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The Accretion Discs and Bipolar Jets in Orion KL

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Abstract. The fine structure of active regions in Orion KL has been studied. It is shown that accretion disks and bipolar outflows accompany star formation. The accretion disks are divided into protoplanetary rings. The H_2O super maser emission is associated with the rings and bipolar outflows. The surrounding medium (V_{LSR}=7.74 km/s) amplifies the emission within the maser window by more than two orders of magnitude.

1. Region of the H_2O super maser emission

Star formation in gas-dust complexes is a collective process accompanied by H_2O maser emission. Orion KL contains 8 zones (Genzel et al. 1978). During the first active period 1979-1987 outbursts of the H_2O super maser $F \leq 8{\cdot}10^6 Jy$ were observed in a zone $RA = 05^h35^m14.^s121$, $DEC = -05^o22'36.''27$ (2000). The emission was dominated by a chain of 5 groups of compact sources, the sizes of which were $\sim$ 0.2 mas (Matveyenko 1981; Matveyenko, et al. 1988; 1998). The length of the chain was 10.5 AU. Velocities of components were V_W=6.45 km/s to V_E=8.75 km/c and the brightest sources $T_b \leq 10^{17}K$ V=7.5-8.0 km/s.

In the quiescent period 1995 $F \leq 10^3 Jy$ we studied the super maser region with VLBA. The chain of compact components was invisible. But we discovered a bipolar outflow: the jet and two compact components, brightness temperatures of which are $T_b \sim 2{\cdot}10^{12}K$, $V_{NE} = 7.45$, $V_{SW} = 7.95$, and $V_{jet} = 7.66$ km/s (Matveyenko et al. 2000).

In the second active period 1998-1999 maser emission is $F = 4{\cdot}10^6 Jy$, $V \sim$ 7.7 km/s and shows an increase of the brightness temperature of the jet $T_b = 2{\cdot}10^{15}$ K in May - August 1998. During March 1999 the central part of the jet - ejector had $T_b = 5{\cdot}10^{16}K$, Fig.1a-c. The changes of the jet brightness distribution correspond to $V \sim 30$ km/s. The projection of velocity on the line of sight is 0.6 km/s. We conclude that the outflow is located in the sky plane or can be the result of visibility across the narrow maser window.

1.1. Second active zone

In this zone, which is located at distance 1500 AU from the super maser region, we also see an accretion disk and bipolar outflow . The accretion disk is divided

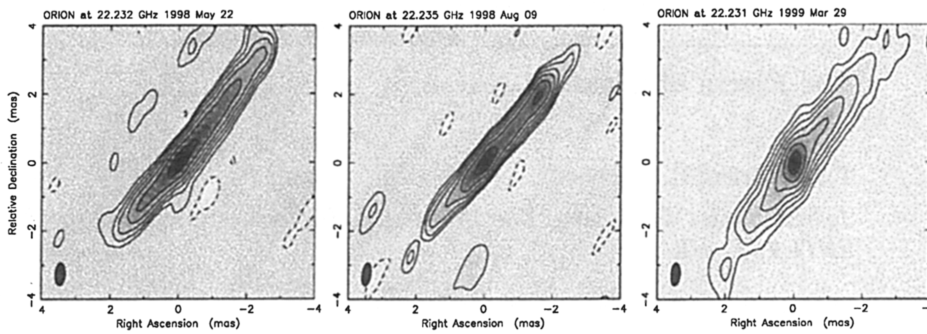

Figure 1. Maser emission brightness of outflow: a - 22.05.98, $T_b \sim 2 \cdot 10^{15}$K; b - 9.08.98; $T_b \sim 2 \cdot 10^{15}$K; c - 29.03.99, $T_b \sim 5 \cdot 10^{16}$K

into 4 rings, the diameter of the disc is 3.4 AU, V_{rot} = 1.85 km/s, V_{LSR} = 7.2 km/s and $M = 0.01 M_\odot$. The brightness temperatures of the compact components are $T_b \leq 5 \cdot 10^{12}$ K and the outflow $T_b \leq 10^{10}$. In this zone we also see an elliptical structure . This structure could be an elliptical shell 7.5x2.6 AU, or a ring oriented at 70°. The velocities of the structures are outside the maser window and brightness temperatures are low (Matveyenko et al. 2000).

1.2. Conclusion

Our results shown that the star formation is accompanied by the the formation of an accretion disk, a bipolar outflow, and H_2O maser emission. The disk is located at the stage of separation into protoplanetary rings. The chain of compact sources corresponds to tangential direction of the rings, the emission of which is concentrated in the azimuthal plane and changes with disk precession. For protostar velocity V=5 km/s and Keplerian motion, the radius of the disk will be 16 AU, $V_{rot} = 9.4 km/s$, and $M \sim 0.01 M_\odot$. The H_2O molecules of the maser ring can be excited either by stellar wind and IR emission or by accretion. We suggest $M = (0.2{-}0.5) M_\odot$, ring internal radius R=6 AU, $V_{rot} = 5$ km/s, V_{exp} = 3.8 km/s. The accreting matter is accelerated and ejected in the bipolar streem. The streams collide with surrounding matter and generate maser emission. The matter (OMC-1), V=7.74 km/s, amplifies by more than two orders of magnitude the brightness of the structures, the velocities of which are inside the maser window ΔV=0.6 km/s (Matveyenko et al. 2000).

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