Visualization and Analysis of Synthetic Observations of Embedded Protostellar Outflows

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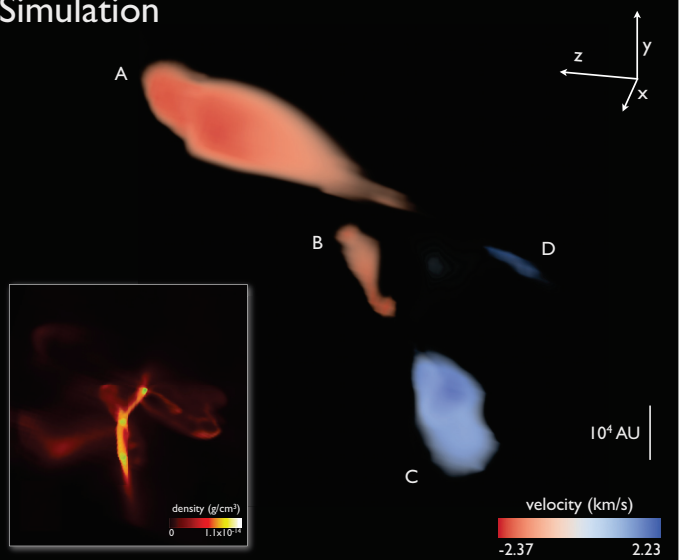
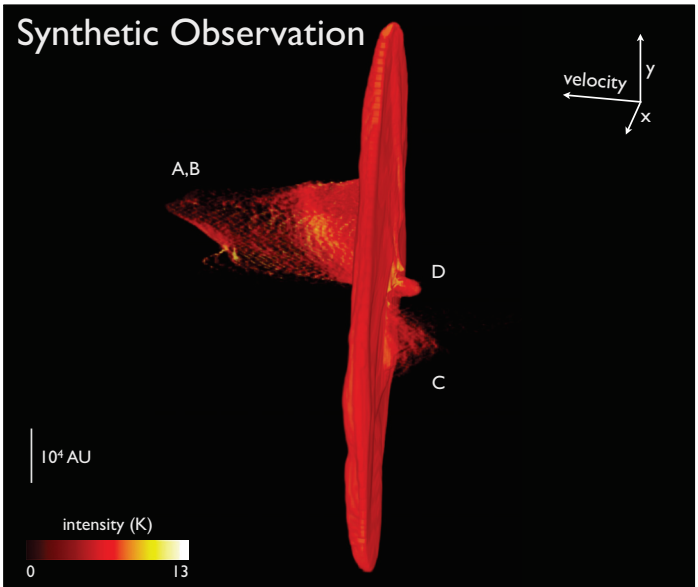
Simulation



Above: Close-up of simulated outflow region after evolving for ~20,000 years. Two outflows are visible with the color mapping to red and blue shifted velocities along the z direction. *Inset:* Same region as above image displaying all gas with color mapped to density. Note the three protostellar objects.

Synthetic Observation



Above: Synthetic single-dish ^{12}CO observations of the simulated (*left*) outflow region. The "pancake" represents the main distribution of gas in the cloud, and the high velocity gas is visible as peaks extruding left and right. The velocity ranges from -1 to 5 km/s.

Summary

We present 3D visualizations used for the analysis and exploration of synthetic observations and in comparing synthetic with real observational data cubes. By comparing synthetic observations (i.e., *position-position-velocity* cubes) to the original simulation output (i.e., *position-position-position* cubes) utilizing 3D visualization techniques we are able to more effectively and efficiently compare these types of data, in particular kinematic structures such as outflows. We investigate simulations performed with the ORION adaptive mesh refinement (AMR) three-dimensional gravito-radiation-hydrodyanics code, which follows the collapse and evolution of protostars with outflows down to AU size scales. The ^{12}CO synthetic observations are produced using MOLLIE, a molecular line radiative transfer code. Comparing the 2D column maps, 3D p-p-v cubes, synthetic ^{12}CO *p-p-v* cubes, and 3D *p-p-p* cubes allows us to connect real and observed physical structures and enhance the interpretation of astronomical data cubes. For instance, in the pictured example we can see smaller outflows ejected by companion protostars which may be hidden within the data at the current level of observational accuracy.

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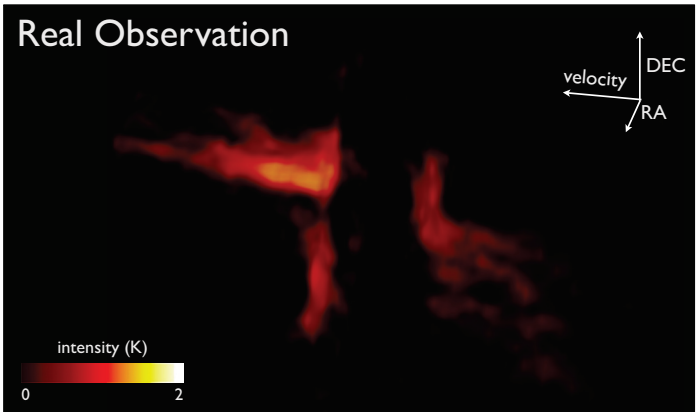
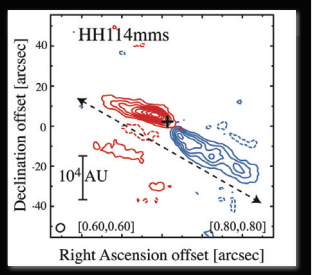
Real Observation



Above: 3D representation of the outflow HH114mms in ^{12}CO, rotated to the same orientation as the synthetic observation. The data were gathered using the OVRO millimeter array. This outflow is ~10^3-10^4 years old, and is 460 pc away. *Right:* Integrated intensity contour map of the data with its Class 0 driving source indicated with a "+" (Arce & Sargent 2006). The velocity ranges from -10 to 8 km/s, and the map is centered at 5:18:15.4 +7:12:00 (J2000).



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