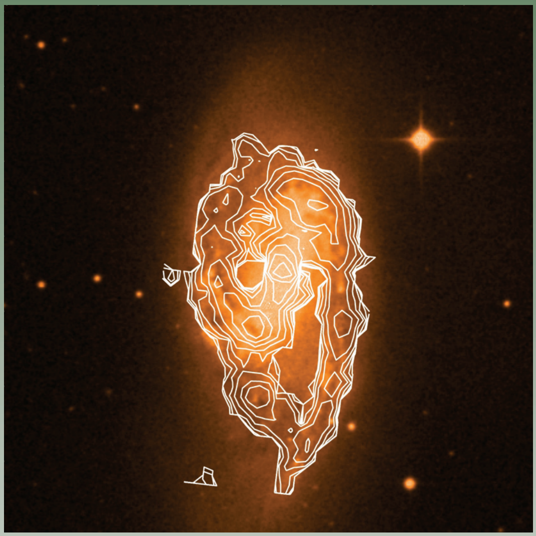
JCMT NEWSLETTER

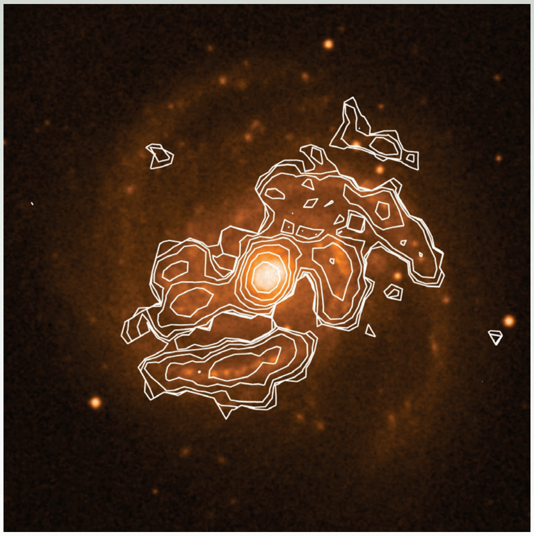
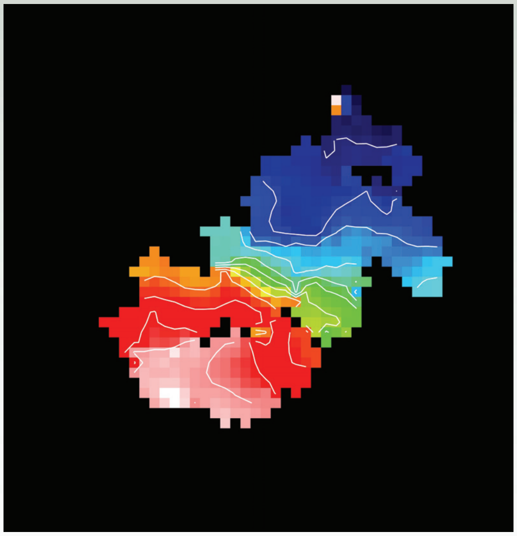
JAMES CLERK MAXWELL TELESCOPE

AUTUMN 2008 · #29




JCMT Legacy Survey: The First Year

Nearby Galaxies Survey

Very Long Baseline Interferometry Results

HARP/ACSIS Galactic Plane Results

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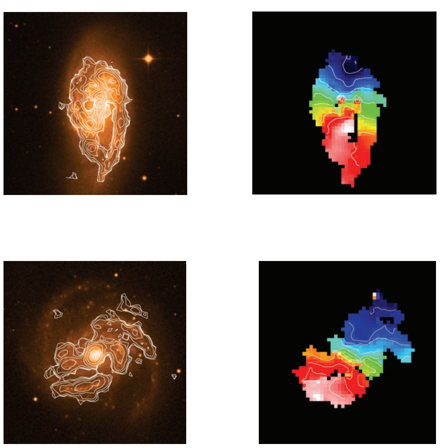
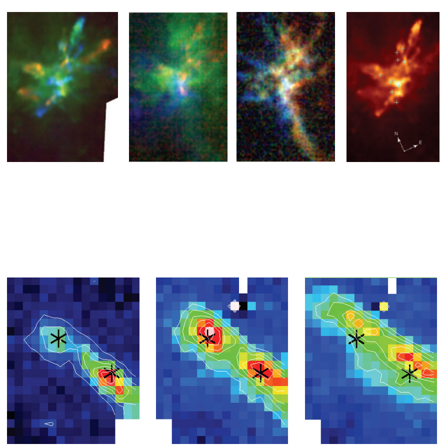


On the front cover: JCMT Legacy Survey (JLS): Nearby Galaxies Survey (NGS). (top) NGC 3627 (M 66). (top left) $^{12}CO(3-2)$ integrated intensity contours overlaid on a DSS optical image. (top right) Doppler-shifted ^{12}CO (3–2) velocity field. (bottom) NGC 4321 (M 100). (bottom left) $^{12}CO(3-2)$ integrated intensity countours overlaid on a DSS optical image. (bottom right) Doppler-shifted $^{12}CO(3-2)$ velocity field. (Please also see http://www.jach.hawaii.edu/JCMT/surveys/ and http://outreach.jach.hawaii.edu/pressroom/2008_legacysurvey1/ for more information.)



On the rear cover: (top) JCMT Legacy Survey (JLS): Gould Belt Survey (GBS), Serpens star forming cloud center. (top left) ^{12}CO emission. (top center left) ^{13}CO emission. (top center right) $C^{18}O$ emission. (top right) Crosses mark known newly formed stars overlaid on the ^{12}CO map. (bottom) JCMT Legacy Survey (JLS): Spectral Line Survey (SLS), Orion Bar. (bottom left) SO emission. (bottom center) H_2CO emission. (bottom right) C_2H emission. Asterisks mark the same sky positions. (Please also see http://www.jach.hawaii.edu/JCMT/surveys/ and http://outreach.jach.hawaii.edu/pressroom/2008_legacysurvey1/ for more information.)

JCMT Newsletter, James Clerk Maxwell Telescope, is published biannually and is edited by Antonio Chrysostomou and Jonathan Kemp.

ISSN 1351-5497.

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The Joint Astronomy Centre provides services and support to enable visiting and staff astronomers to undertake top-quality, front-line international-class research using the James Clerk Maxwell Telescope (JCMT) and the United Kingdom Infrared Telescope (UKIRT); to develop these facilities in order to maintain their position as the most advanced of their kind in the world; to operate them in the most cost effective and efficient manner on behalf of the funding agencies; and to be responsive to the changing needs of the contributing organizations.

The JCMT is supported by the United Kingdom's Science and Technology Facilities Council (STFC), the National Research Council Canada (NRC), and the Netherlands Organization for Scientific Research (NWO); it is overseen by the JCMT Board.

The JCMT is a member of the RadioNet consortium.

From the Desk of the Director

Professor Gary Davis (*Director JCMT*) & Antonio Chrysostomou (*Associate Director JCMT*)


Gary Davis, Director JCMT

Rejoice!

The agreement between the funding agencies in the UK, Canada and the Netherlands contains a break point in 2009. We are very pleased indeed to be able to announce to the JCMT's user community that, in order to enable the full scientific exploitation of the observatory's new capabilities (SCUBA-2, eSMA, HARP/ACSIS), the agencies have agreed to continue operating the JCMT, under the terms of the current agreement, until at least 2012. This marks the culmination of a process that began with a strategic review of the JCMT in 2005 by a panel chaired by Martin Harwit, and included (in the UK) the PPARC Programmatic Review of 2005/6 and the STFC Programmatic Review of 2007/8. Once these processes were finally out of the way and the political stars were adequately aligned, the JCMT Board issued a public statement confirming the extension of the agreement following its meeting in June. This is a major step forward for the observatory and it is a relief to have finally made it.

Having secured one extension, our minds immediately turn to the next one. The JCMT will again be reviewed in 2010, and the outcome of this exercise will inform the JCMT Board's strategy for the future of the facility beyond 2012. It remains our view that if SCUBA-2 is fully up and running by then and performing to specification, the case for continuing to operate the JCMT will be self-evident: in particular, the JCMT Legacy Survey represents a 5-year programme of fabulous, ground-breaking science which will only scratch the surface of possibilities with the new suite of instruments.

We reported last time that the SCUBA-2 instrument had been delivered to Hawaii and had been mounted on the telescope. Since then, the instrument team and JAC staff have been working hard to integrate the instrument into the observatory environment. Excellent progress has been made but a number of unanticipated problems were encountered in this process, as is only to be expected with such a novel and complex instrument. The good news is that none of them appear to be show-stoppers and the instrument and observatory teams are, at the time of writing this column, working through them and implementing solutions. We expect to commission the system, containing two commissioning-grade arrays, by the end of semester 08B. A set of two science-grade arrays, one at each wavelength, is currently scheduled to arrive in Hawaii in March 2009 and we therefore anticipate releasing the instrument to the community in semester 09B.

Excellent progress has also been made in preparing the JCMT for observations in interferometric mode, in collaboration with the SMA and the CSO. For details, see the article by Remo Tilanus in this Newsletter.

The JCMT Legacy Survey (JLS) is, at the time of writing, into its 10th month of operations and data collection is progressing well. In that time there have been 11 observing runs which the teams have supported by readily providing observers — we are all very thankful for this support from the survey teams. In fact, it is pleasing to see that a number of students have come out for JLS observing, indicating that the JLS is being utilised as a training ground for our future astronomers. In the main, the JLS data look excellent (and at times spectacular) and first papers are already in preparation. At this time, the three teams (Spectral Legacy Survey, Gould Belt Survey, Nearby Galaxies Legacy Survey) with HARP/ACSIS components in their surveys are focussed on their preparations for a review of the JLS, to be conducted by the JCMT Surveys Oversight Committee (JSOC) on behalf of the JCMT Board. The community will be appraised of the results of the review following the December meeting of the JCMT Board. As always, survey progress can be followed at `http://www.jach.hawaii.edu/JCMT/surveys/` .


Antonio Chrysostomou, Associate Director JCMT

An unfortunate event at the end of August resulted in the loss of two receptors from the HARP array, leaving just 12 working receptors. Instructions have been posted on the JCMT web site explaining how project PIs should be amending their MSBs to minimise the effect of this on their data. Replacement of the 4 broken receptors has now become a high priority and we are working with Cambridge to expedite the fabrication of new receptors which we aim to install in HARP by February 2009.

There are now new versions of the ORAC-DR data reduction pipeline, using new recipes which significantly improve the quality of the final data product. A quick version of the pipeline runs at the summit and at the end of each night a more advanced version of the pipeline is run which uses iterative techniques to determine better baseline masks and thus produce much improved reduced observations. These are then shipped to CADC along with the raw data where they are made available for download. These new recipes are now publicly available

(Director's Desk, continued on page 4)

Starlink Software Collection: Lehuakona Release

Brad Cavanagh (*JAC Software Group*)

The Joint Astronomy Centre has released another version of the Starlink Software Collection. Named after Antares, the Lehuakona release offers speed improvements for multi-core processors for certain applications, a greatly-improved ORAC–DR data-reduction pipeline for ACSIS observations, and the ability to create simulated time-series cubes from sky cubes with UNMAKECUBE.

As always, bug fixes and other improvements have been made. The Lehuakona release is available for 32- and 64-bit Linux and PPC and Intel OS X. Further information and download links are at `http://starlink.jach.hawaii.edu/` .

eSMA observing at dusk on 2008 May 27. (Image courtesy Jonathan Kemp/JAC.)

(Director's Desk, continued from page 3)
with the latest Lehuakona Starlink release. [Please also see the article at the top of this page.]

Finally, we have one significant staffing change to report: Gerald Schieven left the JAC in July to take up a position as leader of the Millimetre Astronomy Group at HIA in Canada. Readers of the Newsletter may be aware that Gerald was one of two staff at the JAC employed by the Canadian funding agency NRC and deployed in Hilo to support Canadian users of the telescope. Gerald was at the JAC for nearly 13 years, and he was well known throughout the JCMT community because for several of those years he was the JCMT scheduler and the editor of this Newsletter. This is an excellent career move for Gerald and we wish him well. His duties as scheduler have been taken over by Iain Coulson, another long-time member of the JCMT staff. Completing the reshuffle, we welcome Holly Thomas to the JAC as our newest support astronomer. Holly joined the JAC in September, having recently completed her PhD at Manchester under the supervision of Gary Fuller, and she will take over Iain's work as keeper of the telescope pointing and focussing models.

The Night Shift

Ben Warrington (*JCMT Telescope System Specialist*)

Well it seems that it is time for me to write another newsletter article, and I am finding myself somewhat at a loss for words. I cannot think of any really earth-shattering developments in the world of a JCMT Telescope Systems Specialist. Operations at the telescope are continuing in a smooth manner for the most part. This, of course, is good news, but it is hardly enough exciting material with which to fill a page.

Last time I wrote something for this newsletter, Saddle Road was still under construction. The section from the 19 mile marker to the summit turn-off is now complete. It is a genuine highway, including things like passing lanes and a 55 mph speed limit. I hear that it is safe to drive much faster than that, but not in a JAC vehicle, of course. There is no plan, in the near future, to upgrade the section of the road from Hilo to the 19 mile marker where the speed limit remains 35 mph, but that was previously the best part of the road anyway. There is still a long stretch of poor road towards Waimea. It is my understanding that the next phase of construction involves continuing the work in that direction.

Over the last year or so, JAC has upgraded all save one of its fleet of four-wheel drive vehicles to Nissan Xterras. The new Xterras are pretty good vehicles (better than Xterras of previous model years) and, if nothing else, the newer vehicles have fewer rattles than the Isuzu Troopers had developed over many thousands of miles of driving on the summit access road.

The JAC terminal room at Hale Pohaku has received an ergonomic upgrade. There are new chairs and monitor stands. There are also adjustable keyboard trays and footrests available for use. No more hunched-over afternoons of reviewing data at HP. The terminal room also has a coded door lock similar to the ones at the entrance to HP, but with a different code. This gives observers and staff somewhere a little more secure to hide their laptop bags and such while at Hale Pohaku.

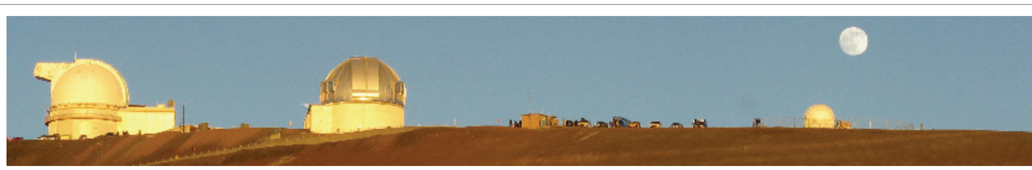
On November 12, there was a ribbon cutting ceremony for the eSMA. Ceremonies aside, the eSMA is making considerable progress with a commissioning science observing run done on the night of November 6–7. This was a science run on a known bright source in order to test a realistic night of observing to make sure that CSO and JCMT can be properly integrated into the SMA array, and that calibrated science can be extracted from the data. As Head of Operations Remo Tilanus put it to me, “This is the acid test to see if we can do science with eSMA.” The test went well, and from an operator’s point of view everything went smoothly ... boringly so. [Please also see the article on page 10 of this issue.]

As regular observers know by now, there are four missing or malfunctioning HARP receptors out of its nominal complement of 16. Unfortunately, there is very little we can do about it right now, but a warm-up has been scheduled for February when an attempt to replace the missing receptors will be made. In the meantime, we are still getting good science from the instrument even if the coverage is not as good as we would like.

It will be quite a while yet before it is released for science, but SCUBA-2 is coming along. This past summer, first light was obtained with the engineering array: a crude image of Saturn. There have been a number of interesting hurdles to clear including an unexpected sensitivity to the Earth’s magnetic field, and a radiological incident at a laboratory where a couple of the arrays were located. The engineering and commissioning team has been meeting the challenges, however, and we can be confident that eventually SCUBA-2 will deliver. As a TSS, I am looking forward to night-time commissioning with both anticipation and a bit of trepidation. I am not sure if the scars have healed yet from the HARP/ACSIS/OCS commissioning a couple of years back.

Unfortunately, D-band observations with RxW are still on hold. We are pretty certain that the receiver is properly aligned and ready to go. Unfortunately, we have to wait for grade one weather to do any testing which makes it a very slow process. By the time you read this, we could be taking science data, or we could still be waiting for the weather.

Speaking of the weather, it is starting to turn towards winter. Nights are getting colder, and we got our first snow of the season early in the morning on October 25. The snow melted after no more than a few hours, but I am sure there is more to come. On the positive side, winter usually means more grade one and two weather.



Moonrise over the Mauna Kea summit ridge as seen from JCMT. (Image courtesy Olja Panic/Leiden and Jan Wouterloot/JAC.)

Detecting Emission Near the Event Horizon of Sgr A*

Shep Doeleman (*MIT/Haystack Observatory*)

On 2007 April 10 and 11, the JCMT participated in Very Long Baseline Interferometry observations of 6 bright quasar calibrators and of the massive black hole candidate at the Galactic center, Sgr A*. Sgr A* is the compact source of radio, Infrared and X-ray emission at the center of the Milky Way Galaxy, and represents a low luminosity version of the AGN phenomenon, and the best chance to confirm the existence of massive black holes and to study their environments. Models of emission and of matter dynamics at the innermost accretion region have become increasingly sophisticated, and now predict signatures of strong GR effects and MHD instabilities that require observations on angular scales of <40 μas. VLBI at high frequencies (≥230GHz) is the only currently available technique that can probe Sgr A* on these scales, which correspond to only twice the size of the black hole itself. Extending VLBI to 1.3 mm and sub-mm wavelengths is technically quite challenging and this experiment was made possible by an international collaboration including researchers at JCMT, MIT Haystack Observatory, Submillimeter Array, Harvard Smithsonian Center for Astrophysics, Caltech Submillimeter Observatory, University of Arizona, and CARMA. The observations carried out by this group were successful in all respects and represent the highest angular resolution detection of the Galactic Center.

Increased angular resolution is not the only requirement for resolving the most compact emission near the black hole. The ionized Interstellar Medium scatter broadens images of Sgr A* with a λ^2 dependence, and though VLBI at 7 mm and 3.5 mm has detected evidence for intrinsic structure of Sgr A*, these observations remain dominated by scattering effects, and angular resolutions at these frequencies correspond to ~10s of Schwarzschild radii (R_{sch}). The only published 1.4 mm VLBI observations of Sgr A* to date (Krichbaum et al. A&A, 335, 106, 1998, on a 1100 km baseline) gives a larger size estimate of 110 μas (~11 R_{sch}), and for many years it was argued that longer baselines at 1.3 mm would over-resolve, and not detect the source.

The three station VLBI array consisted of the 10 m Submillimeter Telescope Observatory (SMT) on Mt. Graham in Arizona, one 10 m element of the Combined Array for Research in Millimeter-wave Astronomy (CARMA) in Eastern California, and the 15 m JCMT (Figure 1). At each site, two passbands, each 480 MHz wide, were recorded on two high-speed VLBI systems using 2-bit sampling for an aggregate recording rate of 3.84 Gb/s. On Mauna Kea, the JCMT obtained its Hydrogen-maser locked receiver reference signal from the SMA facility via the eSMA optical fiber link, and the received astronomical signals from the JCMT were sent to VLBI recorders at the SMA. It should be emphasized that the eSMA infrastructure was essential to the success of this experiment. In fact, it was detection of robust eSMA fringes on the calibrator 3C 111 that proved critical in verifying the technical setup at the SMA and JCMT. Six bright quasars observed as calibrators were detected with high signal to noise on all three baselines, and these detections allowed the positions of the telescopes to be refined, and instrumental delays and frequency offsets to be accurately determined. Because there is always some uncertainty in VLBI array geometry, a search over interferometer delay and delay-rate is performed to find detections. The array information gleaned from the calibrator sources dramatically reduced the size of the necessary search for detections of Sgr A*. JCMT personnel used geodetic GPS receivers to provide the initial JCMT location. The data from all three sites were processed on the Mark4 correlator at MIT Haystack Observatory.

On both 2007 April 10 and 11, Sgr

(VLBI, continued on page 7)

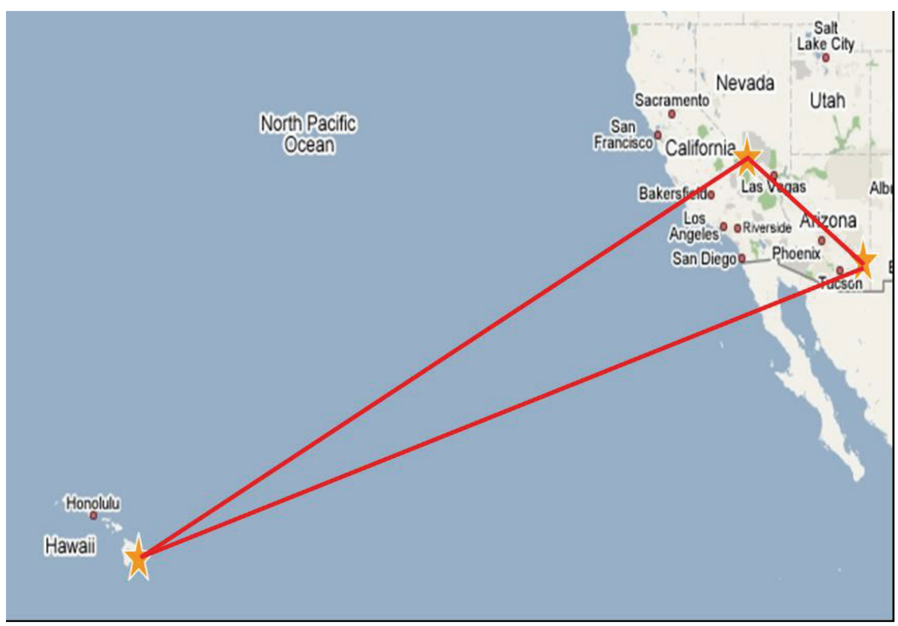


Figure 1. — Location of 1.3 mm VLBI array stations during the April 2007 observations. Participating sites were JCMT (Mauna Kea, HI), SMT (Mount Graham, AZ), and CARMA (Cedar Flat, CA). The longest baseline was ~4550 km.

(VLBI, continued from page 6)

A* was robustly detected on the short SMT–CARMA baseline, but only on April 11 was it detected on the SMT–JCMT baseline. On neither day was Sgr A* detected on the CARMA-JCMT baseline, which is most likely due to the lower sensitivity on that baseline. To avoid coherence losses due to atmospheric turbulence, the VLBI data were segmented in time and incoherently averaged, a standard practice at short wavelengths. A final fringe search resulted in 4 detections of Sgr A* on projected baselines of ~3.5 Gλ (4550 km) with an angular resolution of 59 μas.

The data are well fit by a Gaussian brightness distribution with a full width half max size of 46.0 μas. The intrinsic size of Sgr A* can be extracted from this measurement assuming the scatter broadening of the ISM adds in quadrature with the intrinsic size. This results in an intrinsic size of Sgr A* equal to 40.2 μas. This size is a factor of 3 smaller than the most recent 3 mm VLBI work. Assuming a lower limit to the mass of Sgr A* of $4\times10^5\ M_\odot$ from proper motion work, the new intrinsic size yields a mass density lower limit of $6.9\times10^{22}\ M_\odot/\mathrm{pc}^3$. Since any conceivable aggregation of matter with this density would coalesce or evaporate on time scales well below the age of the Galaxy (Maoz, ApJ, 494, 218, 1998), this result is the best evidence to date for the existence of massive black holes (MBH).

What further differentiates this work from longer wavelength VLBI is that the measurements are no longer dominated by the scattering, and we have clearly detected and measured the intrinsic size without the need to precisely model very small differences in observed size vs. expected scatter broadening. Figure 2 shows both the observed size and intrinsic size of Sgr A* over a range of wavelengths. The new 1.3 mm size is clearly much larger than the scattering size, a direct consequence of the reduced effect of the scattering on the measurements at short wavelengths. The intrinsic sizes in Figure 2 show a λ^α dependence, which implies that the emission at different wavelengths in Sgr A* comes from different radii. What is notable is that the intrinsic sizes are smaller than the scattering size until one reaches ~1.3 mm. For this reason, only VLBI at these short wavelengths will be able to pierce the scattering screen to model and image Sgr A* on R_{sch} scales.

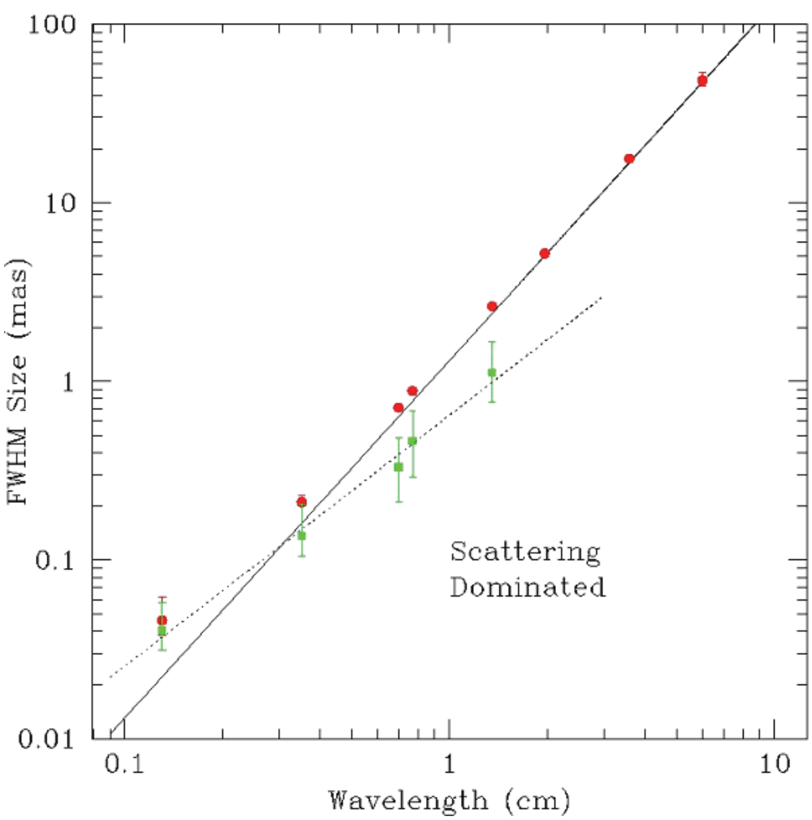


Figure 2. — Observed and intrinsic size of Sgr A as a function of wavelength. Red points show major axis observed sizes of Sgr A* from previous VLBI (all errors 3σ). Data at 7 mm<λ<6 cm are from Bower et al. (ApJL, 648, 127, 2006), data at 3 mm are from Shen et al. (Nature, 438, 62, 2005), and data at 1.3 mm are from the recent observations with JCMT. The solid line is the best fit λ^2 scattering law from Bower et al. (2006), and is derived from measurements made at λ>17 cm. Below this line, measurements of the intrinsic size of Sgr A* are dominated by scattering effects, while measurements above the line sample intrinsic structure more directly. Green points show derived major axis intrinsic sizes at 1.3 mm<λ<2 cm and are fit with a λ^α power law shown as a dotted line. The intrinsic size at 1.3 mm corresponds to just twice the diameter of a non-rotating $4\times10^6\ M_\odot$ black hole.*

Distortion of light paths caused by extreme gravitational lensing near the event horizon should create a dark 'shadow' at the position of the black hole (Falcke, Melia & Agol, ApJL, 528, 13, 2000; Broderick & Loeb, MNRAS, 367, 905, 2006). The resolution of the 1.3 mm VLBI experiment, and the size derived here are commensurate with the expected 'shadow' size, and indicate that future short wavelength VLBI will be sensitive to signatures expected from a true gravitational singularity. The collaboration that carried out this experiment is planning technical enhancements that will increase the sensitivity of the VLBI array by factors of 3 to 10. Foremost among these is an effort to phase together all the mm/sub-mm apertures on Mauna Kea, forming a VLBI site with an effective aperture diameter of 23 m, and an endeavor for which the eSMA infrastructure is a key element. Combined with ongoing enhancements in VLBI recorder technology, future short wavelength VLBI will be able to sensitively search for structural periodicity due to orbiting plasma hot spots, and model GR modification of the quiescent accretion disk. We wish to acknowledge the support of the many people at all participating observatories and collaborating facilities that made these observations possible.

HARP Observations of the Bubbling Galactic Plane

Christopher Beaumont & Jonathan Williams (*Hawaii*)

Massive stars have a dramatic influence on the interstellar medium. The radiation from rare but luminous O stars creates huge volumes of ionized gas. The less massive, but far more numerous, B stars produce impressive wind-blown bubbles. The Spitzer Space Telescope found that the Galactic plane is filled with parsec-scale rings and loops (Churchwell et al. 2006, 2007). These features, which appear bright in the mid-infrared due to excited PAH emission, vary markedly in eccentricity and degree of symmetry. The discoverers suggested that the differences were due to inhomogeneities in the surroundings of the bubbles and that their expansion triggered star formation, most clearly evidenced by occasional groups of bubbles. To study the molecular environments, and to search for additional evidence of very young protostars, we carried out a HARP mapping survey of CO 3–2 toward the bubbles.

Our JCMT observations, carried out in the summer of 2008, nicely complement the Spitzer data and radio observations of ionized gas (Figure 1). The *J*=3–2 CO line highlights the warm edges of the bubbles and embedded sites of star formation but also reveals the cooler surrounding molecular cloud. The efficient raster mapping mode of the HARP array allowed us to make 45 maps, each approximately 10'×10' in size, in just seven nights of observing. We also mapped seven objects in HCO^+ 4–3 to constrain the density of the shells and embedded cores.

Even a casual examination of these maps reveals their complexity, and these objects are characterized more by disparity than homogeneity (Figure 2). Nevertheless, the HARP data reveal some interesting general trends. By comparing the location and velocity of shells to their surrounding molecular environments, we can broadly divide the bubbles into two categories. Bubbles in the first group have cleared a cavity in a dense cloud and appear to be illuminating the inner wall of this cavity. The second group of objects lie in a lower density environment. Their winds have swept up a dense shell of material in an otherwise tenuous medium, and the rings seen in Spitzer are truly localized regions of higher density. While this division is not always clear-cut, it points to two broad physical interpretations to the ring-like structures seen in the infrared.

Conspicuously absent from our maps are objects which display the kinematic structure of expanding spherical shells. While simple geometric arguments place an upper limit on the contrast ratio between the edge and center of an expanding spherical shell of about 10 — a value that the high dynamic range of our data is easily sensitive to — the fronts and backs of these objects are rarely seen, and then only at a lower than expected brightness. The absence of the fronts and backs to these objects suggests that the molecular surroundings of the massive stars are sheet-like with thicknesses less than the ring radii, typically about 5 pc. Bubbles thus blister at the front and back of these sheets and dissipate into the tenuous exterior.

A few cases exist where we have identified CO outflows in the ring material at the interaction of the massive star bubble with the molecular cloud but, in general, there is little evidence for enhanced star formation and the HCO^+ observations do not show a large amount of dense gas. We are exploring a possible exception to this rule in regions where shells from two bubbles collide. Densities here seem to be higher, as indicated by their generally enhanced brightness in both Spitzer and JCMT data. We are also conducting an analysis of infrared excess sources to study the density of young protostars in and out of these regions.

Our analysis of this spectacular HARP dataset has just begun. The CO velocities provide kinematic distances to each object, many of which were previously unknown, and allow us to determine the bubble sizes

(Galactic Plane, continued on page 9)

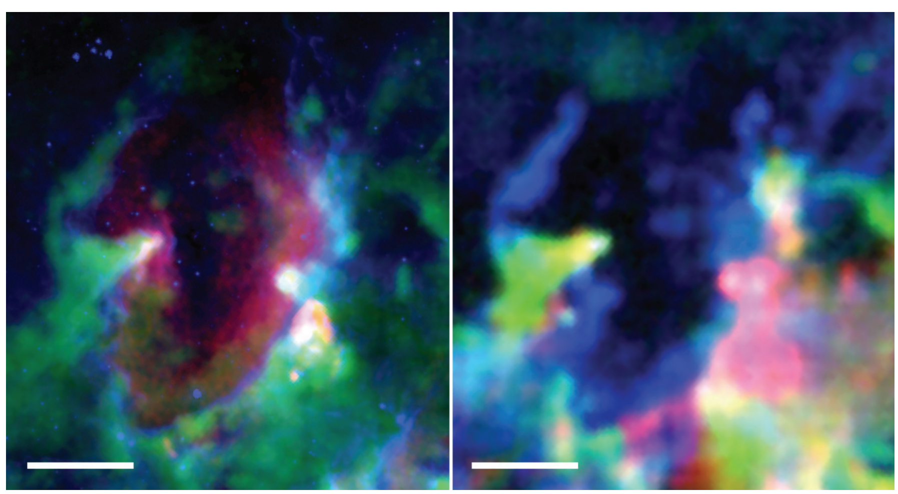


Figure 1. — (left) Three-color image of bubble N 036 from the Churchwell catalog. Red emission is 6 cm continuum from the NRAO MAGPIS survey. Green is JCMT CO 3–2 emission, integrated from 98 to 120 km/s. Blue is 8 μm data from Spitzer. The scale bar denotes 2 arcmin. The color scaling is chosen to highlight emission in each of the three bands. (right) 3-color JCMT map. Integrated emission from 98 to 107 km/s is shaded blue, from 107 to 110 km/s is shaded green, and from 110–120 km/s is shaded red. The color scaling is chosen to balance each shade.

(Galactic Plane, continued from page 8)

and luminosities, as well as the mass and temperature interior to, within, and exterior to the shells. We are continuing to explore the relationship between the shell like structures with the larger scale molecular environment and are also comparing our observations with radiative transfer models to further discriminate between putative bubble geometries. The properties of bubbles with and without radio emission (from the NRAO MAGPIS survey) will provide a comparison between the more energetic but rarer bubbles driven by O stars with the gentler, more numerous bubbles around B stars. This will help to determine which objects, as a group, are more instrumental in shaping the ISM. The wealth of data from a week's worth of HARP observations will likely keep us busy throughout the following year!

References

Churchwell, E. et al. 2006, *ApJ*, 649, 759.
Churchwell, E. et al. 2007, *ApJ*, 670, 428.

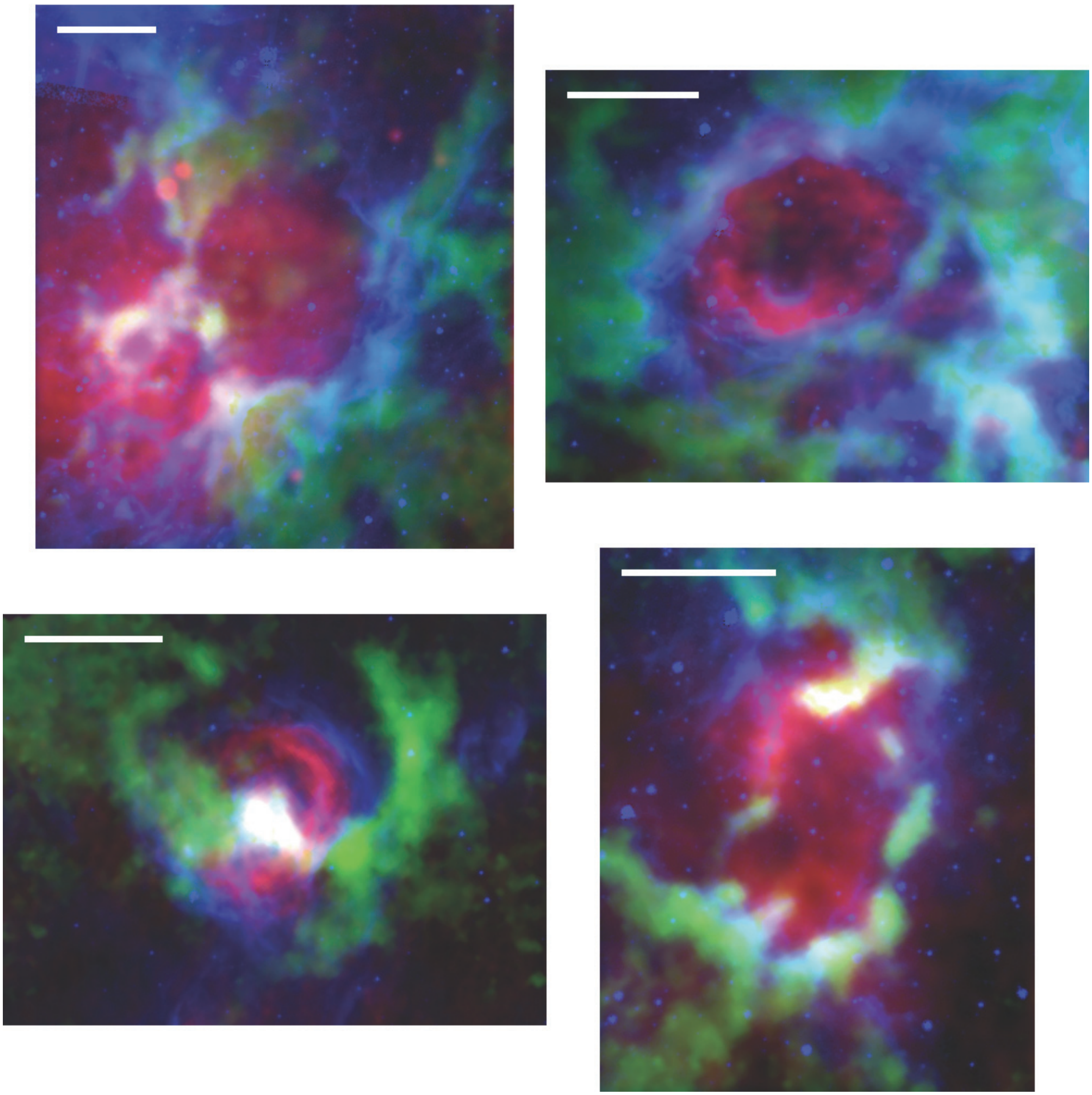


Figure 2. — (clockwise from upper left) 3-color images of N 010, N 045, N 022, and N 029. Scale bars and colors are as in the left panel of Figure 1.

eSMA Developments

Remo Tilanus (*JCMT Head of Operations*) & The eSMA Commissioning Team

This article reports on the eSMA project. The Extended SubMillimeter Array (eSMA) is a collaboration between the SMA, JCMT, and CSO to join all three observatories into a single interferometric array with nearly twice the collecting area of the SMA alone and an increased resolution resulting from its longer baselines. It will operate part-time in the 345 GHz atmospheric window. A technical description of the eSMA can be found in Bottinelli et al. (Proceedings of SPIE, Vol. 7012, 2008).

Since the last eSMA article in the Autumn 2007 Newsletter, reporting on first fringes at 345 GHz, development of the eSMA has proceeded at an accelerated pace, especially since March of this year. A protracted effort to determine special phase terms associated with the heterogeneous nature of the array was concluded in August. An example of such a term is the contribution from the non-intersection of axes at the CSO, a feature of its construction. But as part of the phase tests, two observations have delivered the first scientific results of the eSMA and are in the process of being published.

The first observation, led by Sandrine Bottinelli from Leiden Observatory, targeted the lensed quasar PKS 1830-211, which is seen through the disk of a foreground spiral galaxy at a redshift of z=0.866. The two lensed images of the background quasar were easily resolved with the eSMA (Figure 1) which was in its extended configuration resulting in a resolution of 0.55"×0.22" at the observing frequency of 1.1 mm.

An absorption profile of redshifted CI ($^3P_1$–$^3P_0$) was observed towards the SW component, but not the NE component. Together with complementary CO observations from the SMA, this is the first direct determination of the ratio of atomic carbon to CO

(eSMA, continued on page 11)

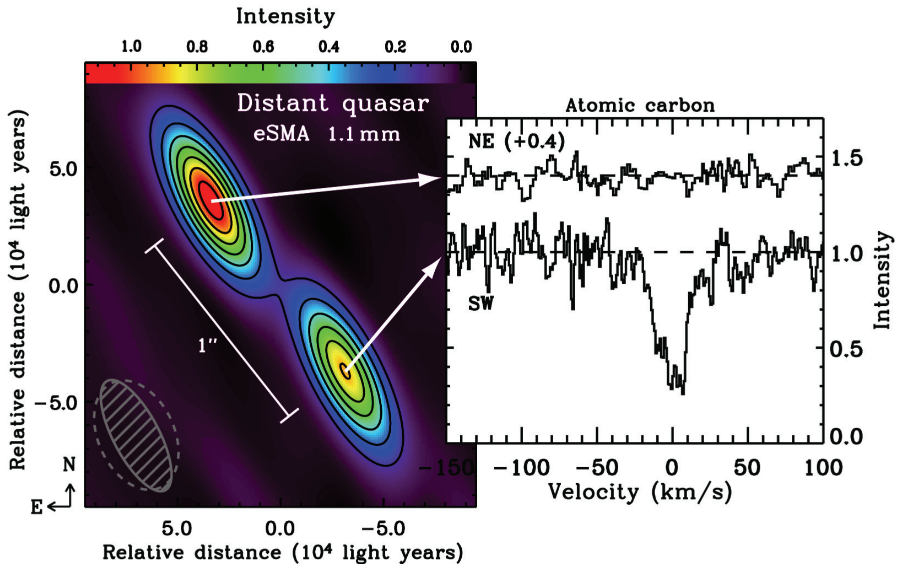


Figure 1. — eSMA observations of the lensed quasar PKS 1830-211 with the absorption profile of [CI] towards the SW component at the redshift of 0.866 of the intervening spiral galaxy. The separation between the two images is about 1". (Courtesy Sandrine Bottinelli/Leiden and Meredith Hughes/Harvard-Smithsonian).

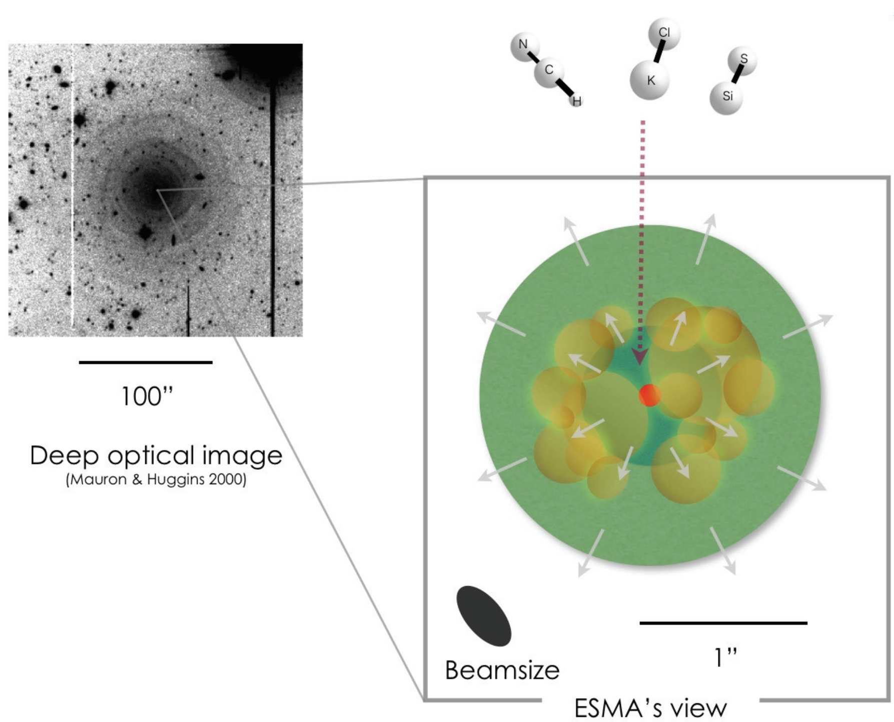


Figure 2. — The picture at the top left shows a deep optical image of the star, IRC+10216, taken with the Canada-France-Hawaii telescope. At the end of its life as a sun-like star, IRC+10216 is shedding its out layers, visible as shells in the picture which obscure the image of the central region in optical light. The artist rendering on the bottom-right, illustrating the eSMA observations, shows IRC+10216 itself as the red circle at the center. Several hundred million miles above the star's surface, shown as the darker green region, the temperature of the expelled material becomes low enough for dust and molecules, such as HCN, KCl, and SiS, to form. Radiation pressure from the photosphere accelerates the material. Outside of this innermost portion of the dusty envelope, the material reaches a high velocity and is found to have a clumpy distribution, illustrated here as yellow blobs. (Courtesy Hiroko Shinnaga/Cal Tech.)

(eSMA, continued from page 10)

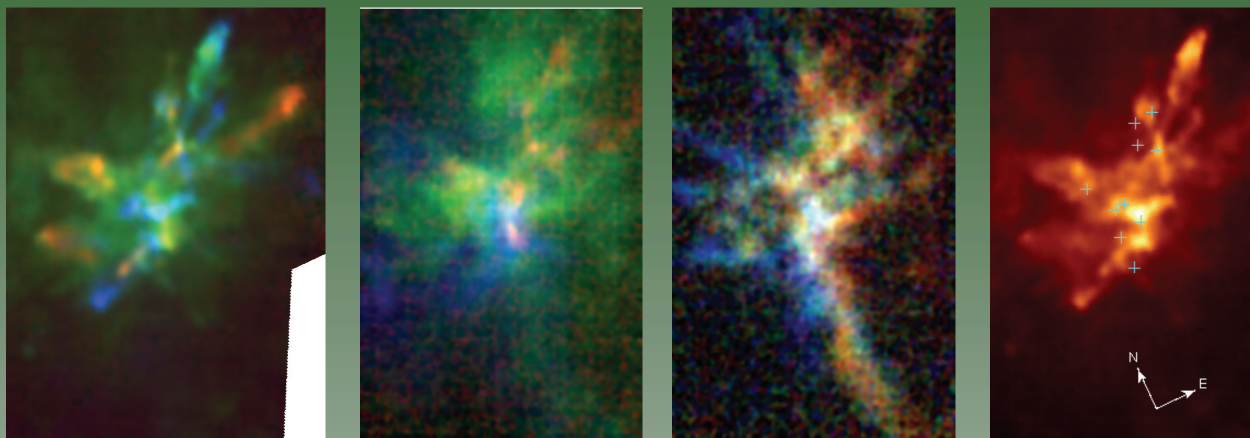
in a molecular cloud of a galaxy at *z*>0.1. The CI and CO absorption profiles can be decomposed into two and three velocity components, respectively, with different C/CO ratios that are representative of different environments of dense cores or diffuse/translucent clouds. Alternatively, the different ratios can represent a different evolutionary stage of the molecular clouds.

In a second result, obtained by Hiroko Shinnaga (CSO) et al., the eSMA zoomed in on the envelope of the nearby carbon star IRC+10216 (CW Leo). The eSMA imaged the innermost circumstellar envelope (within ~290 $R_\odot$) directly with a 0.2"×0.5" beam, detecting HCN and other molecular lines. The HCN maser components are spatially resolved for the first time in an astronomical object. Based on the kinematics of the gas two discrete regions were identified: the first is a region with a radius of less than <15 $R_\odot$, where molecular species probably were formed recently and the molecular gas is being accelerated by radiation pressure from the stellar photosphere. The second is a region out to 23 $R_\odot$ where the expansion velocity reaches up to 13 km/s, just below the terminal velocity of ~16 km/s seen in the outer envelope. These eSMA observations are the first time that the acceleration region of a carbon star has been spatially resolved and the kinematics of that region studied in detail (Figure 2).

Figure 3. — Pictures of the eSMA dedication ceremony held on Mauna Kea on November 12. (top) The ribbon cutting ceremony on the summit ridge next to UKIRT and overlooking sub-mm valley. Doing the honors is Louis Vertegaal, Director Physical Sciences of NWO (The Netherlands), which provided funding in support of the eSMA project. On his right is Tom Phillips, Director CSO. On his left, Gary Davis, Director JCMT, and Rob Christensen, Summit Leader SMA. Holding the ribbon are Stuart Putland, Head of Administrations JCMT (left) and Antonio Chrysostomou, Associate Director JCMT (right). (bottom) Afterwards the eSMA, under remote control from Boston by Ken "Taco" Young (SMA), slewed in unison to 'target' the ridge. Special thanks to "Taco", Hiroshige Yoshida (CSO), Jim Hoge (JCMT), and Ken Brown (JCMT) for their behind-the-scenes support. (Images courtesy Inge Heyer/ JAC.)

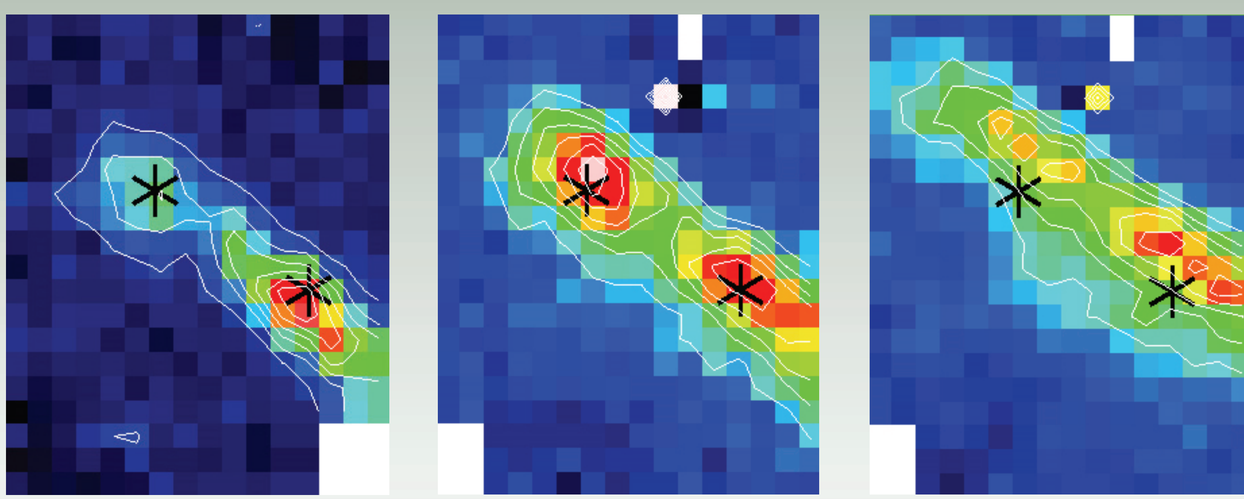
PKS 1830–211 and IRC+10216 were bright enough to be able to self-calibrate the observations without the need for a separate phase calibrator and allowing for successful imaging under rather poor weather conditions. However, recent tests with the eSMA have achieved an important milestone by demonstrating a successful 'phase-transfer' at 267 GHz with 3C 84 as the phase calibrator for 3C 111 which is bright enough to be self-calibrated for comparison.

Nearing the completion of the commissioning targets in the 230 GHz atmospheric window, our efforts during the recent months have increasingly shifted towards the target window of 345 GHz, where a number of technical issues still remain to be solved before a call for proposals for the eSMA Pilot Program can be issued.



JCMT Legacy Survey: The First Year

Gould Belt Survey
Spectral Line Survey



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