MODELLING A CIRCUMSTELLAR DISC TRACED BY METHANOL MASERS. M. R. Pestalozzi, *School of Physics, Astronomy and Mathematics, Univ. of Hertfordshire, AL9 10AB Hatfield, UK (michele@star.herts.ac.uk)*, M. Elitzur, *Univ. of Kentucky, KY 40506-0055, USA*, V. Minier, *SACLAY, Paris, France*, J. Conway, R. Booth, *Onsala Space Observatory, Sweden*, J. De Buizer, *Gemini Observatory, La Serena, Chile*, Gerd Weigelt, *Max-Planck Institut für Radioastronomie, Bonn, Germany*.

We present the accurate modelling of one methanol maser feature in NGC7538-IRS1. The aim of this work is to test whether this particular maser feature traces a disc or an outflow in the immediate surroundings of a massive protostar. From our data it is clear that we are in the presence of probably the most smooth and regular maser emission discovered until now. The disc model seems to fit remarkably well the data, while a bi-cone jet model fails to reproduce most of the features seen in the maps and position-velocity diagrams.

NGC7538 IRS1 N is a furnace of star formation in which many methanol masers have been detected and mark different objects (see Poster by V. Minier et al.). Methanol maser emission is detected all over the region and seems to be cospatial with the very young protostellar objects or cluster of protostellar objects in the region: IRS 1, IRS 9, NGC7538 S. All these sources possibly host discs and outflows at different scales and traced by different types of emission (e.g. [7, 9, 8, 2, 1]). The masers in IRS 9 and NGC7538 S have been recently positioned (features G and F, see Fig. 2, [6]) and cannot yet be identified as having a clear shape. The maser emission toward IRS 1 comprises features A, B, C, D, E which spread over an area of approximately 600 x 400 mas. The most prominent feature is feature A, which was suggested to be a Keplerian rotating disc in previous works [3].

Feature A shows an extremely smooth and linear structure both in space and velocity (Fig. 1). Moreover, the same structure is marked by maser emission at two frequencies (6.7 and 12.2 GHz), which appear to be perfectly cospatial (within VLBI position accuracy, 1-2 mas). For the model we consider the 12.2 GHz mainly as this data shows the highest spatial resolution.

A general assumption for all modelling is that the maser amplifies the background (HII region) continuum radiation. Its intensity is then:

$$I_\nu(x,y,v) = I_B\, e^{\tau_\nu(x,y,v)} \qquad (1)$$

where x, y is the plane of the sky, v the line-of-sight (LOS) velocity, I_B the background intensity. Taking the logarithm of the data we obtain the function $\tau(x,y,v) = \ln(I(x,y,v)/I_B)$. The whole point is to express the LOS velocity coherence path length (or amplification path) according to a given geometry. We assume that the maser is unsaturated, so that the optical depth τ is linearly dependent on the length of the radiation path. Then we have the general expression:

$$\tau(x,y,v) = \int \eta(z)\, \exp\left[-\frac{1}{2}\left(\frac{v-u(z)}{\Delta v_D}\right)^2\right] dz \qquad (2)$$

where z is the LOS direction, the length of the path is set by a Gaussian of constant width Δv_D (e.g. the Doppler width of the line) and it is weighted by a function η which contains all effects of temperature and density gradients. The chosen geometry will determine the explicit expressions for $u(z)$ and η, as well as the most convenient integration variable.

For the disc model we assume a Keplerian rotating thin (no y-component) edge-on disc where the masing gas lies between an inner an outer radii with ratio $h = R_o/R_i$. We further parameterize η as a power law with exponent p. The first results are shown in Figure 3 where the fit to the position velocity diagram is presented. Due to the almost scale-freedom of the model, we assume a central mass of 30 $M_\odot$ with which we have the best fits when $h \sim 0.3$ and the masing gas lies between 270 and 750 AU from the central protostar.

For the bi-cone outflow model we try different configurations varying the opening angle β, the inclination from the LOS i, the ratio h (as above), and the outflow velocity law $u(r)$ (r is distance from the centre). The function η is defined from mass conservation $\dot{M} = \Omega r^2 \eta(r) u(r)$, where $\dot{M}$ is the mass-loss rate, Ω the cone solid angle and $\eta(r)$ the density. Preliminary results show that the bi-cone geometry does ot fit the data (a preliminary figure is shown in Fig. 3).

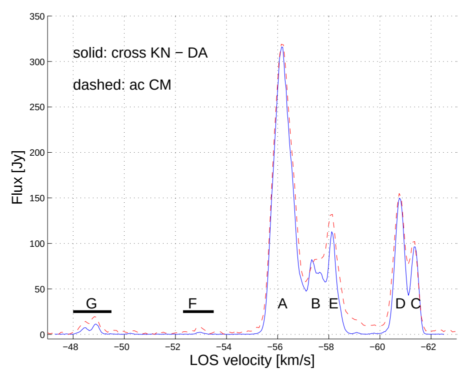

Figure 2: Spectrum of the 6.7 GHz methanol masers emission in the NGC7538 region. Dashed line: autocorrelation spectrum. Solid line: cross correlated spectrum taken on the Knockin-Darnhall MERLIN baseline. All features are marked with a letter following the scheme adopted by Minier [4].

References

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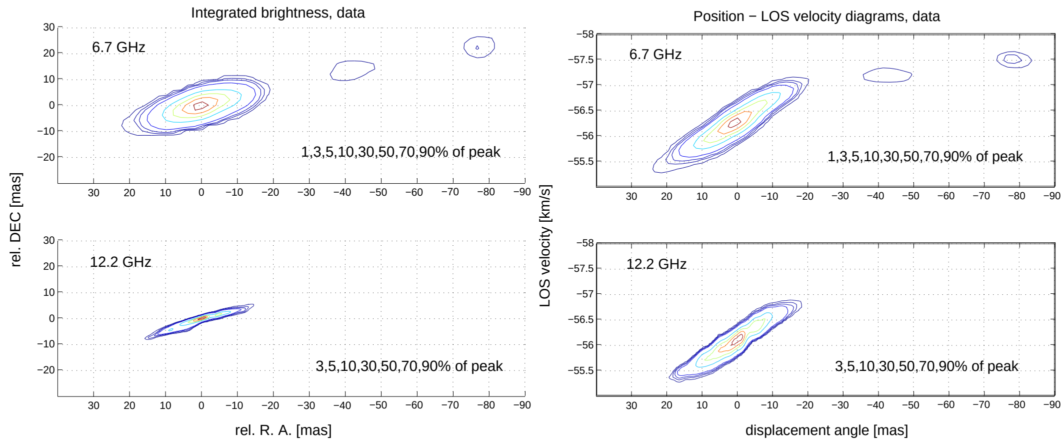

Figure 1: Maps (left) and position velocity diagrams (right) of the methanol masers at 6.7 and 12.2 GHz (upper and lower panels respectively) in NGC7538 corresponding to the spectral feature A ([5]).

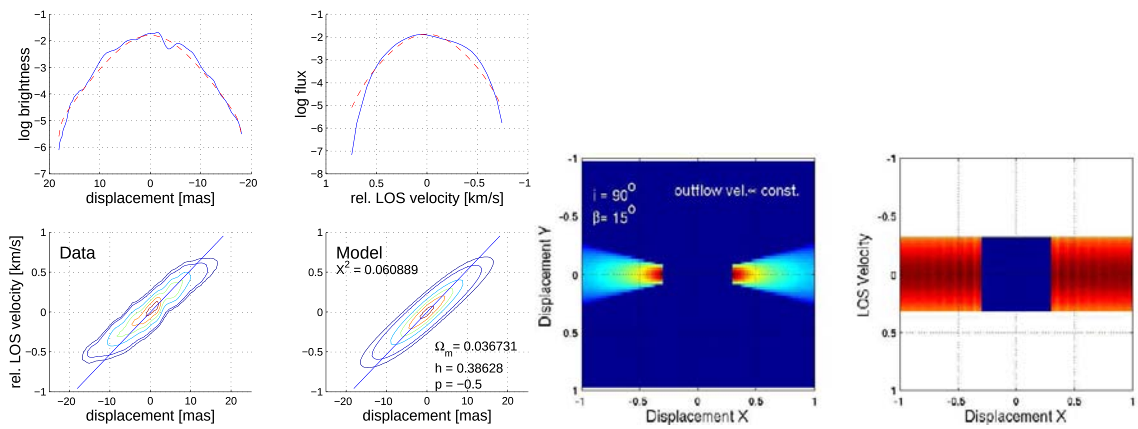

Figure 3: *Left panel*: fit of the 12.2 GHz position velocity diagram as a Keplerian rotating disc seen edge-on. Dashed lines are model, solid lines data. Upper left intensity profile, upper right spectrum, lower left optical depth data, lower right optical depth model. *Right panel*: Preliminary result of the modelling of a bi-cone outflow. Optical depth maps in space (left) and velocity (right) of a cone-shaped outflow with opening angle $\beta = 15°$, inclination $i = 90°$, outflow velocity $u \propto const.$ and $h = 0.3$.

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