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MODELING THE BUILDING BLOCKS OF WATER MASERS IN CEPHEUS A

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Recent VLBA observations of water maser emission from the star-forming region Cepheus A have shown that this emission actually comes from a set of coherent features or "building blocks".

These building blocks are small linear structures of water maser spots that conform a larger configuration with a well-defined linear/arcuate shape. In small angular regions, the VLBA observations (Torrelles et al. 2001) show that:

1. The water maser spots form a well-defined linear chain in the plane of sky.
2. A single spectral line with a width of 0.5 to $1\,\mathrm{km\,s^{-1}}$ in the flux density vs. velocity graph.
3. A coherent structure and a well-defined velocity gradient in the position-velocity diagrams.

A conspicuous example of these results is the R5-a block containing the strongest maser spot of the entire region ($\sim 200\,\mathrm{Jy\,beam^{-1}}$, see Figure 1).

This building block is modeled as a thin disk of radius r, and thickness h, of material flowing in the direction θ with a linear velocity gradient a. The observer is in the disk plane.

The following equation was used to express the intensity from each point of the disk at a given velocity:

$$I(v,y,z) = I_0 \exp\left\{ \int \kappa_0 e^{-(v-v_\mathrm{r})^2/\Delta v^2}\, dx \right\}, \qquad (1)$$

where the term in brackets is the optical depth and v_r is the radial velocity of the flow at the position (x,y). I_0, κ_0, and Δv are supposed homogeneous throughout the disk. Once the parameters are specified, we compute the flux density, $F(v)$, and the coordinates of the emission centroid at velocity v, $y_\mathrm{c}(v)$ and $z_\mathrm{c}(v)$. The results are compared with the observed maser spots of the R5-a block (Figure 2).

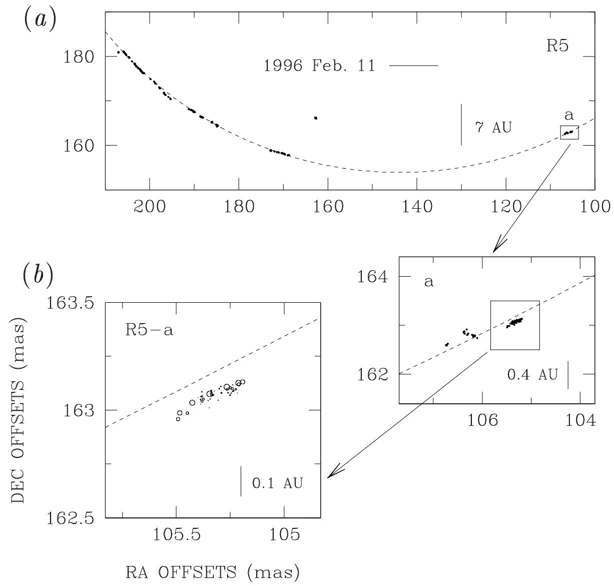

Fig. 1. (a) R5 water maser offset positions on 1996 February 11. The dash line shows the least-squares fitted circle. (b) Close-up of the R5-a block. The sizes of the circles are proportional to the maser spot intensity.

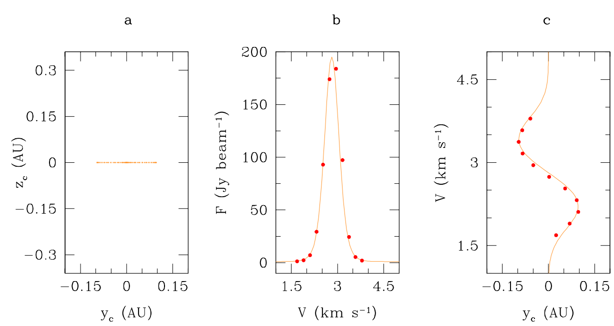

Fig. 2. (a) Emission centroid positions on the plane of the sky, (b) flux density as a function of velocity, and (c) position-velocity diagram: solid line—model, dots—observations. The observed positions are measured along an axis with position angle $\simeq -63°$. The zero position corresponds to the geometrical center of the R5-a block. Model parameters: $I_0 = 2.25\,\mathrm{Jy\,beam^{-1}\,AU^{-2}}$, $\kappa_0 = 2.24\,\mathrm{AU^{-1}}$, $\Delta v = 0.67\,\mathrm{km\,s^{-1}}$, $v_0 = 2.85\,\mathrm{km\,s^{-1}}$, $r = 1.5$ AU, $h = 0.15$ AU, $a = 0.29\,\mathrm{km\,s^{-1}\,AU^{-1}}$, $\theta = 9°$.

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