OUTFLOW STRUCTURES FROM THE YOUNG HIGH-MASS STAR NGC 7538 IRS1 REVEALED BY NEAR-INFRARED BISPECTRUM SPECKLE INTERFEROMETRY. S. Kraus (skraus@mpifr-bonn.mpg.de), K.-H. Hofmann, Th. Preibisch, D. Schertl, G. Weigelt, *Max-Planck-Institute for Radioastronomy, Auf dem Hügel 69, 53121 Bonn, Germany*, M. Elitzur, *Department of Physics & Astronomy, University of Kentucky, Lexington, KY 40506, USA*, M. R. Pestalozzi, *School of Physics, Astronomy and Mathematics, Univ. of Herfordshire, AL9 10AB Hatfield, UK*, M. Meyer, E. T. Young, *Steward Observatory, University of Arizona, 933 North Cherry Avenue, Tucson, AZ 85721, USA.*

We present bispectrum speckle interferometry of the massive protostellar object NGC 7538 IRS1 in the near-infrared K' band. Our observations were carried out on the 6.5 m Multiple Mirror Telescope (MMT) using our speckle visitor camera. The recorded speckle interferograms were used to reconstruct images with high dynamic range.

IRS1 is located on the southeast corner of the NGC 7538 H II region and is the suspected driving source of a bipolar outflow, which was detected by CO (J=1-0) spectral line mapping (P.A. $\approx -40^\circ$, [2]). In 1998, Minier et al. [4] reported the discovery of linear-aligned methanol masers at the position of IRS1 (oriented with a position angle of $\approx -62^\circ$) and interpreted them as an edge-on circumstellar disk. The accuracy of the alignment and the stunning precision with which the velocity diagram of these masers could be modelled [6] make the maser feature NGC 7538 IRS1-A one of the most intriguing candidates for Keplerian-rotating protostellar disks. The outer radius of this disk was modelled to be 750 AU, corresponding to 270 mas at a distance of 2.8 kpc. An alternative scenario for the origin of the maser emission was presented by De Buizer and Minier [1], who suggested that the methanol masers might trace an outflow cavity.

Morphology in our NIR speckle images

In our speckle images, the Airy disk of IRS1 itself appears asymmetric, being more extended towards the northwest direction (P.A. $\approx -70^\circ$, see figure 1). In the same direction (P.A. $\approx -60^\circ$), we find two strong blobs of diffuse emission at separations of $\approx 1''$ and $2''$. These blobs and more diffuse emission seem to form a conical (fan-shaped) region with a 90° opening angle extending from IRS1 towards the north. Embedded within this diffuse emission, 15 point-sources were discovered. More than half of these faint sources are aligned $\approx 3...4''$ north of IRS1 in a chain (P.A. $\approx 40^\circ$).

Outflow cavity cleared by a precessing jet?

We interpret the observed fan-shaped region as a cavity that was formed by outflow activity from the massive young stellar object IRS1. This is supported by the fact that the strongest blobs discovered in our speckle images are located on a line with P.A. $\approx -60^\circ$, which roughly coincides with the direction of the CO outflow (with the blueshifted lobe oriented in the direction of the observed blobs, [2]). Most remarkably, the maser disk modelled by Pestallozi et al. [6] is not orientated perpendicular to the identified outflow direction, but nearly parallel (P.A. $\approx -62^\circ$). As most outflow and jet launching mechanisms (e.g. the jet-driven bow shock model [7] or the wind-driven-shell model [8]) predict flow directions perpendicular to the disk plane, we suggest jet precession as one possible explanation for this unexpected alignment. This scenario could also explain the observed morphology within the flow, which suggests a sinusoidal (S-shaped) fine-structure of diffuse emission extending from IRS1 towards the northwest and north. In this scenario, the blobs observed close to IRS1 (P.A. $\approx -60^\circ$) represent the most recent ejecta, whereas the weak features which appear further away in our images trace earlier epoches of the history of the outflow. The large-scale structures reported by various authors (e.g. [5]) might represent even older relics of this precessing jet. The fan-shaped diffuse emission in which this sinusoidal structure is embedded can be explained as scattered light from the walls of an outflow cavity, which was cleared by the proposed precessing jet (see the numerical simulations by Smith and Rosen [9]), as observed in several other objects (e.g. Weigelt et al. [10]).

Considering the resolution of our images ($\approx$ 300 mas) and the size of the modelled maser disk (270 mas), another explanation for the detected tail-shaped extension of the central lobe of the IRS1 Airy disk would be that the inner walls of the outflow cavity and the outer parts of the protostellar disk are already marginally resolved in our observation.

An alternative interpretation of the S-shaped diffuse emission would be clumpiness within the outflow cavity, mimicing the observed fine-structure.

Finally, given the uncertainties in the absolute astrometry in comparing infrared and radio observations, it also cannot be ruled out that the methanol maser disk is not associated with the outflow driving source and just coincides with IRS1 - although this scenario seems less likely.

References

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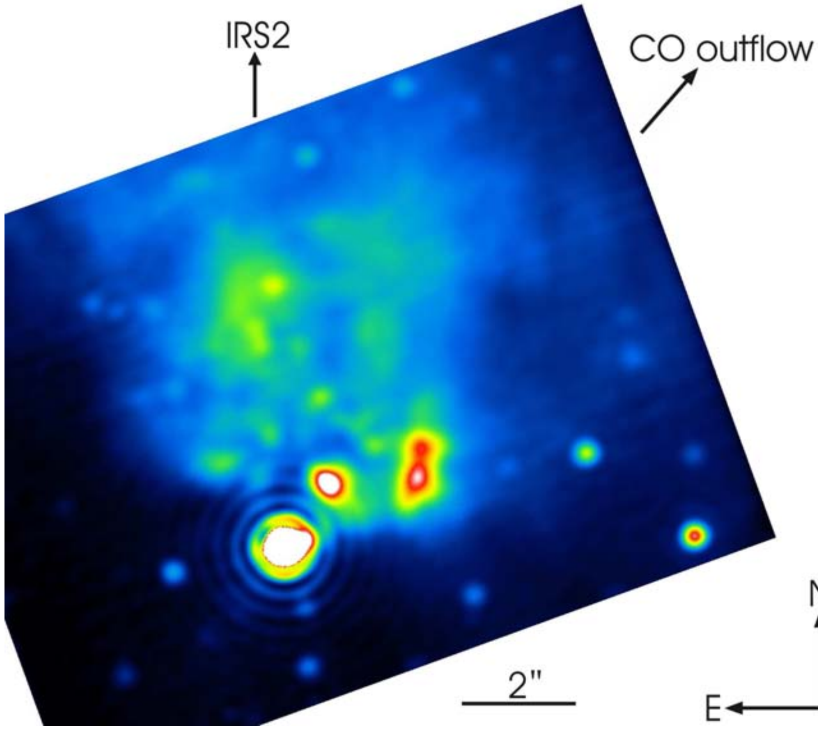

Figure 1: Bispectrum speckle interferometry image of the outflow structures from NGC 7538 IRS1. The direction of the CO outflow was taken from [2].

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