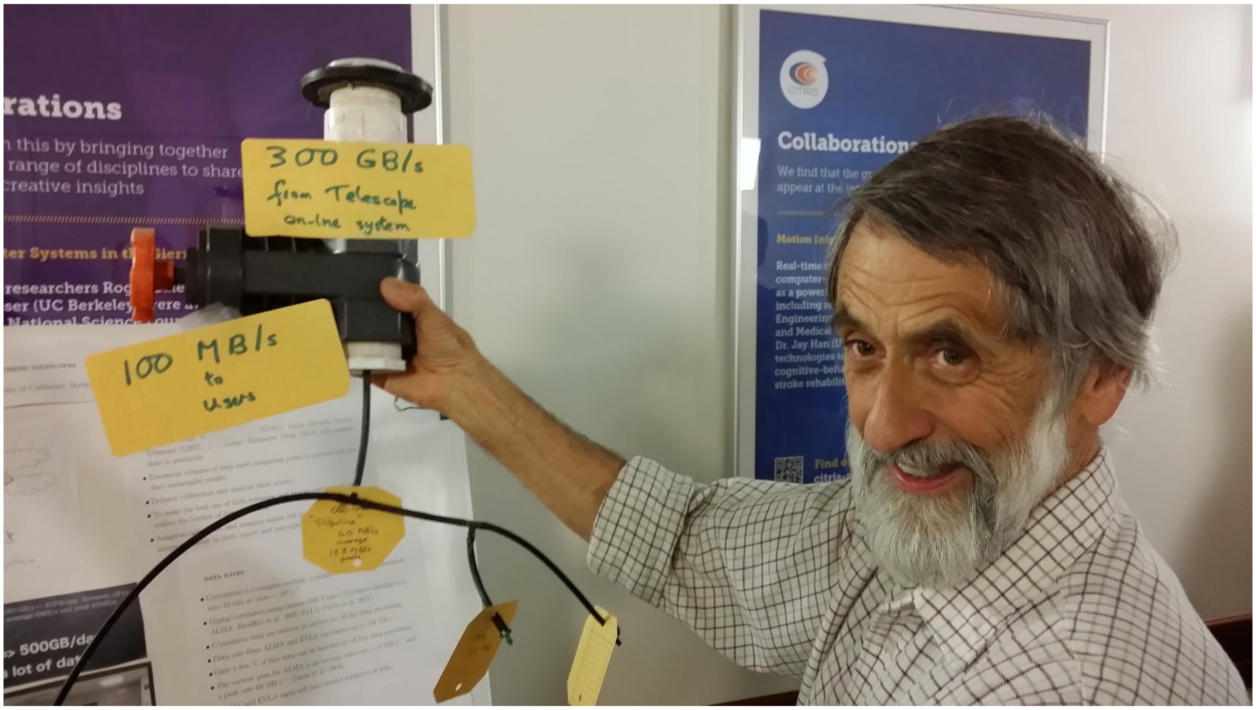
Melvyn Wright - UG Research 2022



ALMA data pipeline: 2 inch to 1/8 inch adaptor reduces data rate from correlator to ALMA users.
Adaptive Real Time Imaging Telescopes. 1980's technology for a state of the art telescope.

Research - Black Holes, Massive Star Formation and Aperture Synthesis

Aperture Synthesis images of Black Holes and high mass protostars.
Both have accretion disks and drive powerful outflows or jets.

Recent research: Observations of the Black hole in M87, and the high mass protostar in Orion KL.
Observations in the 1980's with students at Berkeley and Caltech using the Hat Creek and OVRO millimeter arrays.
Over the years we helped to develop the technology leading to ALMA and Event Horizon Telescopes.

https://public.nrao.edu/telescopes/alma
Event Horizon Telescope

Teaching - Summer Schools and Student Mentoring

Schools at Hat Creek, BIMA, and CARMA Observatories over 25 years.

Research Opportunities

Recent images of high mass star formation from ALMA and JVLA telescopes, are available for detailed analysis.

Black Holes in the centers of galaxies, and high mass protostars have much in common.
Both are hard to see .

Radiation cannot escape from Black Holes.
We observe radiation from accreting material as it falls into the Black Hole.

High mass star formation is hidden in dense dusty gas.
We observe the thermal radiation, and molecular lines from the gas and dust heated by the protostar.

Accretion in Black holes and high mass protostars is mediated by accretion disks
which export angular momentum from the accreting matter, and drive powerful outflows or jets.

In this research note we highlight high resolution observations of the Black hole in M87, and the disk around a young protostar in Orion.

Black Holes

We observed the massive black holes in the Virgo galaxy, M87, and Sgra*, at the center
of our own Milky Way using VLBI techniques at millimeter wavelengths.

The Schwarzschild radii, $R_s = 2 G M / c^2$ are 10 and 8 micro arcsec respectively for SgrA* (4x10^6 Mo) (distance 8 kpc), and the M87 black hole (6.5x10^9 Mo) (distance 16 Mpc) .

We started these observations in the 1980's with Don Backer, Dick Plambeck, Berkeley graduate students, and a similar small team at Caltech using the Hat Creek and OVRO millimeter wave telescopes.
Over years we improved the technology and used more telescopes, leading to the Event Horizon Telescope.
https://eventhorizontelescope.org/

Using radio telescopes around the world at a wavelength 1.3 mm, we obtained an angular resolution,
lambda/earth diameter = 1.3mm/8000 km == 30 micro arcsec,
to image the event horizon, in a collaboration led by Shep Doeleman at Harvard in 2019.

There are some nice movies from the NRAO web site of the M87 black hole:

https://public.nrao.edu/gallery/messier-87-the-very-first-image-of-a-black-hole/

And from Chandra of the M87 X ray, optical and radio jet:

https://www.youtube.com/watch?v=gxC2jpugA9g

Massive Star Formation

The Kleinmann-Low Nebula in Orion, at a distance 415 pc is the nearest interstellar cloud in which massive, ›8 Mo, stars are forming.

The two most massive stars in this region, Source-I (Src I) and the Becklin-Neugebauer Object (BN), are recoiling from one another at 35-40 km/s suggesting that they were ejected from a multiple system via dynamical decay approximately 500 years ago with a bunch of expanding debris mapped in various lines.

Src I has a mass 15 Mo, with a rotating accretion disk and a molecular outflow that is prominent in SiO.
The disk around Src I has been well studied as it is the closest known disk around a high mass protostar.

CHEMISTRY

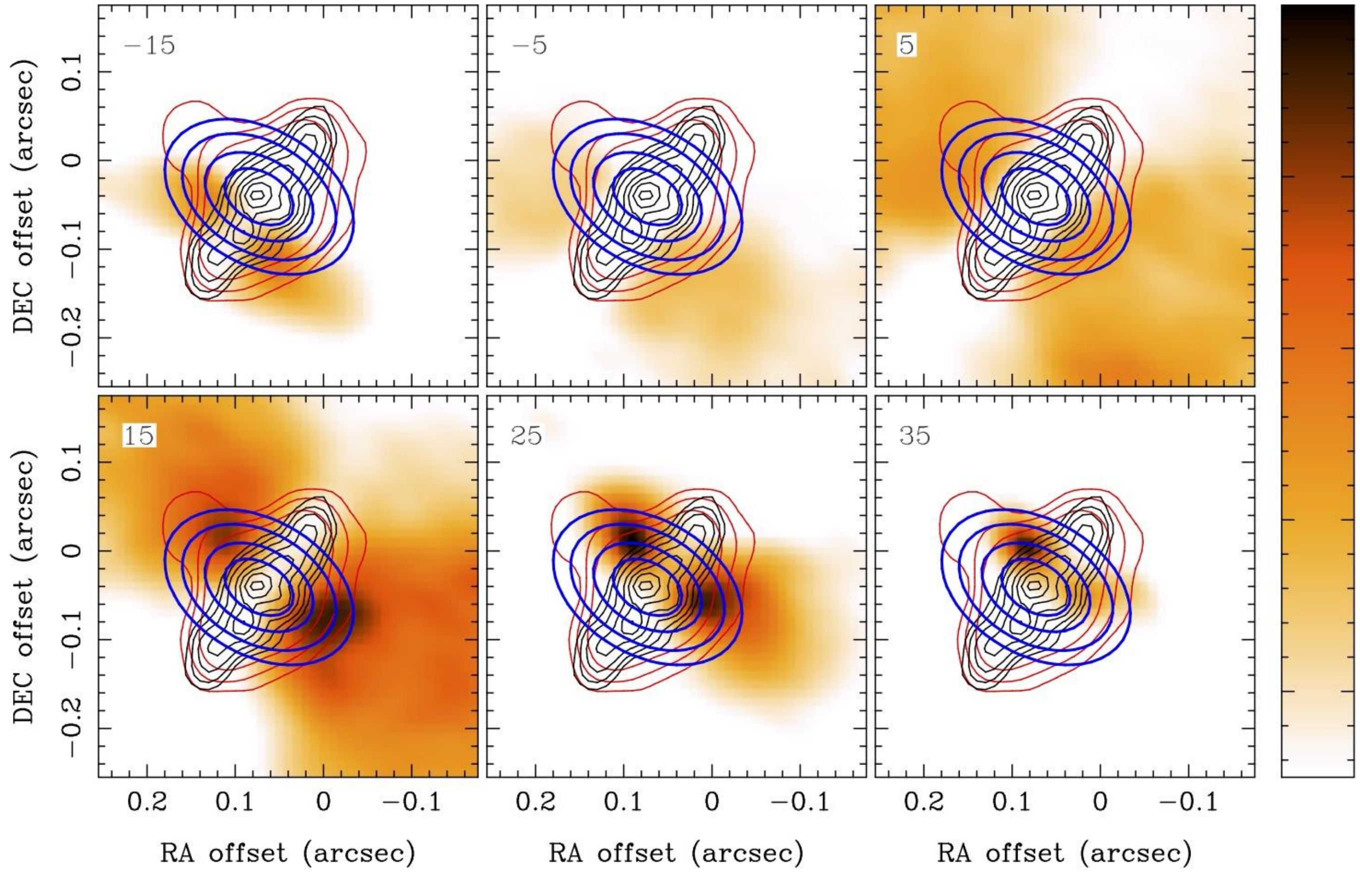
Recently dozens of spectral lines of NaCl and KCl were identified in this disk.
Salt (NaCl) emission is visible where the dust is optically thin,
provides a unique tracer of the velocity field within the disk.

Other molecules that we have mapped -- H2O, AlO, SiO, SiS, SO, and SO2… -- appear primarily in the bipolar outflow. The base of the outflow is corotating with the disk. A magneto centrifugal outflow.

The molecular distributions suggest that Si and Al, released from dust grains in the disk, react with oxygen derived from H2O to form SiO and AlO, and with SO and SO2 to form SiS.

We imaged the continuum and molecular line emission from Orion Source-I (SrcI) with 12 AU resolution at 43, 86, 99, 223, and 340 GHz probing the structure and chemistry of the circumstellar disk and bipolar outflow associated with this high mass protostar.

COLOR image shows SiO v=0, J=5-4 emission (217.10498 GHz) at 10 km/s intervals.
BLACK contours at 99 GHz shows the inner structure in the disk. Note the twisted inner ridge.
RED contours at 43 GHz show the structure at the edge of the disk. Note the bulge to the NW.
BLUE contours show the 6 GHz emission along the minor axis of the dust disk.



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RA, DEC, VRAD = 05:35:14.513, −05:22:30.58, −1.50000E+01 km/s at pixel (51.00, 51.00, 1.00)
Spatial region : 26,26 to 68,68     Spectral inc/bin : 1/1 =10/10 (km/s)
Pixel map image: sio54.10kms.regrid.B2 (orion_bn)  Min/max=−2.518×10^−3/0.04578  Range = 5×10^−3 to 0.05 JY/BEAM (lin)
Contour image: B2.cm.imcat.ave.regrid.B3.adjust (orion_source_i)  Min/max=−3.483×10^−5/2.786×10^−3  Contours x 3.569×10^−
Contours : 25, 50, 100
Contour image: cont.mfs.cm.03.regrid.B2 (orion_source_i)  Min/max=10^30/−10^30  Contours x 7.245×10^−6 JY/BEAM
Contours : 50, 100, 200, 400, 600, 800, 1000
Contour image: 6GHz_100kl_srcI.imfit.adjust.imgen (orion_source_i)  Min/max=10^30/7.824×10^−3  Contours x 1.763×10^−6 JY
Contours : 50, 100, 200, 300, 600, 800, 1000
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