The young protostellar system IRAS 15398-3359

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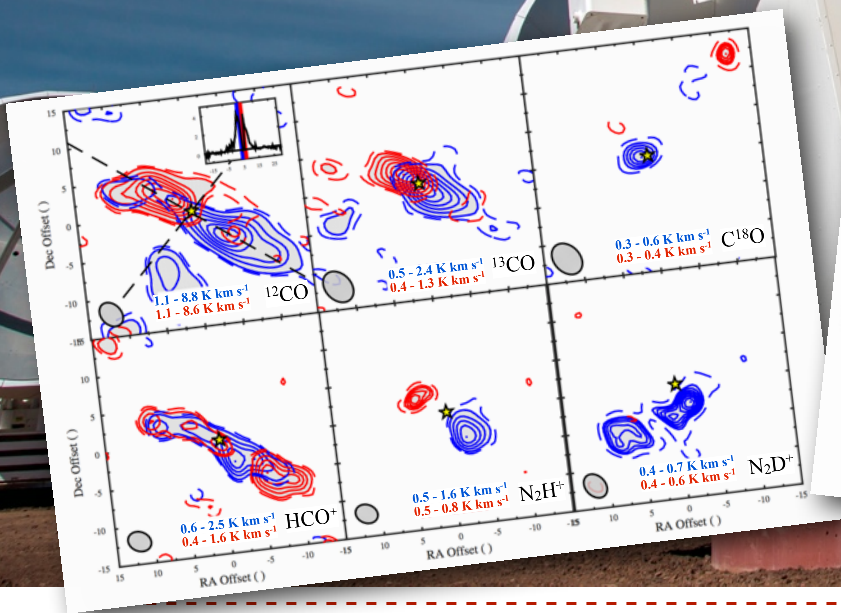
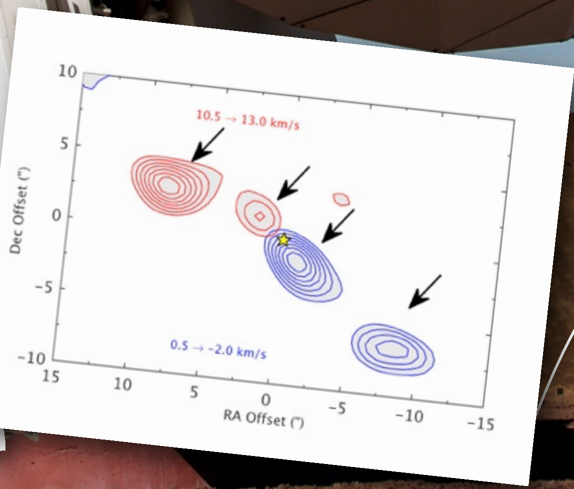
The star formation process is often revealed though the observations of molecular outflows. Swept up material from the parental cloud, excited in the interaction with the ambient medium, can be observed on large distances from the central source.

Changing physical conditions in these environments allow for a rich and interesting chemistry to occur. Heating and cooling of the gas allows molecules to be released from and frozen out on dust grains, and the kinematical information allows us to distinguish between different scenarios describing the infall of matter and the launching of molecular outflows and jets.





Evidence for episodic ejection and accretion

Periodic mass-ejection events are clearly visible in the ^{12}CO channel maps. The time-scale between the knots are of the order 100 years.

Fig. 1. Integrated emission in the red and blue outflow lobes as observed with the Sub-Millimeter Array. ^{12}CO, ^{13}CO, $C^{18}O$, HCO^+ and N_2H^+ all show clear red- and blue-shifted asymmetries. N_2D^+ does not seem to be associated with the outflow.

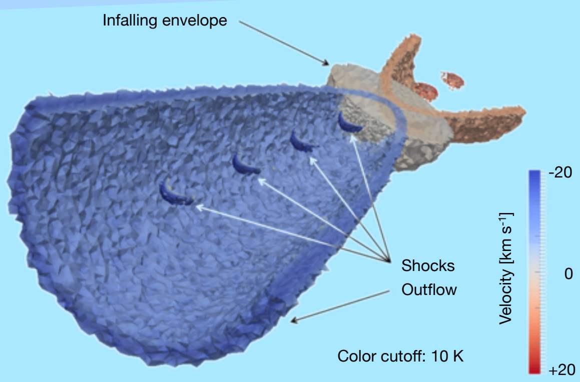
Fig. 2. ^{12}CO emission at high velocities reveal episodic mass ejection events, possibly accompanied with periodic mass accretion events.

The emission from IRAS 15398-3359

We present observations from the Sub-Millimeter Array (SMA) and ALMA, showing the spatial distribution of several different species. The spatial extent of the emission and the absence of shocks suggest that this source is very young, possibly younger than 1000 years. This claim is further supported by the relatively low estimated values on the physical parameters of the outflow. The dynamical time-scale of the outflow is estimated at ~500 years and the high velocity gas shows evidence of episodic ejection events. The dynamical time-scale for these knots is ~100 years, consistent with the analysis presented in Jørgensen et al. 2013, where the luminosity outbursts are estimated to occur on a time-scale shorter than 100 - 1000 years.

3D Radiative transfer modeling

To investigate to which extent each component (infalling envelope, outflow, shocks, surrounding cloud) contributes to the observed emission lines at various velocities, we construct a model of the source, using the Accelerated Monte-Carlo code LIME (Brinch & Hogerheijde 2010). This code allows for the full 3D geometry to be taken into account and does not put any constraint when it comes to the complexity of the models that can be constructed. The morphology of the outflow suggest a wide-angle wind origin and the morphology is taken from the observed extent of the CO and C_2H emission observed with ALMA and SMA. It is clear that an infall model or an outflow model cannot alone explain the observed emission line profiles. Instead, a model taking both the envelope, the outflow and the surrounding cloud material into account is required.



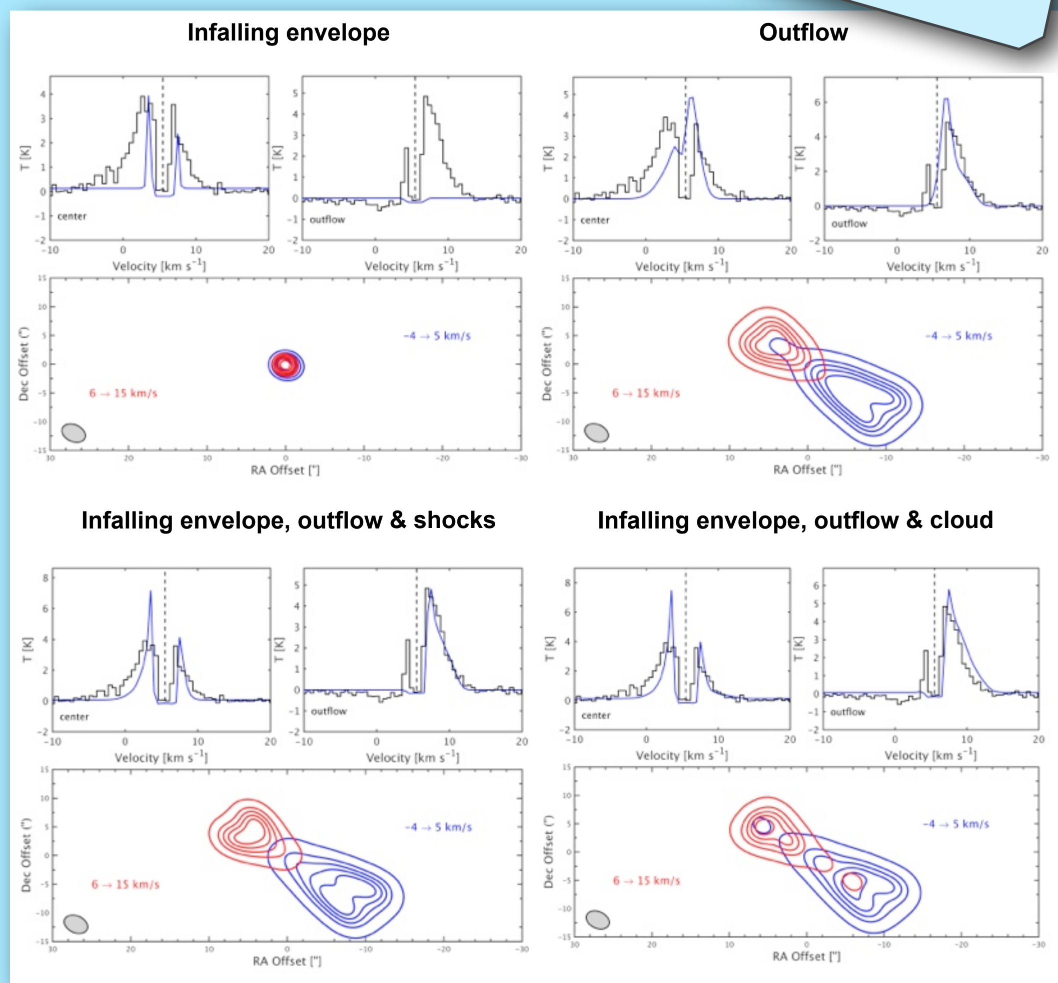


Fig. 3. Four different LIME models aiming at explaining the observed line profiles and morphology of the ^{12}CO emission. In each panel, the modeled (blue) and observed (black) lines towards the central region and one outflow position is presented, as well as contours of the blue- and red-shifted emission. A cut through the model, when all components are present, is presented to the left.

Centre for Star and Planet formation (STARPLAN)
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References:
Brinch, C., et al. 2010, A&A, 523, A25
Jørgensen, J. K., et al. 2013, ApJ, 779, L22