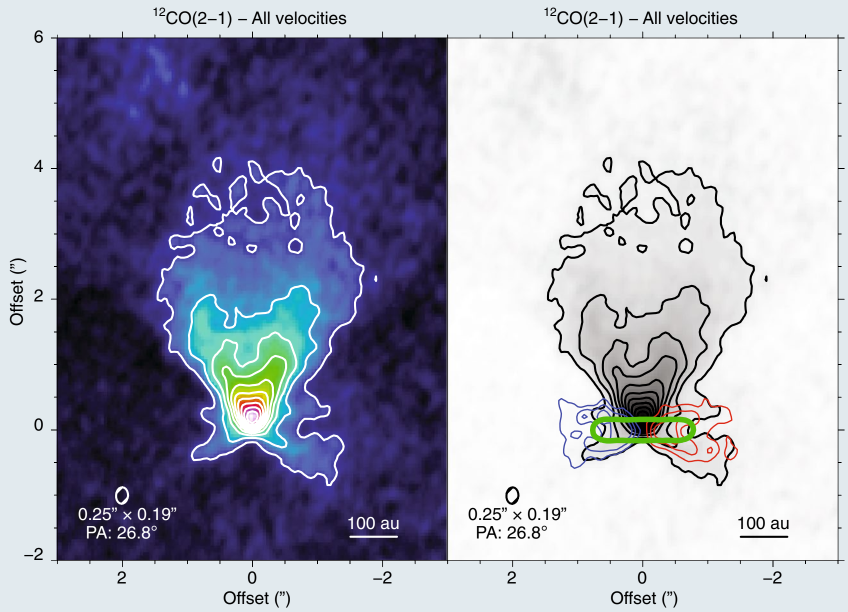
PROTOPLANETARY DISKS

Portrait of a molecular outflow

The Atacama Large Millimeter/Submillimeter Array (ALMA) is now regularly producing visually impressive images of face-on protoplanetary disks that exhibit features (rings, gaps, clumps and spiral patterns) that had not been seen previously.

In a change to the norm, Fabien Louvet et al. (*Astron. Astrophys.* https://doi.org/10.1051/0004-6361/201731733; in the press), have leveraged ALMA's 0.25" angular resolution to study a rare example of an edge-on disk of gas and dust around HH30 in Taurus. The researchers detected a large-scale, conical molecular outflow traced by CO gas above the disk (see image, where red (black) indicates higher velocity in the left (right) panel).



Credit: ESO

In addition, the continuum emission from the disk (bright green contour) shows constant radial brightness out to 75 au, with little sign of flaring. A previous study suggested that the inner radius of the disk was truncated at a distance of 37 au, but there is no evidence of this in the ALMA observations. The disk itself is almost perpendicular to the plane of the sky, and is marginally resolved along the vertical axis by ALMA, giving an upper limit to the disk thickness of 24 au.

Transverse position–velocity diagrams (figure 11 in the paper by Louvet et al.) enable the geometry and kinematics of the molecular outflow to be dissected. At each altitude above the plane of the disk, the velocity profile appears as a narrow ellipse. Fitting a series of these rings produces a 3D model of a hollow conical surface, expanding at a constant velocity of ~10 km s^{-1}, and rotating slowly in the same direction as the disk (rotation direction is shown in the right panel: the red (blue) side of the disk is moving away from (towards) us). The CO emission extends from a disk radius of 22 au outwards, and the cone is detected out to a distance of ~700 au from the disk midplane, opening at an angle of ~35°. Such a morphology and kinematic structure is consistent with a disk wind being launched in the radial region 0.5–7 au. The authors calculate that such a wind would remove ~10^{-7} solar masses of material per year from the disk along with its associated angular momentum.

The model of the conical outflow also allows the authors to determine the degree of 'wiggle' in the cone's axis. An unrelated study of HH30's optical jet indicated a small degree of wiggle, putatively due to an unseen binary companion orbiting at 18 au. Louvet et al. find a very small amount of wiggle in the CO outflow, ruling out an 18-au-separation companion. Instead, the authors suggest a precession scenario, in which the molecular flow originates from a circumbinary disk around a close-separation (≲ 3.5 au), slightly misaligned, pair of stars. ❐

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