and so it remains unclear in which environments they are the most effective to support interstellar clouds against gravity.

For this study, our team used POL-2 observations of the polarized dust thermal emission at 850μm to infer the plane-of-sky orientation of the magnetic field in Barnard 1. Indeed, we now know that this polarized emission originates from the preferential alignment of interstellar dust grains along magnetic field lines in the interstellar medium through so-called Radiative Alignment Torques (RATs). The magnetic field structure inferred from our POL-2 observations of Barnard 1 is shown in the right panel of Figure 3.

Although polarization maps provide a detailed look at magnetic field structures, they are not sufficient by themselves to quantify the magnetic energy in the cloud. To achieve this, we used a modified version of the Davis-Chandrasekhar-Fermi technique, which essentially measures the relative strength of magnetic fields compared to the turbulent energy in a given cloud.

We first obtained the turbulent-to-ordered magnetic energy ratio in Barnard 1 by fitting an angular dispersion function (see Figure 4). We then quantified the density and the velocity dispersion of the dense gas in the cloud with spectroscopic data generously provided by our colleagues of the Green Bank Ammonia Survey (GAS) at the Green Bank Telescope in West Virginia. By combining these parameters,



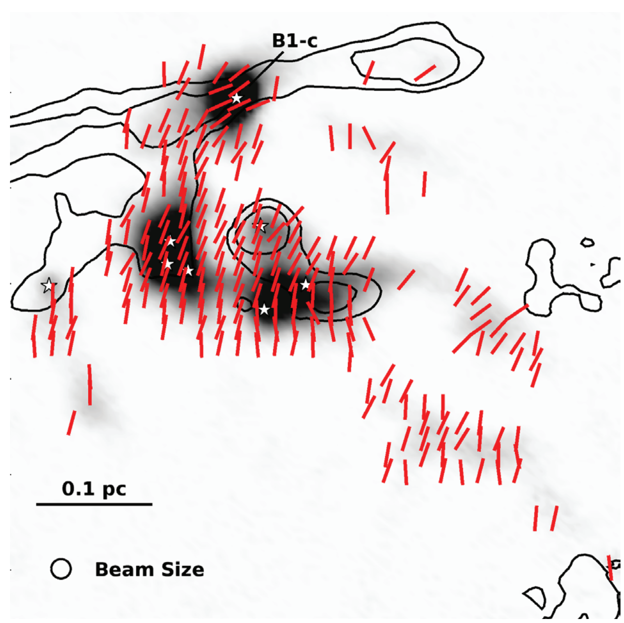


Figure 3: Left: The Perseus molecular cloud complex as seen by the Herschel Space Observatory (Sadavoy et al. 2012, A&A, 540, A10). Right: The magnetic field of the Barnard 1 star-forming region (also Perseus B1) as observed by POL-2. Specifically, the red lines show the orientation of the magnetic field in the plane of the sky. The gray scale traces the emission from the cold interstellar dust in the cloud, and the black contours show HARP measurements of the 12CO J=3-2 molecular line emission. In star-forming regions, emission from the 12CO molecule is typically associated with protostellar outflows. The position of young stellar objects are identified with stars.

we found that the magnetic field strength in Barnard 1 is 120μG, which is at least 10 times weaker than the typical field strengths found in massive star-forming regions such as the Orion nebula.

Given the density of the gas found in Barnard 1, a magnetic field strength of 120μG makes this star-forming region "magnetically supercritical", which means that the magnetic field is too weak to stop the gravitational collapse of the cloud alone. Surprisingly, we also found that nearly half of the magnetic energy in Barnard 1 is contained in the turbulent component of the magnetic field. This finding could be explained by the presence of several protostellar outflows in the region, which are expected to be among the main drivers of turbulence in molecular clouds.

One of the important next steps for the BISTRO survey will be to expand this analysis of magnetic field properties to a wider array of interstellar environments. For example, the study of the neighboring high-mass star-forming region NGC 1333, also

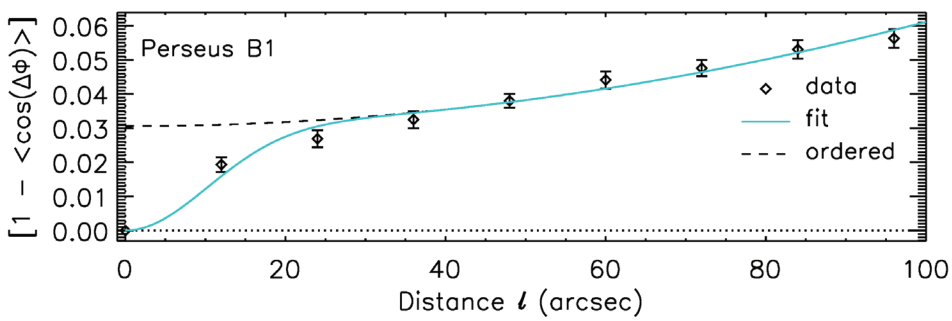


Figure 4: Angular dispersion function for the POL-2 map of Barnard 1. In essence, this function is a measure of the average difference in orientation for every pair of polarization vectors separated by a distance in the region of interest (see right panel of Figure 1 for reference). The fit to this function provides valuable information about both the ordered and turbulent components of the magnetic field, which can then be used to infer the magnetic field strength in the cloud.

in the Perseus molecular cloud complex, is currently underway. NGC 1333 is a region with much stronger stellar feedback than the relatively quiescent Barnard 1. With the growing sample of polarization data sets provided by the BISTRO survey, it now becomes possible to undergo detailed studies on how the magnetic and turbulent properties are affected by cloud mass and stellar feedback in the diverse star-forming regions of our galaxy.

This research, published in the Astrophysical Journal in June 2019, was conducted in part at the SOFIA Science Center, which is operated by the Universities Space Research Association (USRA) under contract with the National Aeronautics and Space Administration (NASA). An open access version of the paper is available at https://arxiv.org/abs/1904.07221.

Highlights From the JCMT Transient Survey

Steve Mairs, Support Astronomer at EAO,
on behalf of the JCMT Transient Survey Team

Probing Variability in Young Stars

Despite decades of research into the formation of stars, there are still many captivating open questions that continue to drive exciting, next generation science at the JCMT. Several of these questions seek a detailed understanding of the rate at which a protostar gains its mass. In the simplest model of star formation, gas and dust steadily accrete onto the central source from a surrounding envelope of material (Shu, 1977). In reality, however, while the initial phase of the growth of a protostar occurs steadily, a protoplanetary disk forms early in this process and introduces complex, multi-scale physics that govern the developing star's accretion. In fact, most of the free-falling material from the envelope is first accreted onto this disk before it is channeled to the protostar via a loss of angular momentum, likely due to viscous interactions and magnetohydrodynamic instabilities. Finally, the mass is funnelled onto the protostar by the stellar magnetic field, which disrupts the disk at scales typically of order a few stellar radii (for a review on accretion processes, see Hartmann et al. 2016 and Figure 5). As one might expect, the non-uniform nature of the disk gives rise to a variable accretion rate that is dependent on instabilities in both the inner and outer disk (see review by Armitage, 2015). This variability in the rate of accretion has far-reaching implications for many of the most important aspects of star formation, including estimating protostellar lifetimes (Offner and McKee, 2011), reconciling a decades-old discrepancy between theoretical and observed brightnesses of young stars known as the "Luminosity Problem" (Kenyon et al. 1990; Evans et al. 2009; Dunham et al. 2015), and describing the physical structure of the circumstellar disk that will go on to form planets (Bae et al. 2014; Vorobyov and Basu, 2015).

Probing the accretion rate variability is tantamount to measuring changes in the protostellar luminosity, since the amount of energy emitted from the central source is dominantly governed by the accretion flow. Most of a protostar's mass, however, is gained during the earliest stages of a star's formation while it is still heavily embedded in a dusty envelope that is optically thick over a wide range of wavelengths. While the most significant luminosity changes should occur in the far-infrared, the lack of space-based instrumentation available at this time necessitates studies from the ground. As a proxy for the central luminosity, the JCMT's SCUBA-2 camera can be used to monitor the cold dust surrounding deeply embedded protostars. If a significant increase in the accretion onto the protostar occurs, the luminosity will increase and it will heat the surrounding material, causing the sub-mm flux to increase (Johnstone et al. 2013). Similarly, if the accretion rate decreases significantly, the sub-mm flux will become fainter. The timescales and amplitudes of these burst and fading events at 450 and 850μm are almost entirely unconstrained in the literature, yet they provide much needed insight into the physical conditions of forming stars at the critical, early stages.

The JCMT Transient Survey (Herczeg et al. 2017) is a Large Program dedicated to measuring the variability of young, embedded protostars at sub-mm wavelengths. The survey covers eight well-known, nearby (<500pc) star-forming regions in the Gould Belt, including Orion, Serpens, Perseus, and Ophiuchus. Each of these circular fields (30 arcminutes in diameter, see Figure 6) is observed at a monthly cadence when it is available in the sky. In total, there are more than 200 Class 0/I protostars and more than 1,000 Class II/III young stellar objects that have previously been discovered across the survey area (Megeath et al. 2012; Stutz et al. 2013; Dunham et al. 2015). The survey began in December, 2015, and will continue through at least January, 2020.

A wealth of work has been applied to developing a reliable calibration scheme that achieves a relative flux calibration uncertainty of 2-3% at 850μm, a factor of 3-4 improvement over the nominal absolute flux uncertainty of the telescope (Mairs et al. 2017a). Using this scheme, the team has been able to construct sub-mm light-curves over 2-4 year timescales (Mairs et al. 2017b, employing archival data from the Gould Belt Survey, [Ward-Thompson et al. 2007]) and design several statistical tests for source variability across the full sample of objects (Johnstone et al. 2018). With the help of EAO scientific programmer Dr. Graham Bell, these tests have been automated to run each time Transient Survey data is obtained. The pipeline also sends a summary of the test results to team members via email as soon as the processing is complete (within 24-48 hours).

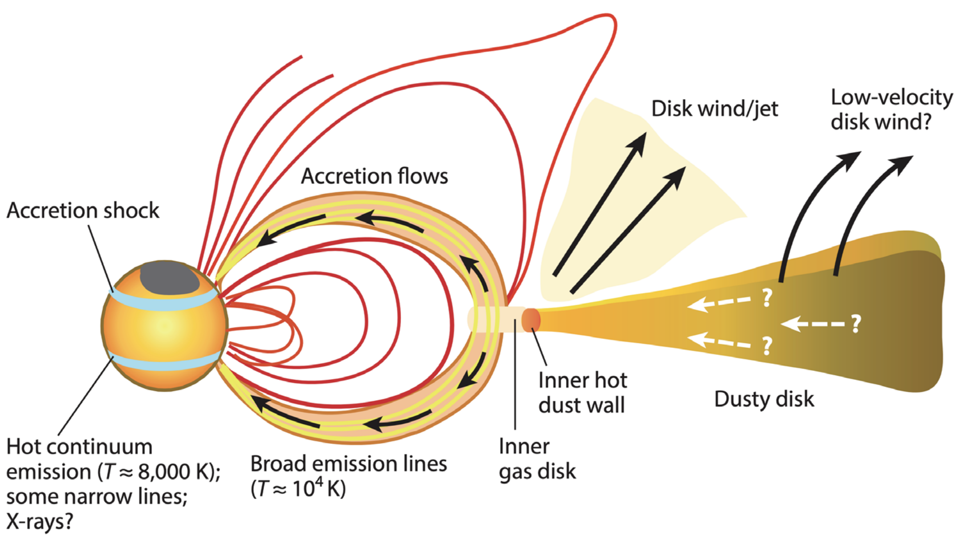


Figure 5: From Hartmann et al. 2016. Viscous interactions in a protoplanetary disk channel accreting material toward the protostellar magnetic field and finally onto the forming star. Gravitational and magnetic instabilities form in the outer and inner disk.

JCMT Transient Survey Results So Far

Over the past two years, many exciting discoveries have been made. The first confirmed sub-mm variable source from the Transient Survey was EC 53 (also known as V371 Ser), a periodic variable with a timescale of ~543 days (Yoo et al 2017; see left panel of Figure 7). This embedded Class I protostar is thought to have a companion orbiting at the variability timescale, influencing the accretion rate of the varying source. EC 53 has been a known periodic variable at infrared wavelengths for several years (Hodapp et al. 2012). Work is ongoing to compare the J, H, and K band lightcurves obtained by the United Kingdom Infrared Telescope and the Liverpool Telescope to the 450 and 850μm lightcurves obtained by SCUBA-2.

EC 53 is currently the only known sub-mm periodic variable. Independent analyses, however, uncovered a further 4 variable sources in 4 separate star-forming regions that showed evidence of significant, secular flux changes over months to years (Mairs et al. 2017b; Johnstone et al. 2018). After these studies were published, a long-term change in the brightness of HOPS 358 (Fischer et al. 2017), one of the youngest and most deeply embedded protostars covered by the survey, was triggered and detected. HOPS 358, in the NGC 2068 star-forming region was initially used to help calibrate the flux in the field due to its flat and consistent lightcurve before it began a linear decrease in brightness in 2017 (See right panel of Figure 7). The discovery announcement of this event was the first ever Astronomer's Telegram to contain the keywords "Young Stellar Object" and "Sub-Millimeter" at the same time. Recently, this decrease in brightness came to a halt and the source began to brighten once more. As ad-

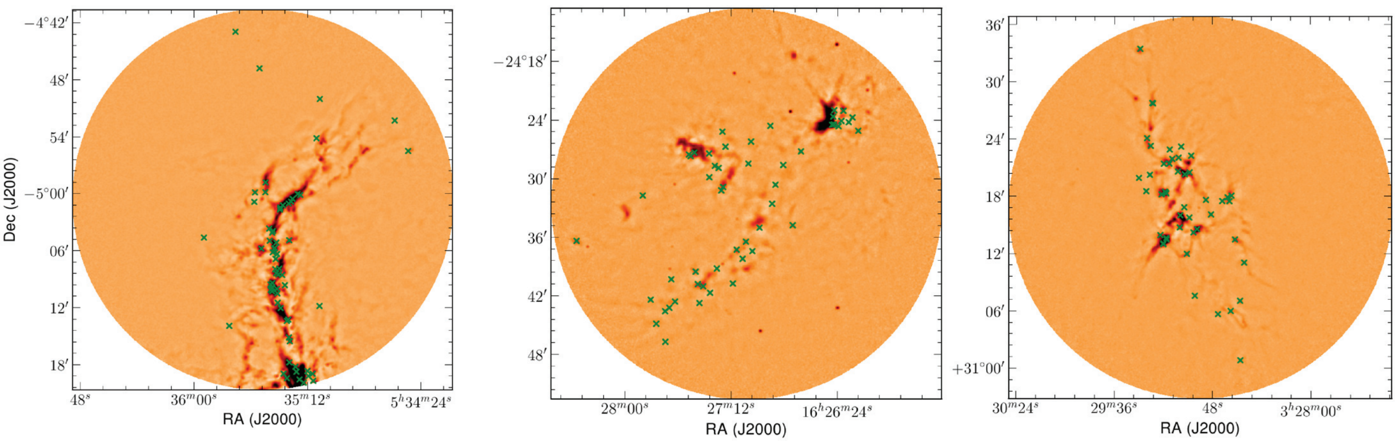


Figure 6: From Herczeg et al. 2017. SCUBA-2 850μm images of three of the eight regions in the Transient Survey, co-added over the first year of data. The green marks show the positions of known young protostars observed by the Spitzer Space Telescope and the Herschel Space Observatory. Left: OMC 2/3, Centre: Ophiuchus Core, Right: NGC 1333. The marks show the location of Class 0, Class I, and flat spectrum protostars, as identified and classified by [7] and [12].

ditional data is obtained, the metrics that allow the team to identify periodic and secular variability are constantly improving.

WISE and NEOWISE mid-infrared data (3.4 and 4.6μm) is also available toward the Transient Survey fields throughout much of the time the JCMT has been obtaining images (Contreras, et al. in prep.). In the left panel of Figure 9, we see a long-term brightening trend in both the MIR and Sub-mm data of an embedded YSO in the IC348 region. In the right panel of Figure 9, we see an example of a stochastic variable candidate in the Ophiuchus Core region with peaks and troughs in the mid-IR but not the sub-mm photometry. Using these observations as constraints, 3D and simplified 2D hydrodynamic modelling plus radiative transfer of protostellar variability has been developed to interpret the SED variability of generic variables (MacFarlane et al. 2019a,b) and for EC 53 specifically (Baek et al. in prep). These models are needed to convert the sub-mm variability into a change in source luminosity while also allowing us to investigate the envelope structure, including outflow cavities and viewing inclination. Further analysis of stochastic and secular variables will be available in Lee et al. (in Prep).

In addition to the long-term variability associated with accretion rate changes, the Transient Survey has also uncovered a non-thermal, short-term variability event signalling the most luminous stellar radio flare on record (Mairs et al. 2019). On 2016 November 26, a bright point source was detected in the direction of the T Tauri Binary system known as JW 566 (Jones and Walker, 1988; see Figure 8). There has been no significant signal at this location during any of the other 26 Transient Survey observations, including data that was observed only 6 days previous to the flare. Upon further investigation, a light curve was constructed that showed the brightness of the source declining by 50% in less than 30 minutes. Short-timescale, non-thermal variability similar to this has been noted before at millimetre and radio wavelengths (Bower

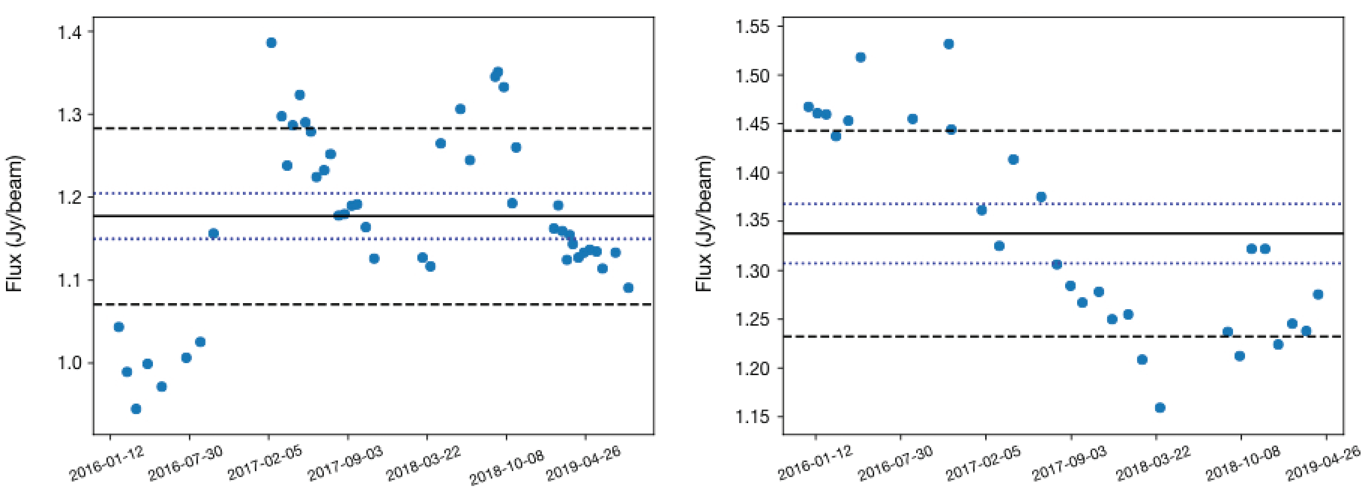


Figure 7: Left: The 850μm light curve of EC 53.The blue (dotted) lines indicate the expected light curve standard deviation in the absence of variability, while the black (dashed) lines indicate the measured light curve standard deviation. Right: The 850μm light curve of HOPS 358.

et al. 2003; Massi et al. 2006; Salter et al. 2008; Forbrich et al. 2008) but this is the first detection in the sub-mm regime. The flare is interpreted as a magnetic reconnection event, releasing (gyro-)synchrotron radiation. Additional observations of short-term variability associated with T-Tauri stars or younger YSOs will help determine the amplitudes and frequencies of these events. This will be an important window into the dominant physics governing material in the scale of the inner accretion disk to the stellar surface. High resolution spectral follow-up studies are currently under preparation. New methods are also under development to search for additional faint, short-term variability events in each observed epoch (Lalchand et al. in prep).

The Future of the JCMT Transient Survey

To date, most of the JCMT analysis has been performed at 850μm because of the stability of the background noise from epoch to epoch (with the exception of an analysis of the 450μm data of EC 53). The 450μm regime is much more unstable to changes in the amount of precipitable water vapour in the atmosphere. The flux calibration pipeline that will process all the survey data at 450μm is nearly complete and the initial results are showing good consistency with the 850μm analyses. Now, taking advantage of both wavelengths and the myriad results generated so far, the JCMT Transient Survey team is preparing to submit a proposal to extend the Large Program for another 3 years starting in February, 2020. Plans include continuing the analysis of the current 8 fields, expanding the coverage of the Gould Belt clouds, and targeting farther, higher mass star-forming regions. Some promising exploratory work of monitoring high-mass star-forming regions has already been performed by combining Transient Survey methodology with JCMT SCOPE Survey (Liu et al. 2018) data (Park et al. 2019).

Further in the future, the team is very much looking forward to the new 850μm MKID array set to be installed at the JCMT in 2022. This camera is expected to increase the mapping speed at 850μm by an order of magnitude. The deeper maps and wider coverage this instrument will provide have the potential of delivering many more years of fruitful science for sub-mm protostellar variability monitoring. A detailed summary of the future survey plans will be available in the upcoming article titled "Submillimetre Transient Science in the Next Decade" in the EAO Submillimetre Futures white paper series.

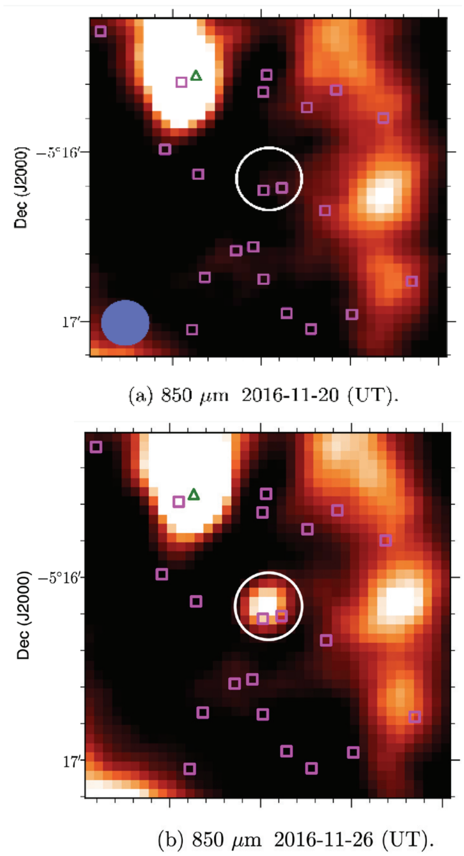


Figure 8: From Mairs et al. 2019. 850μm observations of JW 566. Image (a) was observed on the night of 2016-11-20 (UT); the beam is shown in blue. Image (b) is a consecutive epoch taken on 2016-11-26. The green triangle represents the position of a known protostar while the magenta squares mark the positions of known Class II YSOs. The white circle shows the location of JW 566.

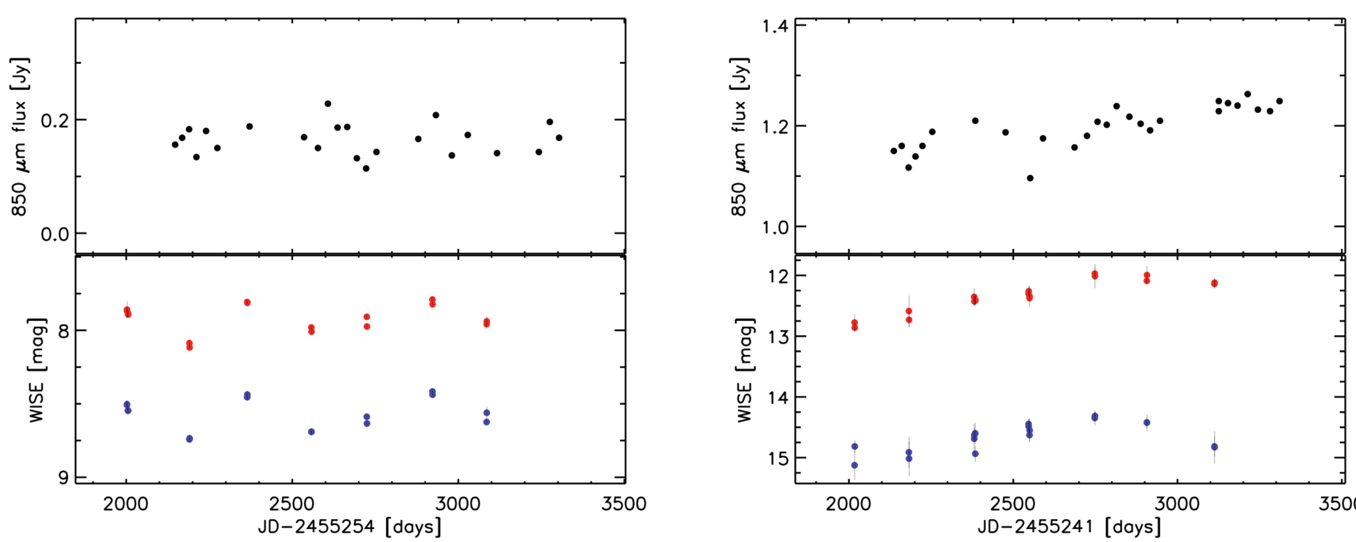


Figure 9: Left: A confirmed secular variable in the IC348 field at 3.4 (blue), 4.6 (red), and 850μm (black). Right: A stochastic variable candidate in the Ophiuchus Core field. The colour scheme is the same as the left panel.

Molecular gas at the center of Andromeda, M31

Zongnan Li, Nanjing University, China

Galactic circumnuclear environments, in which the multi-phase interstellar medium (ISM) and various stellar populations are coupled under the influence of a supermassive black hole (SMBH), are the mecca for a wide array of astrophysical processes. Being the closest large spiral galaxy to us, M31 provides an important and unique view for studying the circumnuclear environment. Central to this environment is the so-called nuclear spiral, which manifests itself in optical emission lines with a remarkable filamentary morphology across the central kpc of M31.

Despite its significance, previous surveys show limited neutral gas detections in the circumnuclear region. To date, there is no unambiguous detection of circumnuclear atomic hydrogen reported. Similarly, surveys of molecular gas, including the IRAM 30m CO(1-0) survey with moderate sensitivity (RMS of ~0.3Kkm s^{-1}), did not yield detection in the central region. Only recently, CO(1-0) and CO(2-1) lines have been detected within the central kpc in deep IRAM 30m and NOEMA observations.

In this work, we present a survey of CO(3-2) molecular line emission in the circumnuclear region of M31 with JCMT, aiming to explore the physical conditions of the molecular gas. Significant CO(3-2) lines are detected primarily along the nuclear spiral, out to a projected galactocentric radius of 700pc at a linear resolution of ~50pc. Due to its intrinsic dimness, the CO emission appears patchy as compared to the dust distribution (Figure 10). Nevertheless, the distribution of CO(3-2) clearly follows the nuclear spiral. Significant CO(3-2) emission is also evident along an outer filament located at the south-east corner of our field-of-view. We find that the line-of-sight velocity of the molecular gas is in rough agreement with that of the ionized gas previously determined from optical observations, i.e., redshifted on the eastern side with respect to the minor-axis of M31, consistent with an overall clockwise rotation pattern when viewed from the north pole of the M31 disk.

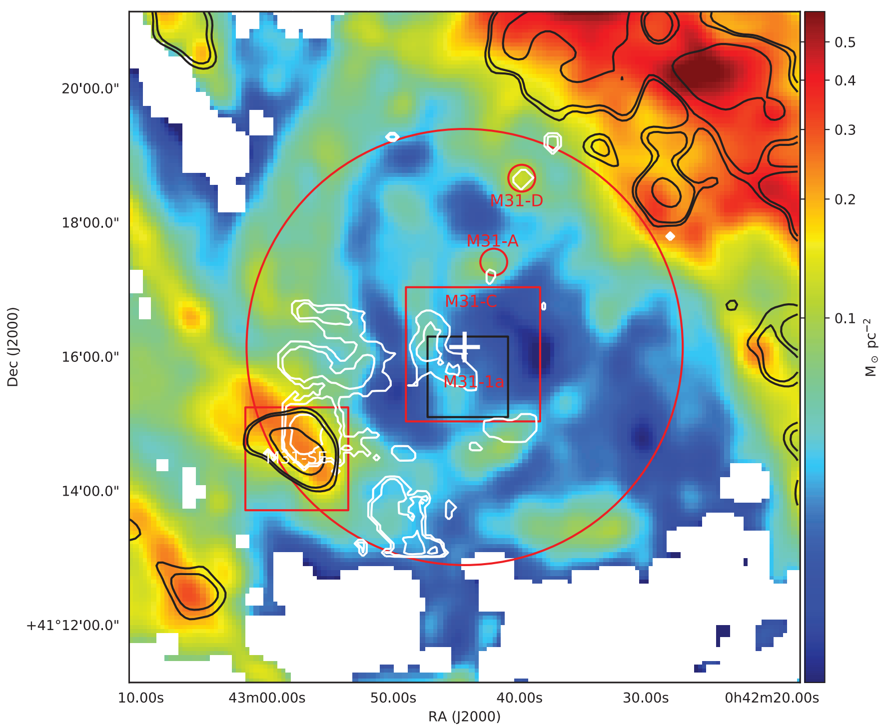


Figure 10: Contours of the integrated intensities of CO(3-2) (white, this work) and CO(1-0) (black) overlaid on the dust mass map of the circumnulear region of M31. Both the CO and dust morphologies trace the nuclear spiral. The center of M31 is marked with a white cross. The large red circle roughly outlines the field-of-view of the CO(3-2) observations, while the large red square indicates the central 2 arcmin × 2 arcmin region of highest sensitivities, referred to as the M31-C field, which encloses the region observed in CO(2-1), referred to as the M31-1a field (shown by the black square). The small red square at the southeast corner, partially covering a major filament of the nuclear spiral, is referred to as the M31-SE field. The two small circles labeled with M31A and M31D indicate the positions with CO(1-0) and CO(2-1) observations.

In various positions, the CO(3-2) lines are found associated with either CO(2-1) or CO(1-0) lines detected in previous work. Utilizing existed CO(2-1) and CO(1-0) measurements in selected regions of the nuclear spiral (Figure 10), we derive characteristic intensity ratios of CO(3-2)/CO(2-1) and CO(3- 2)/CO(1-0), which are both close to unity and are significantly higher than the typical intensity ratios in the disk (0.2 in the M31 disk and 0.4 in the Milky Way disk). Such line ratios suggest high kinetic temperatures of the gas, which might be due to strong interstellar shocks prevalent in the circumnuclear region, given the lack of circumnuclear massive stars and the extremely quiescent SMBH.

Our next step is to extend the CO observations to outer region, covering the so-called ~1kpc nuclear ring that encloses the nuclear spiral (Figure 10). With both IRAM 30m CO(1-0) and JCMT CO(3-2) observations that will be carried out this year, we could probably be able to develop a more comprehensive perspective of the mysterious circumnuclear environment of M31.

Comets and The JCMT

David Jewitt, University of California at Los Angeles, USA

Comets are some of the most challenging yet rewarding targets for JCMT. JCMT has made a surprising number of important cometary observations over the years, and promises more.

The science of comets rests on their status as the least thermally evolved, most primordial relics of solar system formation. They contain ices that, we think, have been preserved with little change for 4.6Gyr. The short-period comets have been stored at ~40K in the Kuiper belt, and are at the end of a ~10Myr plunge to the inner solar system. The long-period comets arrive from the more distant Oort cloud where equilibrium temperatures are ~7K. Both types of comet were formed in the giant planet region of the solar system, over a huge range of distances from perhaps 5AU to 30AU, and then scattered into their storage reservoirs by the growing planets. There are probably 10^9-10^{10} kilometer-sized comets in the Kuiper belt and 10^{11}-10^{12} in the Oort cloud. Some 10^{13}-10^{14} comets were lost to the interstellar medium through the action of planetary perturbations.

Gas

Comets become active when near-surface volatiles sublimate in the heat of the Sun. The escaping gas is dominated by water, but includes numerous other molecules (CO, CO_2) at the ~10% level and various radio-bright species at ~1% and lower abundances. Until the rotational lines of these so-called "parent molecules" were detected, planetary astronomers had to rely on optical spectroscopy of radicals and ions resulting from photodestruction, introducing many additional uncertainties in the interpretation. The parent molecules, in contrast, tell us directly about the composition and isotopic nature of the nucleus ices. The first detection of cometary CO was made in distant comet 29P/Schwassmann-Wachmann 1 at JCMT (Figure 11); at about 0.1km/s width, it is one of the narrowest lines in any astrophysical object. Most astonishing is the finding, since confirmed many times at other telescopes, that the production rate from 29P is 2000 tonnes per second and that the comet is never inactive. This continuous and prodigious supply of CO at distances where water ice is too cold to sublimate is suspected to result from crystallization of amorphous ice, and gives a major constraint on the nature of comets. CO cannot be efficiently trapped at temperatures above about 30K, providing a direct constraint on the formation temperature, and hence radial location in the protoplanetary disk.

JCMT is also useful in the study of isotopes and isotopologues, at least

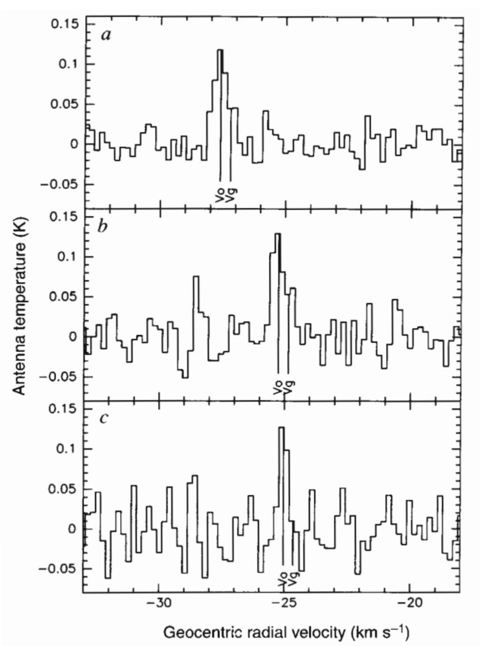


Figure 11: Discovery of CO(2-1) emission in distant comet 29P/Schwassmann-Wachmann 1 at JCMT in 1994 when at 6AU from the Sun. The line was discovered against a theoretical prediction that it could not be detected, and has emerged as a powerful diagnostic of outgassing at distances where water ice is too cold to sublimate appreciably. From Senay et al. (1994). Nature, 371, 271.

in bright comets. For example, Figure 12 shows three lines from isotopologues of HCN(4-3) in comet Hale-Bopp. The double-peaked line structure is characteristic of emission from an expanding gas shell and the separation of the peaks gives the gas expansion speed. The much fainter lines of H13CN(4-3) and HC15N(4-3) give the 12C/13C and 14N/15N ratios in the comet, which turn out to be nearly solar in this object. Abundances and isotopes allow us to examine compositional diversity of the comets (perhaps related to formation location), and to relate the cometary ices to their source material in the interstellar medium.

Dust

As sublimated gas expands at the speed of sound into the adjacent vacuum of interplanetary space, it pulls embedded dust grains out of the nucleus. The dust consists of a complex mixture of silicates and refractory organics collected during the accretion phase. The particles populate a size distribution such that most, by number and by cross-section, are micron-sized particles best sensed at optical wavelengths. A key result from sub-mm observations is that the cometary dust mass is instead dominated by large grains which are essentially unobservable in the optical. JCMT is ideal for studying these millimeter-sized and larger, mass-dominant particles. Sub-mm continuum observations, at first with the single bolometer detector UKT14 and more recently with SCUBA and SCUBA-2, have been very productive. As an example, Figure 13 shows 850µm SCUBA maps of comet ISON in late November 2013, revealing its disintegration within 20 Rsun (0.1AU) of the Sun. The elongation (Sun-Earth-comet) at the time of the bottom right panel of the figure was only 4.6 degrees. More surprising still is the finding that comets eject more mass in dust than in gas, often by a considerable margin. Whipple's "dirty snowball" model has morphed into the "snowy dirtball" model, raising new questions about how and where the comets grew.

Interest in observing comets with JCMT remains high in the EAO era, with both targeted as well as opportunistic ("target-of-opportunity") programs in any given semester. One outstanding question concerns the origin of the compositional diversity that previous sub-mm spectroscopy has revealed. There is a wide dispersion in the compositions of comets but, so far, no systematic difference between comets from the Kuiper belt and Oort cloud reservoirs. We don't even know whether the differences between comets are primordial or evolutionary (perhaps caused by the different outgassing histories of the comets). Comet work at JCMT is ongoing and all of the interesting cases are being tracked. More data from the JCMT's heterodyne suite (including the new Nāmakanui) and SCUBA-2 will hopefully give us the answer.

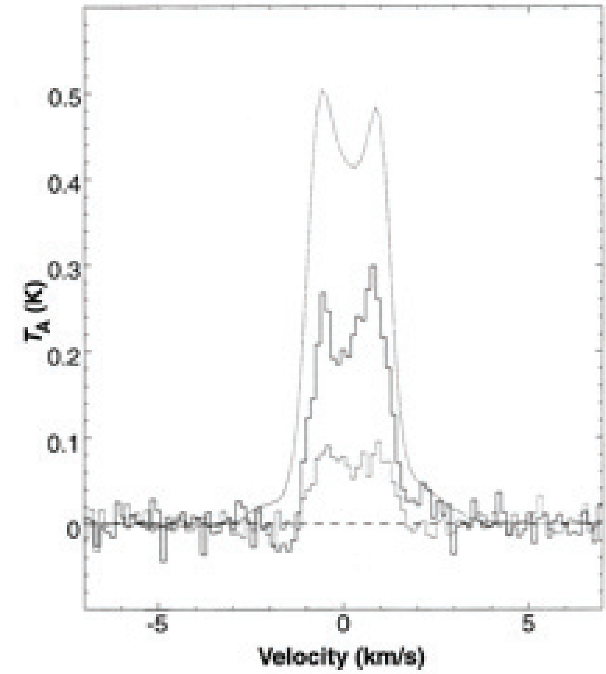


Figure 12: Spectra of H12CN(4-3) at 354.5055GHz (top curve), H13CN(4-3) at 345.3398GHz (middle curve), and HC15N(4-3) at 344.2003GHz (bottom curve) obtained with receiver B3 on 16.71 February 1997 UT. The H12CN line has been scaled down by a factor of 30 for easy comparison. From Jewitt et al (1997). Science 278, 90.

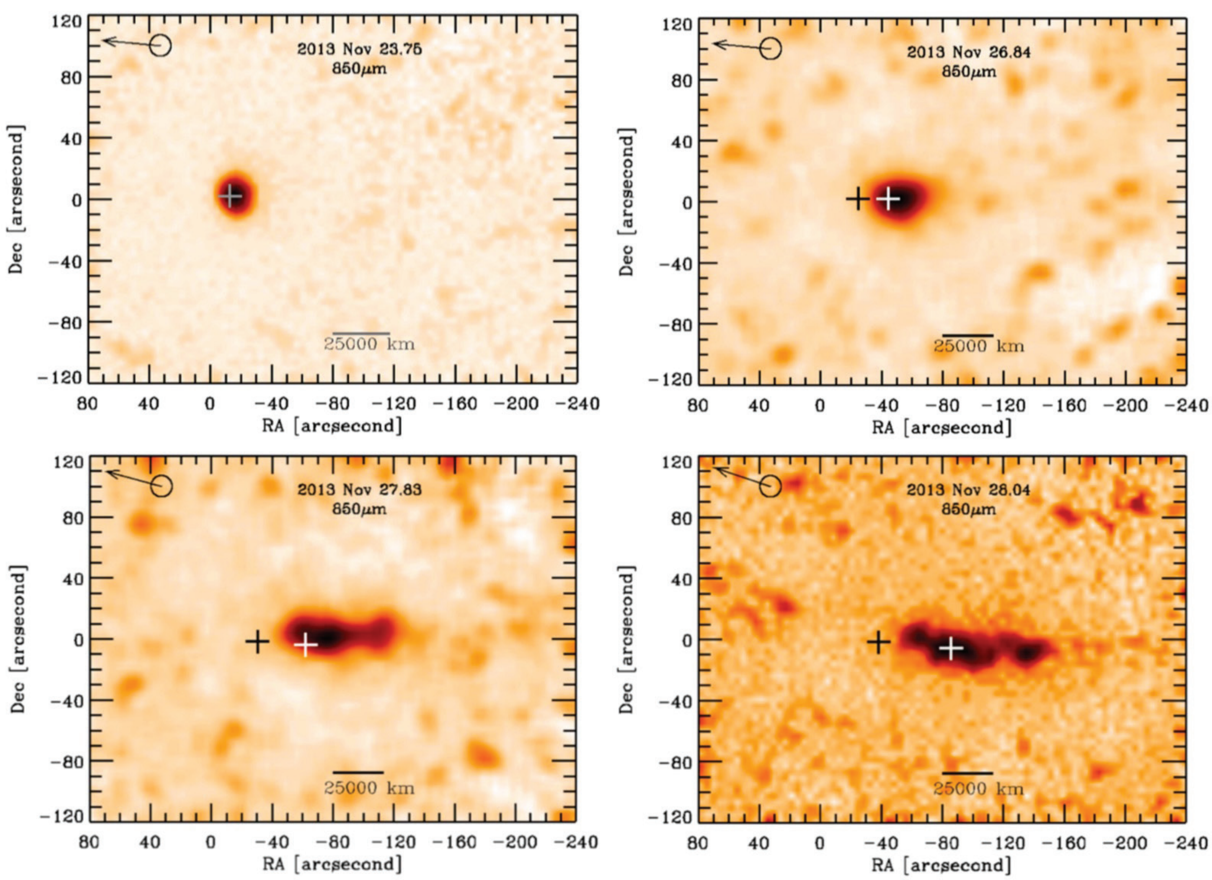


Figure 13: Disintegration of C/2012 S1 (ISON) near the Sun. Keane et al. (2016) Ap. J. 831, 207

NEP: The North Ecliptic Pole Survey with SCUBA-2

Hyunjin Shim, Kyungpook National University, South Korea,
on behalf of the NEP team

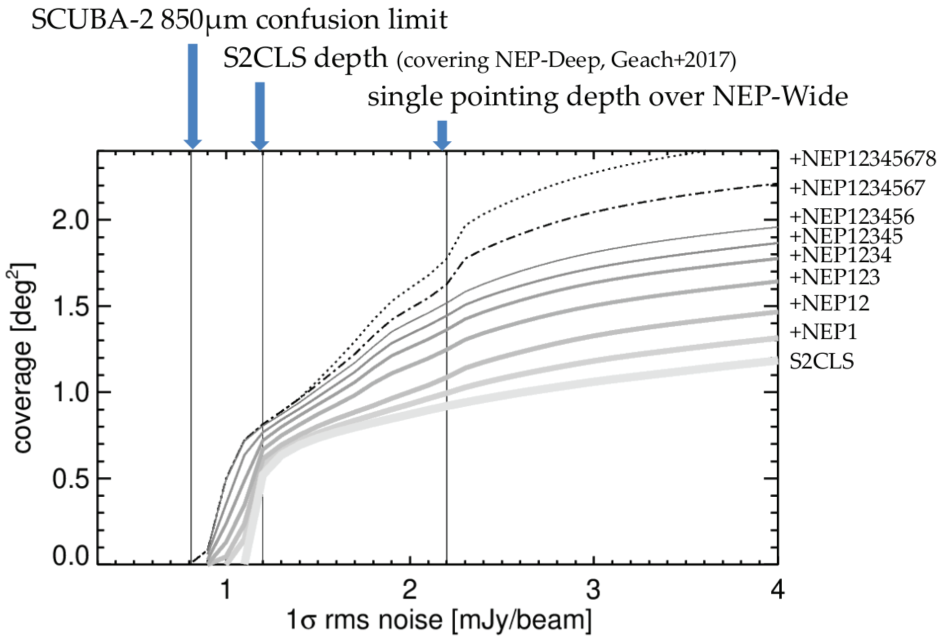


Figure 14. Progress of the NEP survey in terms of survey depth and area coverage (as of July 2019).

A significant amount of galaxy evolution is hidden by dust. Dust is the end product of stellar evolution, and regulates star formation process by playing an important role in molecular clouds. As we move to higher redshifts, i.e., the early times of the Universe, we find more dusty galaxies that emit most of their bolometric luminosities in the far-infrared wavelength. These galaxies are thought to be in the stage of vigorous star formation, galaxy mass growth, and central supermassive black hole growth - enabling us to trace back the history of galaxy evolution through the cosmic history.

The beginning of the multi-wavelength survey around the North Ecliptic Pole (NEP) region dates back to 2006, with the launch of the space-based AKARI infrared telescope. AKARI performed a deep and wide, two-tier survey over 4.3 deg^2 around the NEP at a continuous wavelength coverage of 2-24μm with the initial motivation of measuring the mid-infrared polycyclic aromatic hydrocarbon (PAH) emission. The survey also benefits from other telescopes (including many Maunakea telescopes such as the CFHT, Keck and Subaru). A result of these observations is an extensive ancillary data set from from X-ray to radio wavelengths. Mid-infrared luminosity has long been used as a star formation rate indicator in many cases. However, the infrared spectral energy distribution (SED) of a galaxy depends on the dust characteristics, which means that we need far-infrared, or even sub-mm wavelength data to complement the existing data to study the hidden side of galaxy evolution.

The NEP region was one of the target fields of the S2CLS (SCUBA-2 Cosmology Legacy Survey), the JLA era JCMT large program. Unfortunately the area coverage was limited to 0.6 deg^2, only covering 15% of the entire AKARI NEP survey. In late 2017, the new large program that aims to extend the 850μm imaging data over the entire NEP-region was approved. As of July 2019, the program is ~44% complete in terms of observing time. As the data accumulate, the area coverage is extending and depth of the overlapping regions increases. Figure 14 shows the cumulative area coverage as a function of sensitivity. We now have 40% more data with the comparable sensitivity of the previous S2CLS, and reaching 1.5 times deeper than the S2CLS in the overlapping region, i.e., 0.9mJy rms, slightly above the confusion limit.

The obtained data have been reduced using the oracdr pipeline, applying the appropriate FCF. By now we have ~800 sub-mm galaxies over 1.6deg^2 with fairly robust detection, and the possibility of stacking many optically or near-infrared selected galaxies to get their average far-infrared flux. Figure 15 shows the selected examples that shows the role of 850μm data points in studying physical properties of galaxies. Ancillary X-ray and radio data allowed us to sample numerous z > 1 galaxies with AGN contribution. The first object in Figure 15 shows one such galaxy, with interacting morphology. The effect of galaxy-galaxy mergers on the star formation and AGN activity of galaxy will be studied extensively with our rich multi-wavelength data on the NEP. The second object in Figure 15 is a galaxy located within the supercluster, at z=0.087. The well-defined mid- to far-infrared SED for this nearby galaxies will enable us to study the modelling of infrared SEDs in more detail. Publications for these specific projects is in preparation.

Preliminary results from the previously published S2CLS data have been published in Seo et al. (2018), comparing the AGN fraction of dust obscured galaxies (DOGs) detected in 250-500μm and sub-mm galaxies detected in 850μm. The contribution of AGN to the total infrared luminosity is 2-11% in SMGs, and 19-35% in DOGs. The finding that the AGN contribution is larger in DOGs supports the scenario that sub-mm galaxies are in the vigorous star formation phase, which will later evolve into quasar phase that is observed as DOGs with extremely red optical – midinfrared color after the consumption of molecular gas. Due to the limited area coverage, only a few numbers of DOGs and SMGs were used to draw such conclusion. However with the >50% completion of the NEP survey, we will construct ~2 times larger sample that would reduce the statistical uncertainty.

The NEP program is a collaboration of >70 scientists from various JCMT participating regions. We had a general NEP collaboration meeting in June 2018 and June 2019. The data products are now distributed within the team, and as we make more progress we will make it available to the general community. For further information or participation, please contact the author at shim.hyunjin@gmail.com.

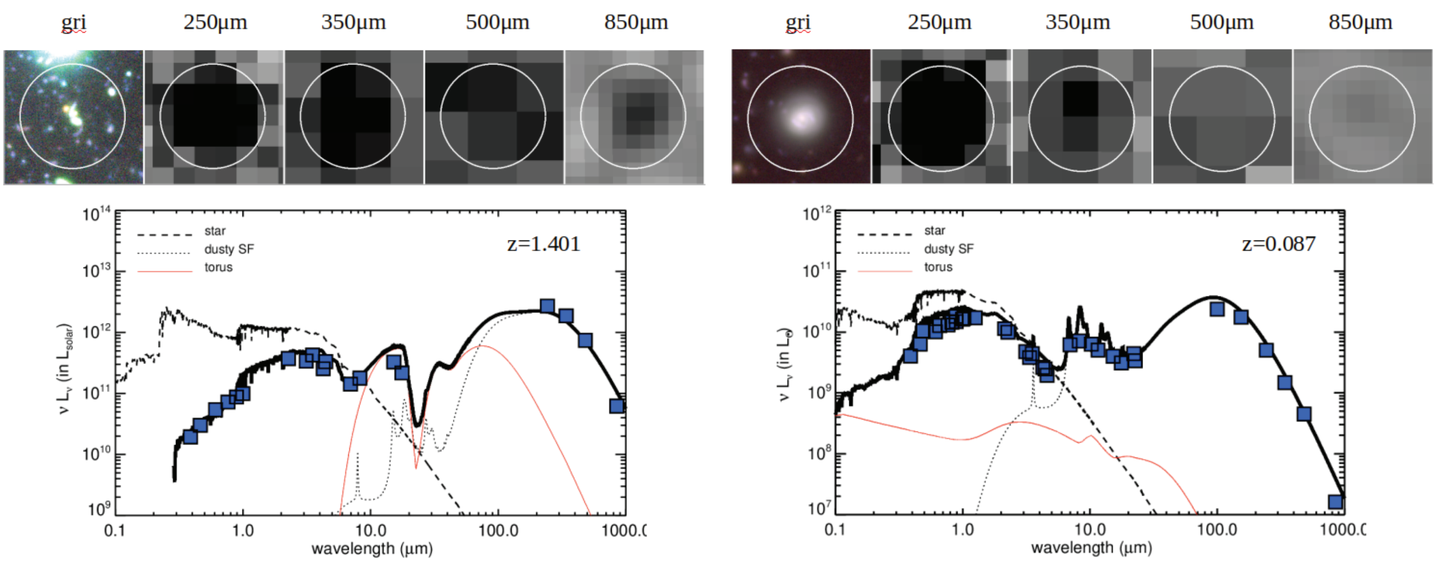


Figure 15. Two examples showing the role of 850μm photometry in studying physical properties of galaxies. Left is an interacting galaxy system with best-fit photometric redshift of 1.4. Combining 850μm photometry with previously obtained 250-500μm fluxes, we can compare the contribution of the AGN and star formation to the total luminosity in this system. In the right, we see a member galaxy in the z=0.087 NEP supercluster. This barred-spiral galaxy shows well-defined PAH emission at 6-12μm as well as the cold dust radiation peaking at ~100μm, which gives hints to the interstellar medium enrichment in galaxy evolution. In this figure, "gri" means that the image was made by a color-composite using astronomical g,r, and i-filters, which in this case were taken from the Subaru Hyper Supreme Cam.

Extreme Jet Ejections from the Stellar-Mass Black Hole V404 Cygni

A.J. Tetarenko, EAO Fellow, on behalf of the JACPOT XRB collaboration

Black hole X-ray binaries (BHXBs) — the stellar-mass analogues of Active Galactic Nuclei (AGN) — provide ideal laboratories to probe the ubiquitous phenomena of accretion and jet ejection. These Galactic binary systems (containing a stellar-mass black hole accreting matter from a companion star) tend to be transient in nature, rapidly evolving through bright outburst periods on timescales of days to months, and allowing us to study jet phenomena in real-time. In particular, data in the mm/sub-mm regime (e.g., Tetarenko et al. 2015) uniquely probe emission originating close to the black hole, at the base of the relativistic jet. Photometric and direct imaging measurements of this jet emission provide information on the timescales of internal processes occurring in the jet, and constrain the geometry, dynamics, and physical conditions in the jet.

While several transient BHXBs may undergo an outburst period every year, only rare (once per decade) outbursts probe the process of accretion and the physics of accretion-fed outflows near (or above) the Eddington limit, making these outbursts essential test-beds for understanding jet launching and acceleration mechanisms in the most extreme environments. After 26 years of quiescence, the BHXB V404 Cygni entered into one of these rare outburst states in June 2015 (Barthelmy et al., 2015), becoming the most luminous BHXB outburst seen in decades. The chance to observe this rare outburst state in V404 Cygni, which is one of the closest known BHXBs in our Galaxy (2.39±0.14kpc from geometric parallax; Miller-Jones et al. 2009), presented us with a unique opportunity. Therefore, we immediately triggered our BHXB mm/sub-mm monitoring program, including the JCMT on Maunakea, detecting V404 Cygni for the first time at mm/sub-mm frequencies.

Over the span of 8 months we took many mm/sub-mm observations of V404 Cygni. In these data, recently published in Monthly Notices of the Royal Astronomical Society (Tetarenko et al., 2017; Tetarenko et al., 2019), we observed dramatic variability, where the flux changed by over 3 orders of magnitude on timescales of minutes (within one observation) to months (between observations). However, our observations on the night of 2015 June 22 stand out from the rest. On this night we were able to organize simultaneous observations across 4 different radio/sub-mm telescopes; JCMT, SMA, VLA, and VLBA, three of which have stations on Maunakea (Tetarenko et al., 2017; Miller-Jones et al., 2019). In this incredible data set, we see multiple, rapidly evolving flares reaching Jy level fluxes, across 9 different frequency bands (see Figure 16 left). In particular, during the largest flare observed with JCMT the flux rose from ~75mJy up to ~8.0Jy on a timescale of ~ 20min. This is the largest mm/sub-mm flare ever observed from a BHXB, far surpassing even the brightest events in famed microquasar, GRS 1915+105 (Fender and Pooley, 2000).

One key pattern we noticed in this multi-band radio/sub-mm emission from V404 Cygni was that the lower frequency emission appears to be a smoothed, delayed version of the high frequency emission, with the flares showing longer rise times at lower frequencies. Both of these emission properties are clear observational signatures of the launching of discrete plasma ejections. Millimetre/sub-millimetre detections of such jet ejecta components are only possible in the brightest BHXB outbursts. Detailed Bayesian modelling of these light curves revealed that the multi-band flaring could be well produced by a series of 8 twin, bi-polar jet ejection events, occurring rapidly over the 4 hour observations, and allowed us to place constraints on jet speed and geometry, as well as map out how the jet size scale and structure change with frequency (see Figure 16 right; Tetarenko et al. 2017).

However, this is only half the story, as in addition to these amazing light curves, we also observed simultaneously with the VLBA (Miller-Jones et al., 2019). This interferometric telescope, consisting of multiple antennas located across the USA (one of which is on Maunakea), allowed us to create high angular resolution images (i.e., mas resolution, corresponding to AU physical size scales) of V404 Cygni. Normally we would make one image of the

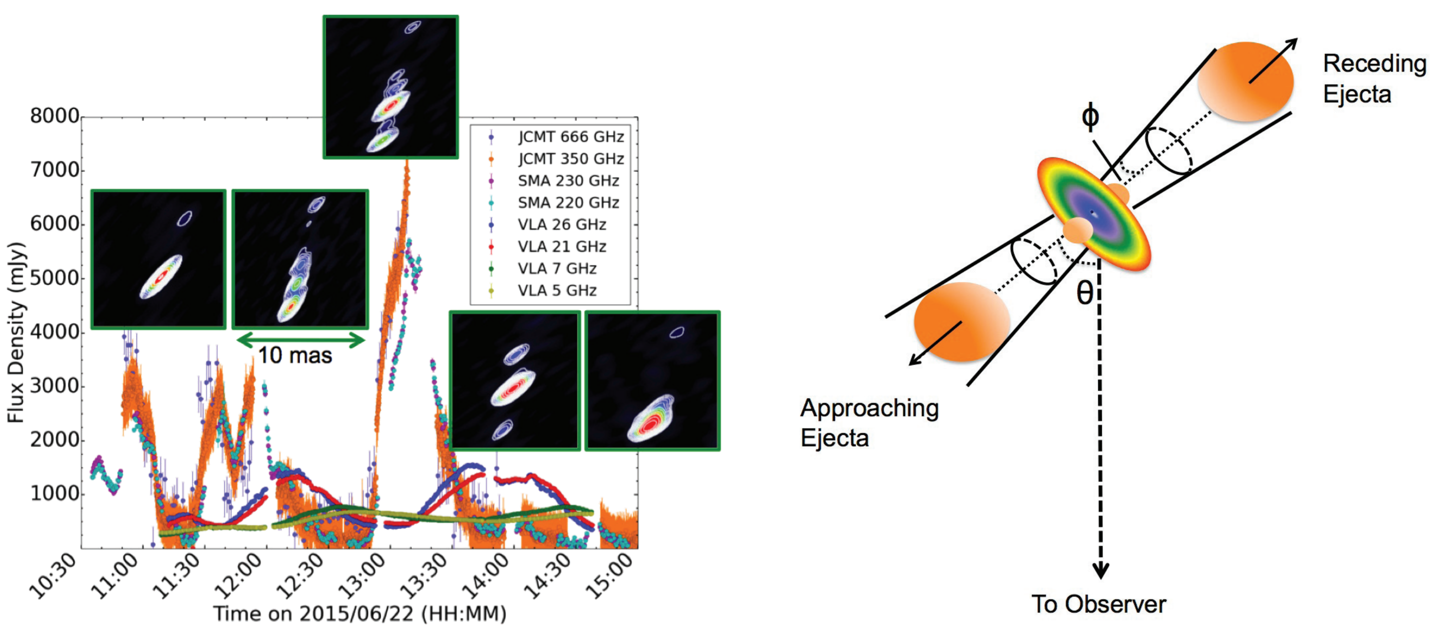


Figure 16: Left: Simultaneous light curves of V404 Cygni at cm, mm and sub-mm wavelengths from the VLA, SMA, and JCMT on 2015 June 22 (Tetarenko et al., 2017). Five representative high angular resolution VLBA images are shown as inset panels, in which we observe multiple, discrete jet components ejected from the system (Miller-Jones et al., 2019). Right: Schematic of our twin bi-polar ejection model viewed from the source frame, where ϕ represents the intrinsic jet opening angle, and θ represent the angle to the line of sight (i.e., inclination angle). Due to relativistic and geometrical effects, the observer sees a beamed and doppler (de-)boosted version of the emission seen in the source frame, and, emission from the receding component is delayed compared to the approaching component. These effects all combine to produce the unique morphology seen in the light curves in the left panel. Through applying this model to the V404 Cygni light curves, we estimate that there were at least 8 bi-polar ejection events during these observations.

whole 4-hour VLBA data set, but the incredibly rapid brightness changes we saw in the JCMT data in particular, forced us to take an alternate approach. One of the fundamental approximations of aperture synthesis (making an image from an interferometric data set) is that your target source is not changing over the timescale over which you image. As such, with our data, we had to create over 100 individual snapshot images, on 2 min timescales. In these snapshot images, we resolve multiple bi-polar jet ejection events, consistent with the light curve modelling we had done earlier (see Figure 1 left). These rapid jet ejection events had never before been resolved in a BHXB.

While these images were spectacular in themselves, though tracking the motion of the jet ejecta components in our series of images, we discovered something even more unexpected; the orientation of the jet axis was changing between ejection events (see Figure 17). What could cause the orientation of the jet axis to change so rapidly? Well, it turns out that in V404 Cygni, a misalignment between the black hole spin axis and binary orbital plane, combined with an extremely high accretion rate, produced the perfect storm of conditions for the accretion disc to start rapidly precessing like a solid body (due to a general relativistic effect called Lense-thirring precession; Lense 1918; Motta et al. 2018; Liska et al. 2018). Our results, recently published in Nature (Miller-Jones et al., 2019), suggest that the dynamics of this precessing accretion disc play a role in either directly launching or redirecting the jets close to the black hole (within the inner few hundred gravitational radii). We expect that similar dynamics should occur in any strongly-accreting black hole whose spin is misaligned with the inflowing gas, both affecting the observational characteristics of the jets, and distributing the black hole feedback more uniformly over the surrounding local environment.

Our work here has made it clear that that mm/sub-mm observations of transient events, like this outburst of V404 Cygni, provide a new perspective on the accretion process and the launching of relativistic jets. The JCMT has been a model instrument for transient followup and we extend our sincere thanks to all of the JCMT staff who helped us obtain these extraordinary observations, which were instrumental in making this observing campaign a success.

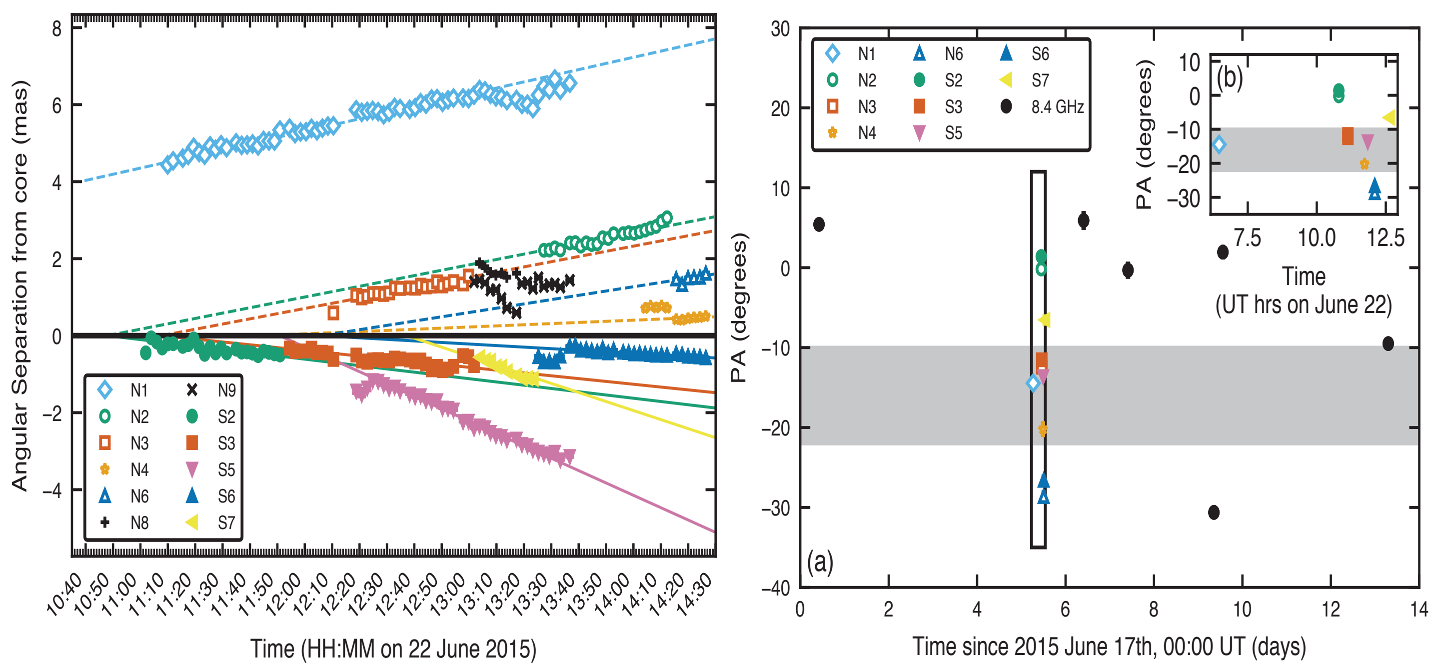


Figure 17: Measurements tracking the motion of the resolved jet ejecta components in our VLBA images (Miller-Jones et al., 2019). Left: Total angular separations from the core for all components. Positive and negative values denote displacements to the north and south of the core, respectively. Corresponding pairs of ejecta have matching colors and marker shapes. The best-fitting proper motions are shown as dashed (northern components; open markers) and solid (southern components; filled markers) lines,and range from ~4-46mas dy^{-1}. Right: Jet component position angles (PA) from the full set of VLBA observations taken during this outburst period, where the inset panel displays a zoom-in on 2015 June 22. The grey shaded region indicates the PA of the quiescent jet inferred from the polarized radio emission during the decay of the previous 1989 outburst (Han and Hjellming, 1992), which is consistent with the central PA that we measure in 2015. Through modelling the bulk motion of the ejected jet components we see remarkable changes in the orientation of the jet axis, in which the PA varied by up to ~30 degrees over 4 hours on the night of 2015 June 22 alone.

The JCMT Roof and Doors

Craig Walther, Chief Engineer at EAO

The JCMT will be shifting to remote observations come November 1st. To ensure safe and reliable operation of the facility the Engineering staff have been overhauling the aging roof and doors system at the JCMT.

The JCMT roof consists of three segments, two of these segments move while the roof is opening and closing. The top segment moves over the middle segment and then both moving segments stack above the bottom segment when the roof is open. A rear gantry, with two tracks for the two moving segments, supports the cantilevered segments while the telescope is open. There are two motors, one on each side of the telescope. They are mounted to the top roof segment and drive the roof open and closed. Each motor has a brake mounted on it.

The two large doors move simultaneously when the telescope is opening and closing. The top (front) section of the roof contains a track which supports the top of the doors when they are moving. Therefore, it is imperative that the roof is closed and locked in position before the doors are moved.

A lot of things must happen sequentially for the roof to close and lock itself. When the roof is approaching its closed position it first has to change into slow speed, then the motors have to be turned off (with the breaks left disengaged), then a pneumatic arm (with a hook) is raised up to grab the roof and pull it into its final position. Once this final position is sensed a large pneumatic locking pin is driven into the roof to hold it in place. After the locking pin is in place the pneumatic arm is released and pushed back out of the way and the brakes are engaged. Of course when the roof opens most things mentioned above have to work sequentially in reverse order. The pneumatic arm is not used in the opening sequence. There is one complete set of this equipment on the right side of the roof and one on the left.

The pneumatic arms and locking pins are driven by rams which are really just cylinders with pistons in them. When the ram is moved in one direction a valve lets air be released from the end of the cylinder the piston is moving towards and another valve allows compressed air to enter the side of the cylinder the piston is moving away from. To move the piston in the opposite direction the valves have to reverse their purpose.

All of this functionality is detected and performed with sensor switches, relays and solenoid controlled valves. In total it takes 18 switches, 8 valves and a great number of relays. This design was part of the original equipment installed in the telescope. Over the years switches and rams have been replaced, but the system has never been overhauled. The insulation on many of the wires is simply so old it has deteriorated enough to expose the inner (still insulated) wires. The electronics boxes are also at end of life and many need to be taped to stay closed. Additionally the mounting location of these items makes troubleshooting very cumbersome, if not dangerous.

The 2019 plan for overhauling the roof control equipment includes replacing the 7 existing electronics boxes with four new ones of high quality. These new boxes will be mounted as to be accessible via a simple walkway. The eight solenoid valves will be replaced with new valves which will also be accessible from the walkway. The only remaining items on the cramped platform will be the rams and switches. All of the deteriorating wires will be replaced with new teflon insulated wiring. This involves moving 160 individual wires and rewiring all 18 switches and 8 valves.

When the overhaul is completed we expect to have a more reliable system that will work well into the future while being much easier to troubleshoot. Not only will the new solenoid valves be easier to access, we will also have a test box which can be used to replace the drive relay circuitry. Using this box we will be able to operate the valves one at a time to help us pinpoint problems. Currently we are over half way through this effort and expect to be complete for remote operations in November.

Figure 18: As the motors close the roof, this device slows the motors then grabs and pulls the roof fully closed. At the end of a cycle a locking pin is inserted with pneumatics.

New Instrumention: Nāmakanui

Dan Bintley, SCUBA-2 Instrument Specialist at EAO
Izumi Mizuno, Instrumentation Scientist at EAO

We are very pleased and excited to announce that our new instrument Nāmakanui (The Big Eyes) is now in the receiver cabin of JCMT undergoing commissioning. The instrument which has three 'ALMA style' receiver cartridges, was named by Larry Kimura, University of Hawai'i Professor of Hawaiian language and Hawaiian studies. The three receivers 'Ū'ū (230GHz), 'Ala'ihi (86GHz) and 'Āweoweo (345GHz) are each named after nocturnal red coloured fish, "that have large eyes to help them to see in the darkness".

The new instrument was built and designed by EAO partner ASIAA as both a spare for the Greenland Telescope (GLT) and to provide a new world class instrument for JCMT. When commissioned, Nāmakanui will become a state-of-the-art instrument for VLBI both within the Asian region and as part of the worldwide Event Horizon Telescope. For VLBI, Nāmakanui is combined with a cutting edge digital backend and data recorders.

Nāmakanui has been offered to JCMT users for single dish observing, initially at 230GHz and later at 345GHz. Both 'Ū'ū and 'Āweoweo are dual polarization 2-sideband receivers, with (in the case of 'Ū'ū) up to 8GHz of bandwidth (less when using ACSIS). 'Ū'ū will be much faster than Rx3Am (which was retired in June 2018) for similar observations. The JCMT Heterodyne Integration Time Calculator https://proposals.eaobservatory.org/jcmt/calculator/heterodyne/ has been updated for 'Ū'ū observing.

The new instrument arrived from Taipei in packing crates in the middle of July, just as access to Maunakea became uncertain due to protests against the TMT. Rather than lose valuable time, EAO staff created a Lab in the Hilo office and preceded to assemble, cool down and test the receivers.

Figure 19: The new instrument has three receivers each named after nocturnal red coloured fish. (From left to right) 'Ū'ū (230GHz), 'Ala'ihi (86GHz), 'Āweoweo (345GHz).

Figure 20: Nāmakanui arrives in Hilo in mid July of 2019. The receiver is carefully removed from its crate.

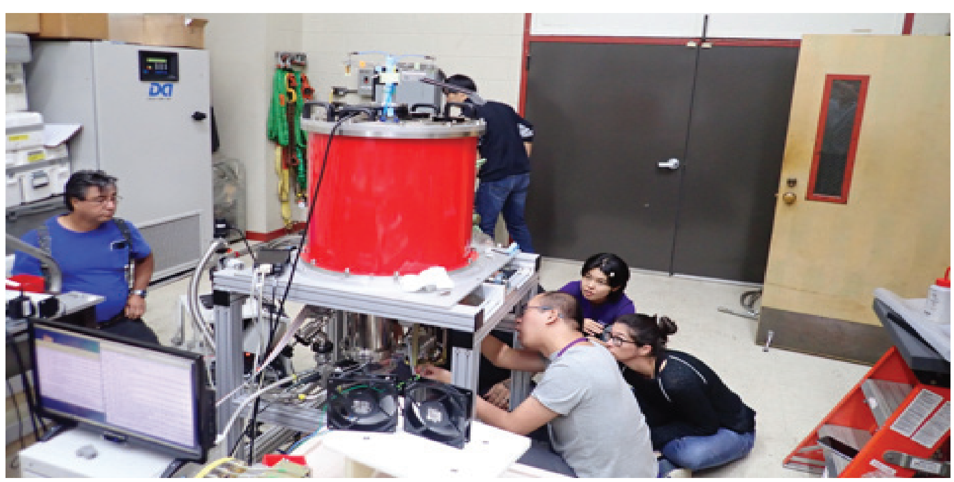


Figure 21: Chih-Chiang Han from ASIAA taught EAO staff how to set cold and warm cartridges components on the dewar. To move the receiver to the summit, the components needed to be removed, and reinstalled at the summit.

Lab testing in Hilo proved to be multidisciplined collaboration between EAO mechanical and electronic technical specialists, instrument scientists and software engineers, all under the watchful eye of Chih-Chiang Han from ASIAA. This was an opportunity to learn how to assemble Nāmakanui, test software that will eventually tune the receivers for observing and begin the task of characterizing the receivers, necessary before we can begin science at JCMT.

After 2 weeks of testing in Hilo and following a collective return to summit operations by the Maunakea Observatories, we decided to take the chance and warm-up, repack everything, transport Nāmakanui up the mountain and reassemble at JCMT.

The assembled instrument was then installed into the JCMT receiver cabin and cooled down to be ready for commissioning.

Commissioning of the three receivers is now underway. The receiver mixers have been cooled to below 4K and we are testing the performance and sensitivity of each receiver. New mirrors will be installed in the cabin and aligned, allowing the team to begin on-sky testing. We are excited with the prospect of first light and Big Eye's first glimpse of the cosmos coming soon.

Figure 22: Kuan-Yu Liu, Jason Fleck, and Izumi Mizuno insert the cold cartridge little by little into the dewer by carefully checking insert angle.

Figure 23: Nāmakanui is set up in the receiver cabin and ready for a performance test.

Introducing 'rapid turnaround' calls for proposals

Graham Bell, Software Programmer at EAO

Since its launch with the 16A call for proposals, our Hedwig proposal system has gradually evolved with new features to improve the proposal submission and review experience. The latest development is a 'rapid turnaround' (RT) scheme featuring a peer review process. This is modeled after the similar 'fast turnaround' program at Gemini (Mason, R.E et al., Proc. SPIE 9149, 2014).

We plan to accept RT proposals on a monthly cycle, keeping the existing semester structure but automati-

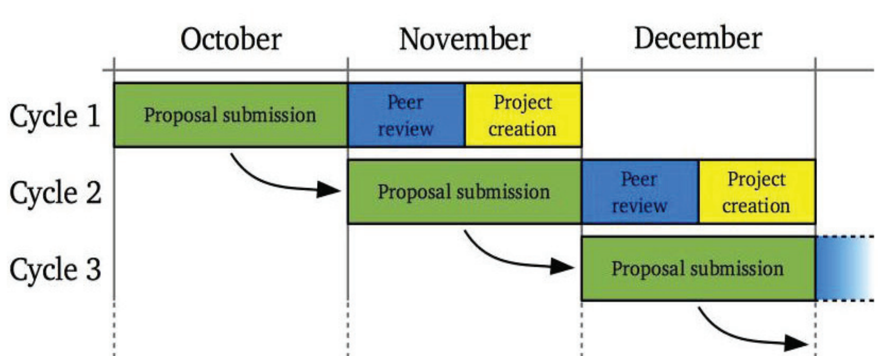


Figure 24: Planned schedule for the first few RT cycles.

cally rolling over accepted projects so that they stay active in the observing queue for six months. Aims of the scheme include encouraging more small time requests and providing another alternative for those needing extra time to complete their science goals prior to publications. It may also allow the observatory to advertise availability in certain weather bands and R.A. ranges, as determined by the telescope demand.

RT proposals will be assessed, as normal, by a JCMT staff member for technical feasibility. Then, instead of going to the Time Allocation Committee, they are graded by members of other proposals received at the same time. Each proposal must nominate a member who will be available to take part in this peer review process. We expect that each person may be asked to review about five other proposals.

We aim to open the rapid turnaround system to everyone from the start of October 2019. There will be monthly closing dates at the end of each cycle. Any proposals not submitted at the end of each cycle will remain active in Hedwig until the end of the semester and can be submitted in a subsequent cycle. The review process will then run for about two weeks to allow time for accepted projects to be set up and MSBs created before the start of the next month. For any projects requiring a faster turnaround than this, it will still be possible to submit urgent proposals at any time.

Remembering Wayne

Jessica Dempsey, Deputy Director of EAO

Figure 25: From Left: Erik Starman, Neal Oliveira, Ken Laidlaw, Wayne Holland, and John Kuroda next to SCUBA.

JCMT and the world-wide astronomy community lost a great man in May of 2019. Wayne Holland left us quietly, as was his way, shockingly young and yet with a legacy at our telescope, and in his field, that will continue to resonate for years to come.

For me, as a young instrument scientist grad, Wayne Holland was a bit of a pop star. I would see him at SPIE meetings, a stand-out figure with spiky blue hair and checked grunge shirt, and viewed him with no small amount of awe. When I found myself sitting opposite him during an interview in Cardiff, I was tongue-tied, but Wayne – the kind soul he was – saw my discomfort and made me at ease. A couple of years later, Wayne brought SCUBA-2 to JCMT, where I was now an instrument scientist. I was lucky enough to get to know him well during this crazy time, to see his keen instincts for his temperamental baby and I tried earnestly to emulate his dedication and passion for getting SCUBA-2 on sky.

I started, then, to understand that it was Wayne, through his years in Hawai'i keeping SCUBA working as it pioneered a new era of sub-mm science, and then by spearheading, tirelessly, SCUBA-2's huge technological leap forwards, that his passion and creations had formed – and continue to be - the foundation for JCMT's incredible successes. His science was also exceptional, and he rounded out these talents by being a deeply kind, generous and considerate soul.

We caught up last in Edinburgh, in September 2018. He was cheerful and enthusiastic as we chatted for hours about how to create the next generation of instruments to keep JCMT at the scientific cutting-edge. We talked about music and lamented never performing together (though his disdain for blues was likely why we didn't!). This is how I'll remember him, and I think now that if I had known it was our last conversation, I wouldn't have wished anything different.

Wayne Holland was a part of our JCMT ohana, now and always, and though his loss cuts deeply, his work and passion remain interwoven in our Observatory. Every night SCUBA-2 collects light from the sky, I pause in gratitude. Thank you, Wayne. You are missed.

A Hui Hou from Henry

Henry Stilmack, Systems Administrator at EAO

I started working for the Joint Astronomy Centre in the summer of 1985 as a part-time, temporary student employee. I stayed temporary for 4 years. One of my first jobs was wiring the (then new) headquarters building for serial terminals - at that time, there was one computer in Hilo, one at UKIRT, and JCMT had two! For those too young to remember serial terminals, they were a video screen with keyboard for text-only entry and output (although some could also do basic line graphics).

Over the next couple of years, the number of computers in the organization continued to increase. Graphical workstations started appearing on people's desks. I started getting involved in the management of this infrastructure, and found I was reasonably good at it. I got to play with computers and networks all day, and get paid for it! That was a pretty sweet gig in the late '80s.

By 1990, the organization decided they needed a full-time systems administrator, and I got the job. In those days, "Windows" was something called "Windows 3.1 for Workgroups", and we were just beginning to get the first Sun Solaris (UNIX) workstations - I had to figure out how to integrate them with the existing VAX-VMS systems. Networking went from a few dial-up modems, a leased 19,200 bit/sec line to the summit, and a 56,000 bit/sec packet connection to the NASA research net - to connection to the UH IP network here and at the summit. I saw the beginnings of the World Wide Web (installed a web browser on a VAX in 1989) and the transformation of the Internet from a research tool to a commercial enterprise.

By the late '90s, we started using Linux instead of Solaris (since the price of Solaris was high, and the necessary astronomy data tools had been ported to Linux by then). The number of distinct computer devices skyrocketed, the networks got more complex, and through all of it I kept surfing the waves of change and adapting the JAC/EAO systems and networks to the new paradigms. I've designed and redesigned networks, set up high-availability servers, virtualized a number of previously-distinct servers, and have, in general, had a great time doing it.

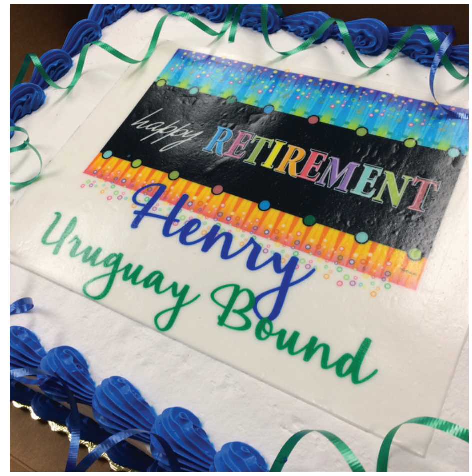


Figure 26: Cake at Henry's retirement celebration on August 30th, 2019.

It's been a truly amazing run over the years. I've been privileged to work with an awesome bunch of brilliant, competent co-workers from all over the world. I've learned an amazing amount, not only in my own field but also bits of astronomy and cosmology. I've been able to work at one of the most forbidding and at the same time magnificent sites in the world on Maunakea. As I close out this chapter of my life and begin the next one, I will always hold the JAC/EAO `ohana close in my heart. Mahalo nui loa, a hui hou!

Figure 27: Staff who attended Henry's farewell celebration on his last day of work at EAO August 30th, 2019.

2019 - The EAO ‘Ohana’s Year in Review

Callie Matulonis, Telescope System and Outreach Program Specialist, EAO

As we celebrate JCMT’s 32nd year, we relish in the bittersweet feeling as some staff move on to exciting opportunities and well-deserved retirement while continuing on their journey as our JCMT ‘ohana (family). With each new bright mind that has joined our team to the youthful newborn babies that have delighted our hallways, our ‘ohana continues to grow each day.

‘E komo mai (*Welcome*)

This year, Alexis Acohido joined EAO as an Extended Operator and was recently promoted to a full time Telesope System Specialist position. In addition to operations, she frequently assists in many outreach related endeavors. Alexis grew up on ‘Oahu, and graduated with a degree in Mathematics from the University of Hawai’i at Manoa.

Dr. Alex Tetarenko is a leading expert in mm/sub-mm observations of black-hole X-ray binaries and is now a 2018 East Asian Observatory Fellow working in Hilo, Hawai’i. Dr. Tetarenko was awarded the 2019 J. S. Plaskett Medal by the Canadian Astronomical Society (CASCA), and is exceptional as an observer and in her insightful physical interpretation of complex observational data.

From Hilo, Hawai’i - Devin-Jacob Estrada joins EAO as a System Administrator responsible for installing/configuring, maintaining, and decommissioning computer equipment - among a variety of other tasks. Devin is concurrently working on obtaining his Bachelor’s in Cyber Security and Information Assurance.

Miriam Fuchs joined our Telescope System Support team last September after working for two and a half years at the SMA. In addition to expertly operating the JCMT for astronomers, Mimi is a passionate leader in outreach and education.

Taishi Nammato spent his summer as an instrumentation intern with EAO. His project was to characterize the performance of our spectral line receiver HARP. He is a Bachelor of Science in Physics candidate expected to graduate from UH Hilo in spring of 2020.

Hongjun Ma has returned to EAO as a Visiting Researcher after having been out previously for a few months at the end of 2017. She is currently working on a variety of projects including the foreground removal towards the Galactic Centre on behalf of the CHIMPS Large program.

Jason Fleck is our new Electronics Technician here just in time to be a great help with Nāmakanui. Jason has been a technician his entire career, but most recently spent six years working in the avionics environment lab and structures test departments at SPACE X.

A hui hou (***Until we meet again)***

After almost 30-years of dedicated work as our Systems Administrator for UKIRT and JCMT, Henry Stilmack embarks on his retirement journey by starting a new chapter of his life in Uruguay (see article on page 20).

Simeon Johnson takes his nearly seven years of experience at JCMT and UKIRT as our Electronics/Electrical Technician over to a new role at the Very Large Baseline Array on Maunakea. Simeon studied Electronics Technology at Hawai’i Community College. We wish him all the best as he diversifies his career on the mountain.

Over 18 years of hard work and dedication supporting countless astronomers, at times being a part-time TSS, under both EAO and JAC, Jan Wouterloot and his family have returned to the Netherlands although he remains actively involved in the JCMT.

Tim Chuter’s countless contributions and accomplishments over his 30 years of dedicated service fulfilling a range of engineering positions at both UKIRT and JCMT will be greatly missed as he returns to his home country of the United Kingdom.

JCMT Researcher and EACOA Fellow Tie Liu left JCMT this summer for a new position at Shanghai Observatory in China.

Figure 28: Left to right: Telescope System Specialist, Alexis Acohido; EAO Fellow, Dr. Alex Tetarenko; System Administrator, Devin-Jacob Estrada; Telescope System Specialist, Miriam Fuchs; Instrumentation Intern, Taishi Nammato; Visiting Researcher, Hongjun Ma; Electronics Technician, Jason Fleck.

Figure 29: Left to right: Systems Administrator, Henry Stilmack; Electronics/Electrical Technician, Simeon Johnson; Support Astronomer, Jan Wouterloot

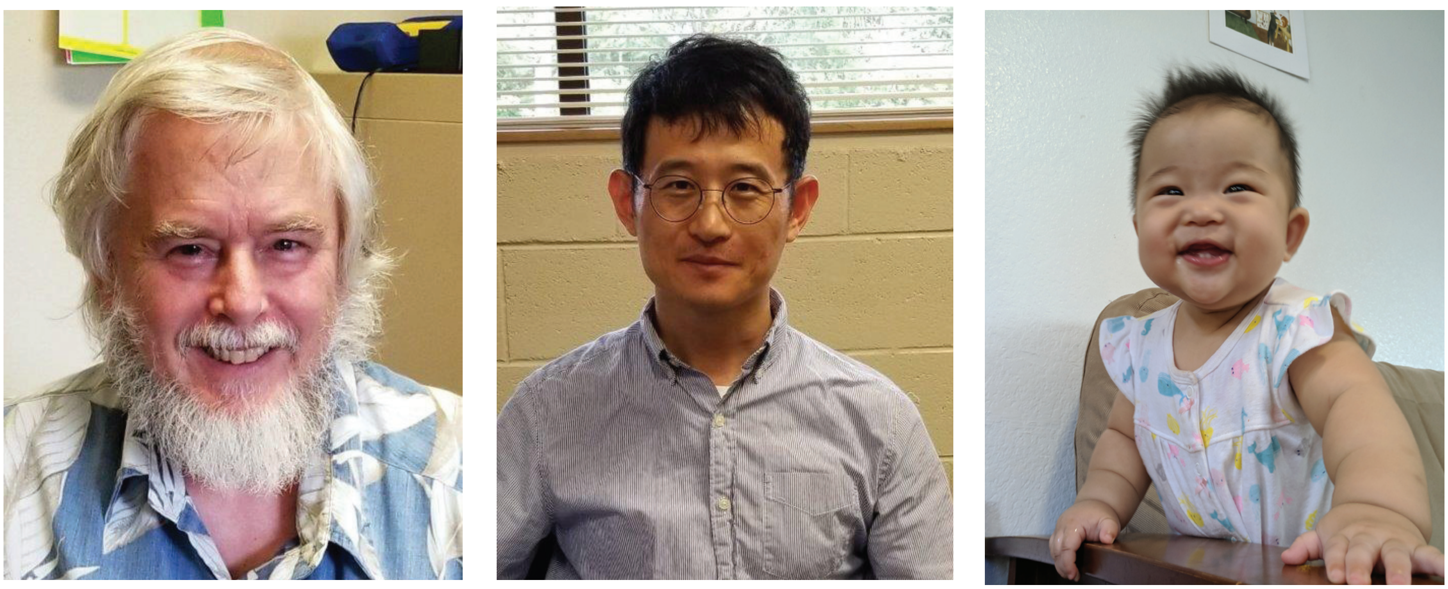


Figure 30: Left to right: Electronic and Instrument Systems Engineer, Tim Chuter; Researcher and EACOA fellow, Tie Liu; Emma Li.

Keiki (***The little ones)***

Instrumentation Scientist, Shaoliang Li, and wife, Enlan, greeted their first born daughter, Emma, on December 20th, 2018.

Soon thereafter on December 29th, 2018, Telescope System and Outreach Program Specialist, Callie Matulonis and husband, Tony, greeted second born daughter, Summer Reed.

Support Astronomer, Steve Mairs, and wife, Desiree, welcomed son, Luke Ezekiel Mairs, on September 17th, 2019, just in time for the publication of this newsletter.

Figure 31: Left to right: Skye and Summer Matulonis; Luke Ezekiel Mairs.

James Clerk Maxwell Telescope
East Asian Observatory