High Angular Resolution Ammonia Observations of the Disk around the Massive Protostar Cep A HW2

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Summary

Cepheus A HW2 is a high mass protostar located at 725 pc. It has a highly collimated radio jet and it is one of the few massive protostars with an angularly resolved accretion disk. The disk was angularly resolved by Patel et al. (2005, Nature, 437, 109) with continuum and molecular SMA observations. The emission showed an elongated rotating structure with a radius of ~350 AU and perpendicular to the radio jet. However, other observations of the molecular emission showed a more complex chemical and kinematical structure. The molecular emission was interpreted as tracing the accretion disk and a nearby hot core (Jiménez-Serra et al. 2009, ApJ, 703, 157). We present new VLA observations of the ammonia (3,3) and (4,4) inversion transitions with ~0.8" angular resolution. The ammonia (4,4) to (3,3) transition ratio is sensitive to the kinematical temperature. Thus, from this ratio we show which are the main heating sources of the region. We analyze our observations assuming two different scenarios.

DISK (-7.5 km/s < v < -2.6 km/s)
HOT CORE (-14 km/s < v < -9.5 km/s)
Previous scenario

We first assume the scenario proposed by the previous studies, with the disk structure between -2.6 km/s and -7.5 km/s and the nearby hot core between -9.5 km/s and -14 km/s.

- ✓ The temperature distribution of the disk shows a peak spatially coincident with HW2. Another peak of temperature appears east from HW2, maybe produced by the interaction with the hot core (Figs. 1, 2).
- × The kinematical structure of the disk is not compatible with a rotating structure, since both emission peaks are detected at the same velocity channels (Fig. 3).
- × Under this scenario, we obtain from the P-V diagram a very low central mass of **0.8 ± 0.5 M_{sun}**. This mass seems too low to explain the observed ~10^4 L_{sun} of HW2, either as stellar or as accretion luminosity.

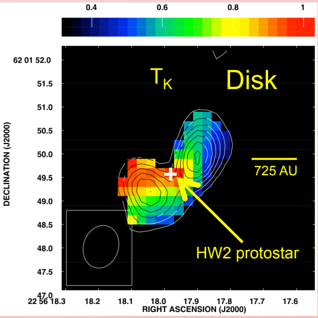

Fig. 1: Colors: Map of the ratio of the ammonia (4,4) to (3,3) emission integrated between the assumed disk velocity range. Higher values of the ratio indicates higher kinetic temperature. Contours: Integrated emission of the ammonia (4,4) transition for the disk velocity range. Beam≈0,8".

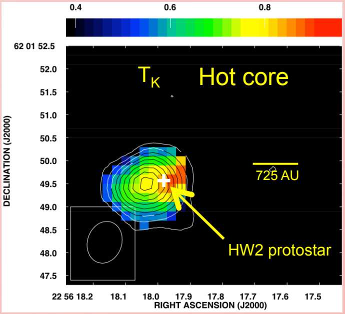

Fig. 2: Same as Fig. 1 but for the assumed hot core velocity range.

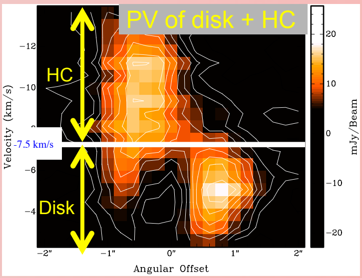

Fig. 3 Position-velocity diagram of the ammonia (3,3) emission along the disk major axis. The velocity ranges for the disk (-7.5 km/s < v < -2.6 km/s) and the hot core (-14 km/s < v < -9.5 km/s) are indicated. Positive angular offsets correspond to the NE side. The position-velocity diagram for the ammonia (4,4) transition is very similar.

DISK (-13.7 km/s < v < -2.6 km/s)
HOT CORE (-10 km/s < v < -3.8 km/s)
New scenario

We propose a new scenario: the rotating disk between -2.6 and -13.7 km/s and the hot core between -3.8 and -10.0 km/s, overlapping at intermediate velocities.

- ✓ The temperature distribution of the disk shows a single peak spatially coincident with HW2 (Fig. 4).
- ✓ The kinematics are easily explained as a rotating disk. We estimate a mass of **8 ± 2 M_{sun}** for the central protostar HW2, which can account for its observed high luminosity (Fig. 6).
- ✓ The main peak of temperature of the hot core is spatially coincident with the H_2O maser structure R6 detected by Torrelles et al. (2011, MNRAS, 410, 627). We interpret this as an interaction between the outflow and the hot core (Fig. 5).
- × Some observed molecular emission asymmetries between the two sides (Jiménez-Serra et al. 2009, ApJ, 703, L157) of the disk are difficult to explain.

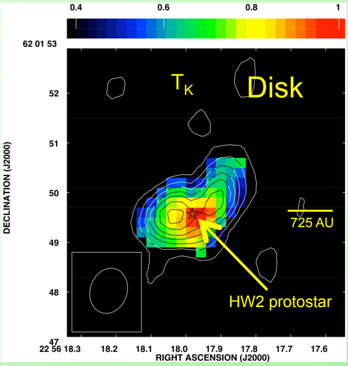

Fig. 4: Colors: Map of the ratio of the ammonia (4,4) to (3,3) emission integrated between the assumed disk velocity range. Higher values of the ratio indicates higher kinetic temperature. Contours: Integrated emission of the ammonia (4,4) transition for the disk velocity range. Beam≈0,8".

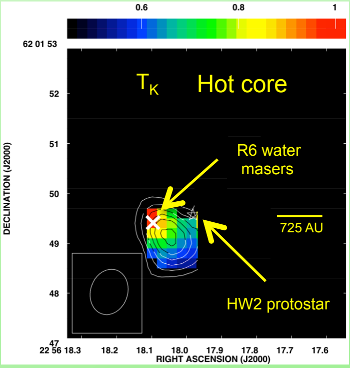

Fig. 5: Same as Fig. 4 but for the assumed hot core velocity range.

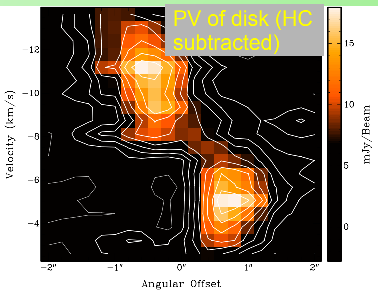

Fig. 6 Position-velocity diagram of the ammonia (3,3) transition emission along the disk structure. The hot core emission, assumed to be between -10 km/s and -3.8 km/s, has been subtracted. Positive angular offsets correspond to the NE side. The position-velocity diagram for the ammonia (4,4) transition is very similar.