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Disc stuff

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ABSTRACT
Abstract here

Key words: circumstellar matter – infrared: stars.

1 INTRODUCTION

1. description of what has been done so far on the modeling and radiative transfer of disks (this includes also more evolved disks – Visser et al., Walsh et al., Aikawa et al. ..) 2. focus on the young disks (work done by Machida et al., Dapp, Basu & Kunz 2012, .. for their formation; work by Boley et al. on the physical evolution ; Ilee et al. for chemistry) 3. previous attempts to observe these young disks: (a) simulations (Cossins et al. 2010); (b) observations: Fuente et al. 2010 (AB Aur); Jorgensen & van Dishoeck ($H_2^{18}O$ and the HDO/H2O ratio); Pineda et al. (2012); other papers talking about "hot corinos" (Bottinelli et al. ....)

2 DESCRIPTION OF THE MODEL

-describe the envelope structure (pre-stellar core) Keto & Caselli model (2010), disc is embedded in an infalling prestellar core, with densities temperatures and velocities given by the model of the collapse of a 10 solar mass Bonnor-Ebert sphere and providing similar line profiles to the pre-stellar core L1544 as described by Keto & Caselli (2010), truncated at 80 au and extending out to 10,000 au. The model is 1D spherically symetric model with inward motions (see figure). For the models using a smoothed disc the same physical and chemical model is used but with the temperature, density and abundance averaged in ϕ.

-describe the physical structure of the disk (density and temperature) – one figure showing the physical structure and the kinematics (2-panels figure) The physical strucure of the disc is the same as the one used in Ilee et al. (2011), based on the work of Boley(2007), Boley & Durisen(2008) and Boley(2009). This model describes a 0.39 $rmM_{\odot}$ self-gravitating disc featuring prominent spiral arms. Densities in the disc range from 10^{10}-10^{21} m^{-3}, and temperatures range from 30-400 K. The dust and gas temperatures in the disc are assumed to be equal. The gas/dust mass ratio was assumed to be 1/100 throughout the model and the opacities were given by the model of dust grains with thick icy mantles and 10^6 yr coagulation from Ossenkopf and Henning (1994). The model is sampled over a regular grid of size 256×256×64 with spatial resolution of 0.5 au in x, y and z. The majority of the mass lies in the midplane of the disc.

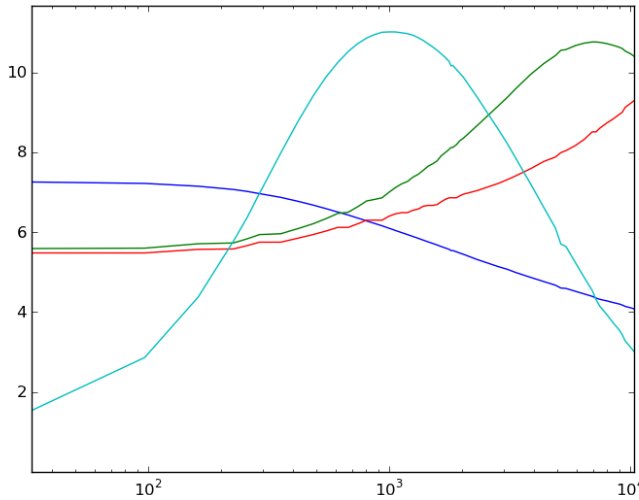

Figure 1. enevlope model with temp and dust temp (red, green) in kelvin, log number density (blue) in cm^{-3} and inward velocity×100 (cyan) in m s^{-1}

-describe the chemistry - refer to Ilee et al. which have been taken as input to the rad transf (RT) code Chemical abundances in the disc were taken from Ilee et. al (2011) which followed the changes of chemical abundances of trace particles moving through the disc as it evolved. The abundances of 125 speices related by 1334 reactions were followed through the time evoltion of the disc. These abundances were interpolated onto a 51^3 grid covering the disc with cells of size 2.2×2.2×0.22 au. Abundances in the envelope model were as follows:

(tableify this?)
HCO^+: as the H2O profile from ??? scaled so that the maximum abundance is 10^{-8}

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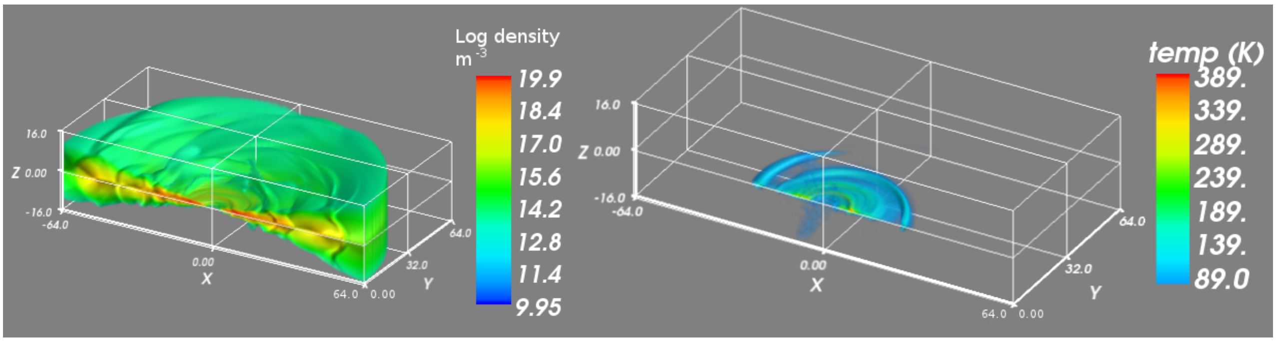

Figure 2. this is a density & temp plot

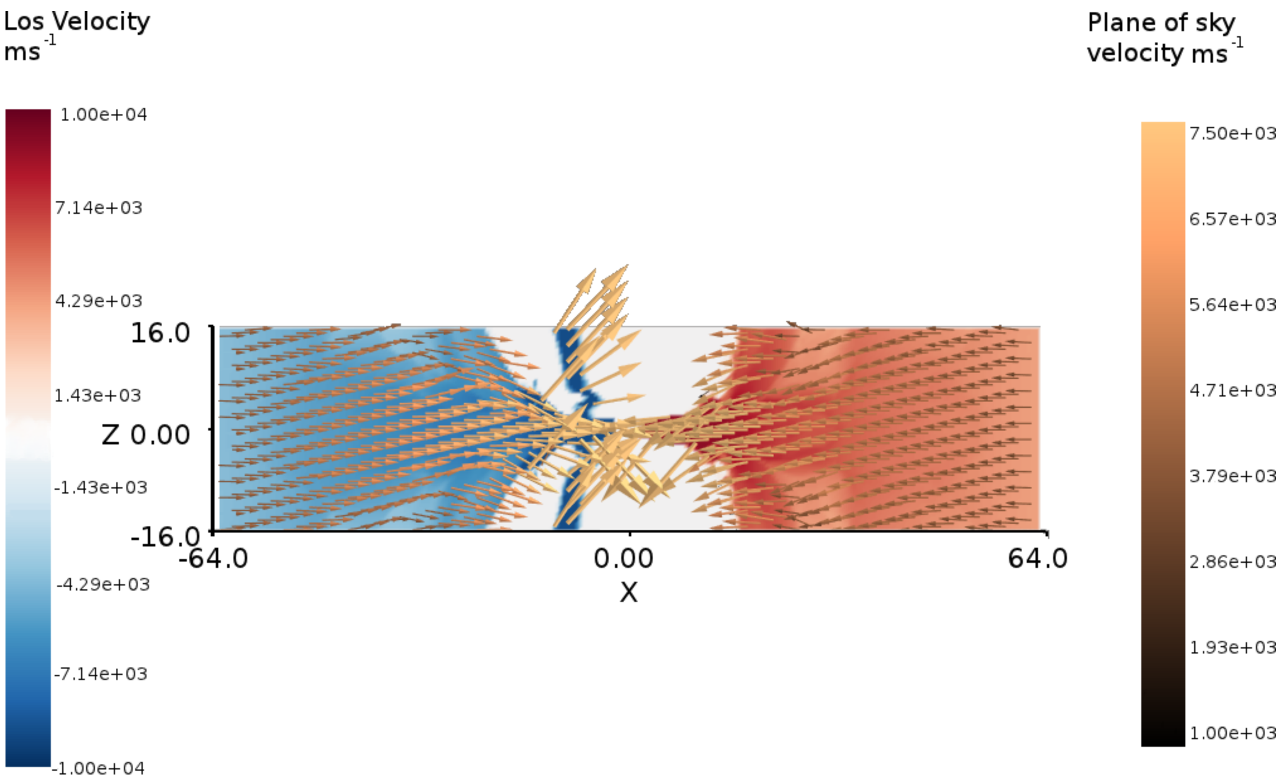

Figure 3. this is a velocity slice in the rz plane

HNO: constant abundance of 5×10−11
HCS^+: 10^{-11}
OCS: constant abundance of 10^{-9}
H_2CO: 1.5×10^{-9} decreased by a factor of 40 at radii less than 8250au (Young et al 2004)
CS: 3×10^{-9} decreased by a factor of 10,000 at radii less than 6700au (Tafalla, santiago-garcia and myers 2006)
CO: as the H2O profile from ??? scaled so that the maximum abundance is CO maximum

-describe the RT used (LIME) LIME (Brinch 2011), the radiative transfer program used, calculates line intensities based on a weighted sample of randomly chosen points in a continous 3d model. The method of selecting these points is given in the gridding section. At each of these points the density of the main collision partner (in this case H_2), gas and dust temperatures, velocity, molecular abundances and turbulent velocity and taken from the model. These points are then smoothed by Lloyds algorithm (Lloyd 1982) in order to minimise the vairiation in distance between points whilst keeping the same underlying distribution. These points are then connected by Delaunay triangulation and it is down these paths that photons are restricted to propagating. The levels of molecules in question are then calculated at each of these points from collional and radiative (de)excitation and the local radiation field is calculated. This is repeated 20 times with the populations of each level converging towards a single value.

In order to construct the grid, points are randomly selected from the volume being simulated then compaired against a reference point. Grid points are selected at random in cylindrical co-ordinates, linearly spaced in z and ϕ and logarithmicly spaced in r. For each point to be selected

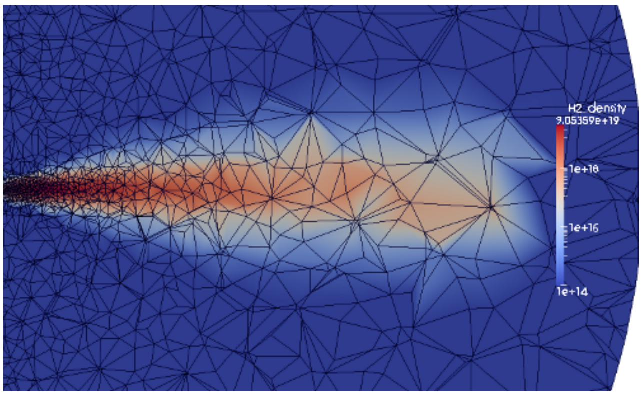

Figure 4. plot of the gridding overlaided on a smoothed density model

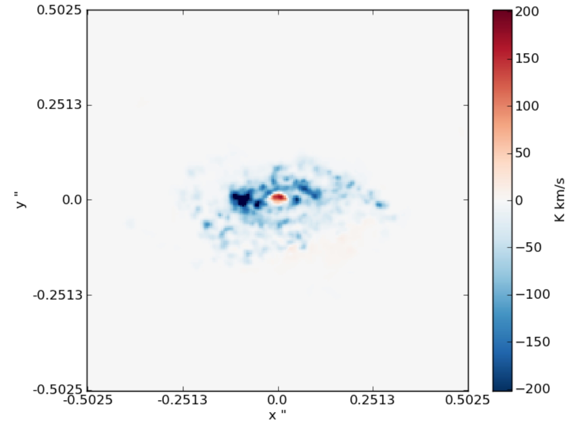

Figure 6. CO 3-2 Continuum subtracted mom0

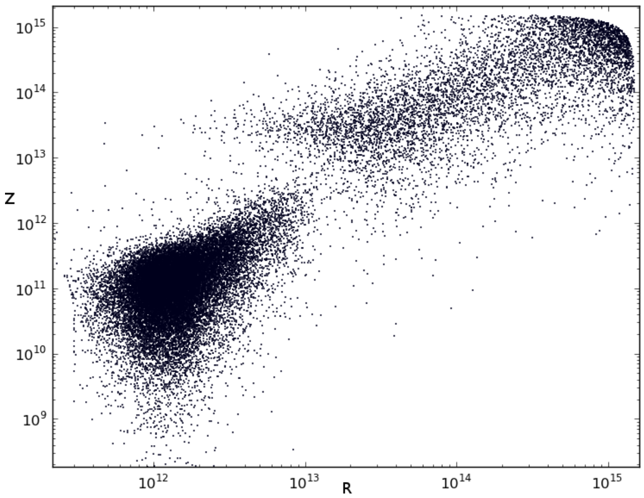

Figure 5. plot of the points selected in the model

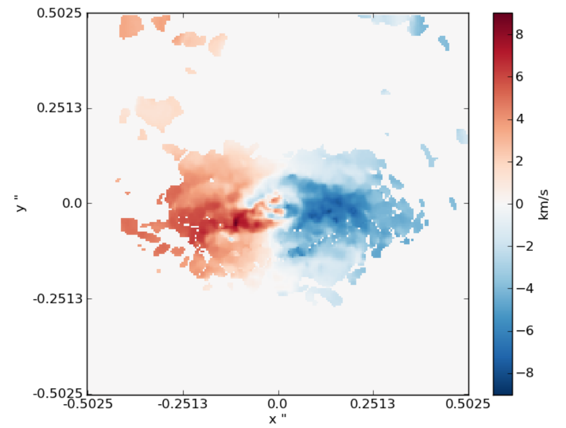

Figure 7. CO 3-2 mom1map

a random number α is drawn from the semi-open set $[0, 1)$ as a threshold. After selection of random co-ordinates the Hydrogen density and molecular density at the point (n and m) are compaired against the densities of a reference point on the inner edge of the disc (n_0 and m_0). If $\alpha < \left(\frac{n}{n_0}\right)^{0.3}$ or $\alpha < \left(\frac{m}{m_0}\right)^{0.3}$ then the point is selected for use, if not then another r,ϕ,z co-ordinte is selected. The weighting function and gridding functions were selected empiricly to sample both the all scales while ensuring the majority of the points went into the inner disc which is the region of interest. 20% of these points are forced to be at radii greater than $\sqrt{R_{min}R_{max}}$ (where R_{min} and R_{max} are the inner and outer radius of the model) in order to stop too many of the selecected points clustering in the high density disc and leaving the envelope undersampled. In addiation to this method of selection 5% of the points are linearly distributed in x, y and z with no bias with regards to density or abundance. This provides a minimum level of sampling for the large low density regions in the outer parts of the simulated volume. See figure 5 for example of the points distribution in r, z.

3 MODEL RESULTS

Figures showing the RT results in a few molecules/transitions (CO, HCO^+, HCN, OCS, H2CO, NH3 — maybe H2O,$H2^{18}O$ [to try first]) (Note the moment 1 and 0 map were created by integrating between -12.5 to -0.5 $km\,s^{-1}$ and +0.5 to +12.5 $km\,s^{-1}$ to avoid being dominated by the contribution from the envelope, this can be seen in the some PV diagrams as the strong absorption feature at all positions around zero velocity, mom1maps are shown with a cutoff of 1/1000 of the peak emission/apsorption value)

These syntetic images of the CO 3-2 line at 345.8 GHz. As the upper level for this line is at 33 K above the ground state this transition should be excited through out disc. CO line will be thick so this is only mapping the outer regions of the disc. Spiral structure can be seen

The OCS lines in alma band 7 (22-21 through 30-29) with upper energy levels between 161 and 271 K above the ground state provide a way to trace hot shocked gas in spiral arms without resolving structure.

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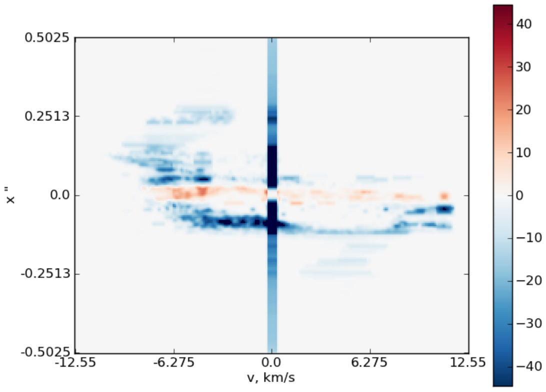


Figure 8. CO 3-2 PV through centre

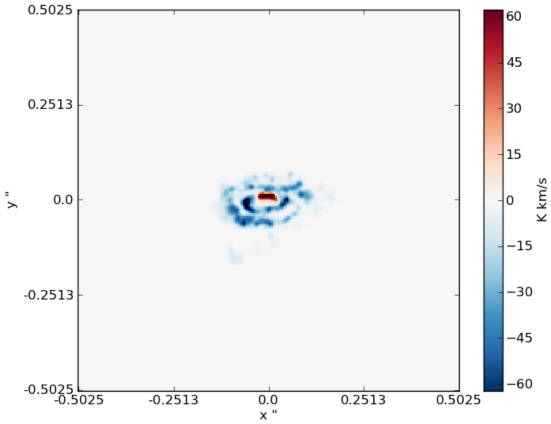


Figure 9. OCS 28-27 Continuum subtracted mom0

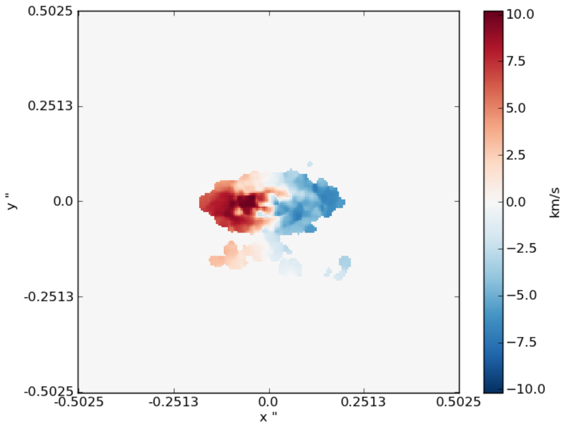


Figure 10. OCS 28-27 mom1map

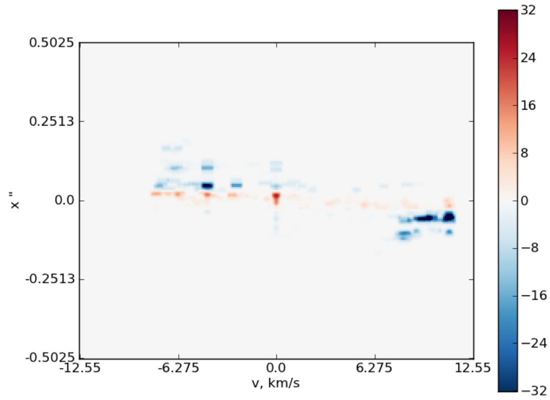


Figure 11. OCS 28-27 PV through centre

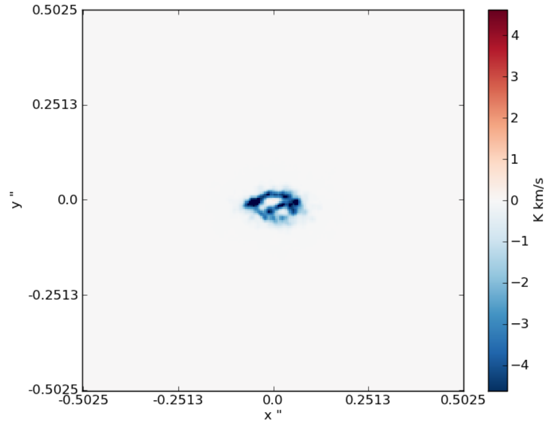


Figure 12. SmoothedOCS 28-27 Continuum subtracted mom0

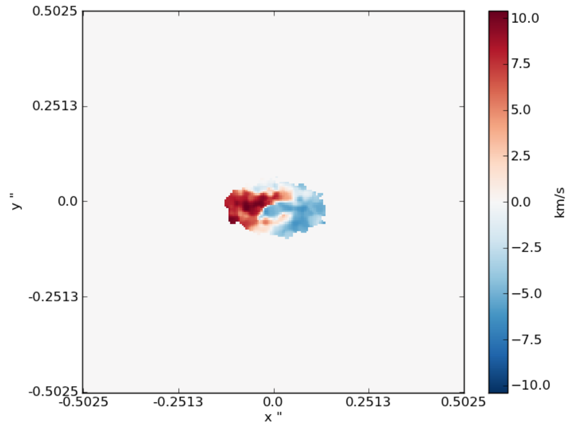
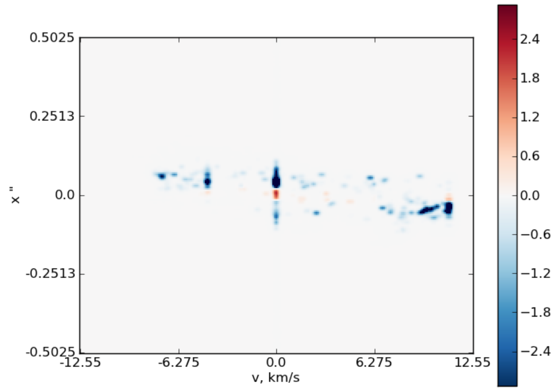


Figure 13. SmoothedOCS 28-27 mom1map



In comparison to the model with spiral arms the absorbtion and emission from this smoothed model is far weaker. gdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfd gfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfds-gfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfd gfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfs-gfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdf fsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfds-gdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfds

Figure 14. SmoothedOCS 28-27 PV through centre

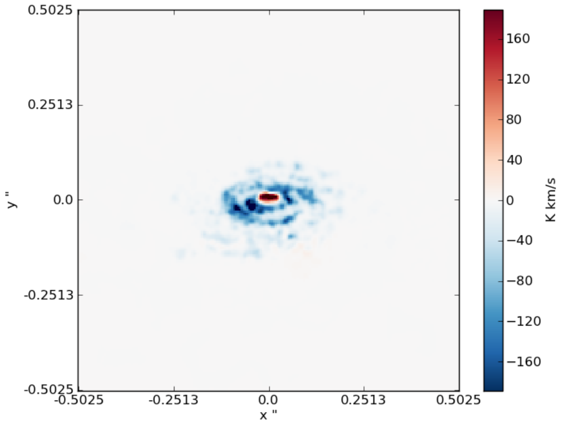


Figure 15. H_2CO 4 0 4 - 3 0 3 Continuum subtracted mom0

gdfsgfdsgfdsgdfsgfdsgfd gdfsgfdsgfdsgdfsgfdsgfdsgdfs-gfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgf sgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfds-gdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfd gdfsgfdsgfds-gdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfds-gdfsgfdsgfdsgdfsgfdsgfdsgdfsgfdsgfds

Figure showing different inclinations

15 deg 15 deg

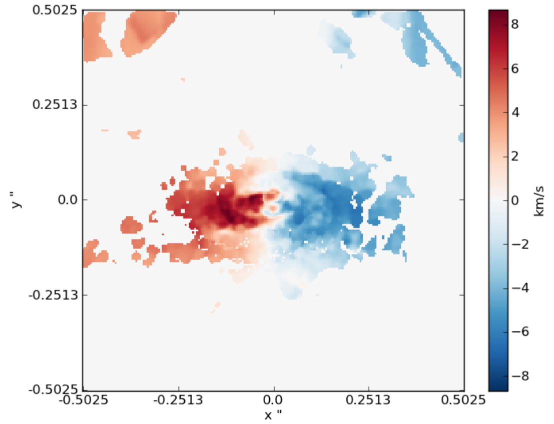


Figure 16. H_2CO 4 0 4 - 3 0 3 mom1map

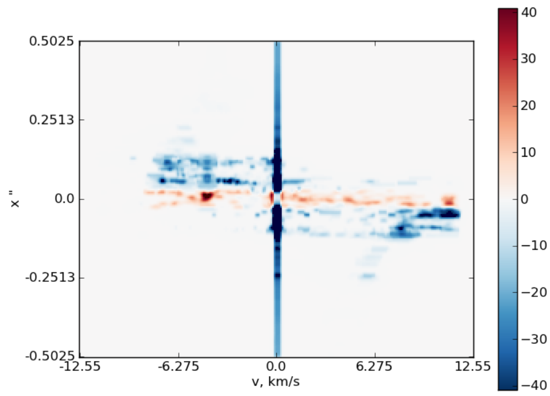


Figure 17. H_2CO 4 0 4 - 3 0 3 PV through centre

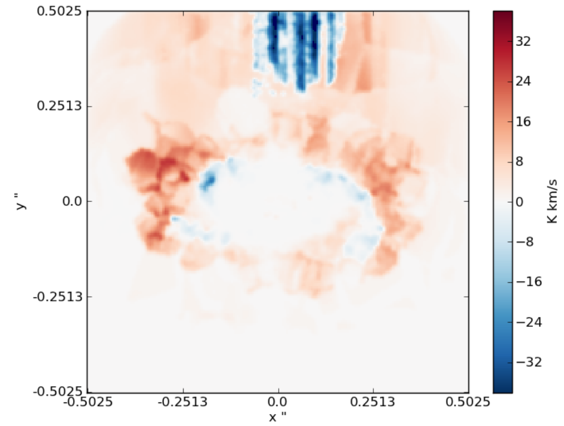


Figure 18. HCO^+ 1-0 Continuum subtracted mom0

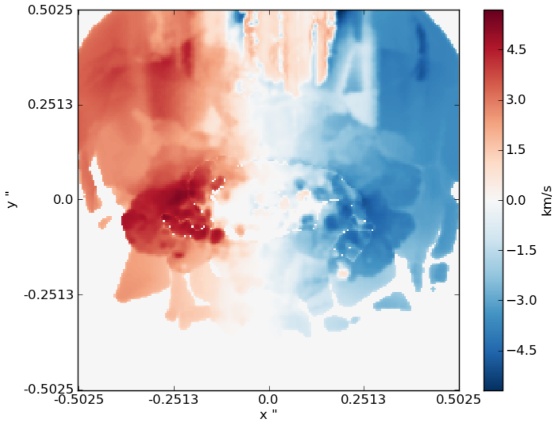


Figure 19. HCO^+ 1-0 mom1map

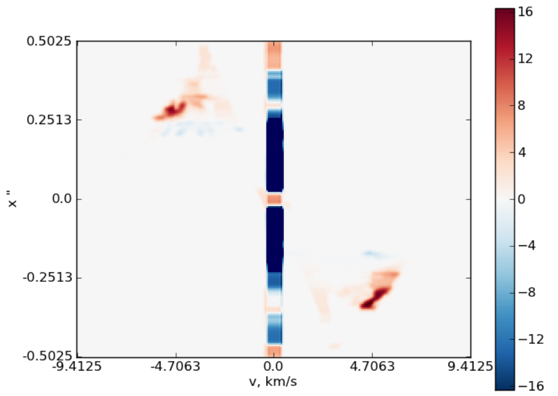


Figure 20. HCO^+ 1-0 PV through centre

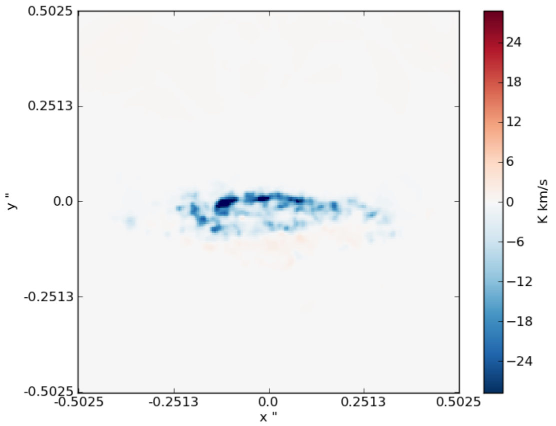


Figure 21. C18O 3-2 15 deg Continuum subtracted mom0

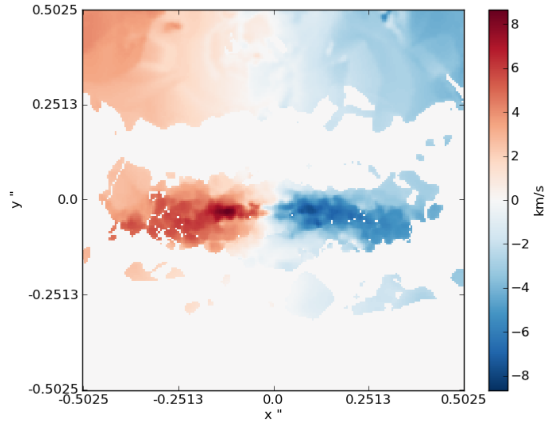


Figure 22. C18O 3-2 15 deg mom1map

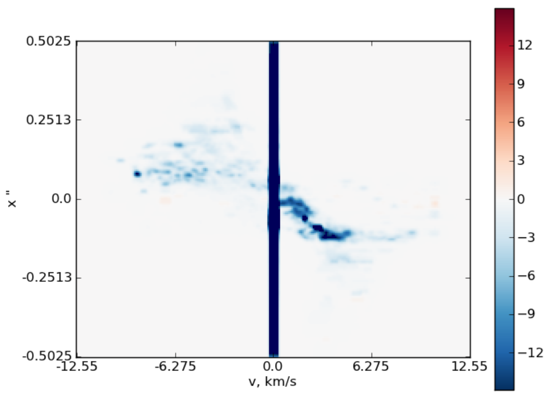


Figure 23. C18O 3-2 PV 15 deg through centre

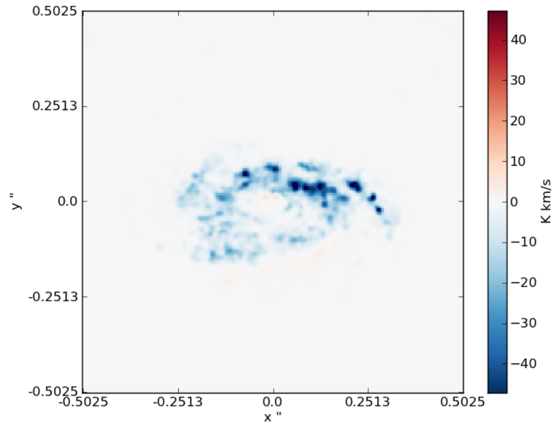


Figure 24. C18O 3-2 30 deg Continuum subtracted mom0

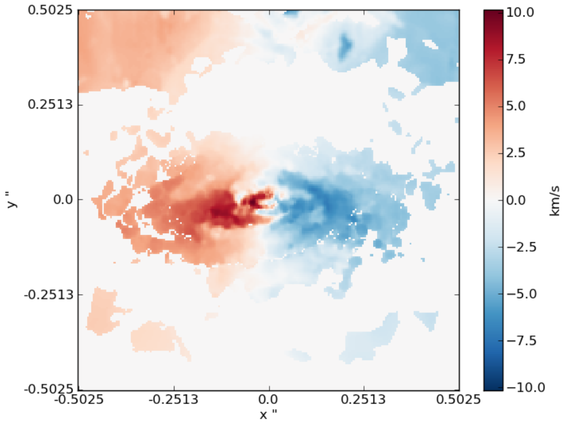


Figure 25. C18O 3-2 30 deg mom1map

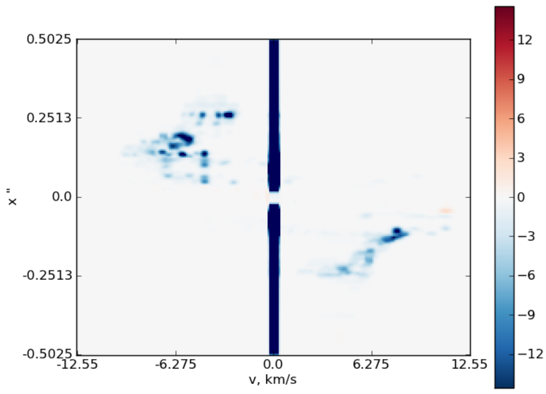


Figure 26. C18O 3-2 30 deg PV through centre

30 deg 30 deg

45 deg 45 deg

60 deg 60 deg

75 deg 75 deg 75 deg 75 deg 75 deg 75 deg 75 deg 75

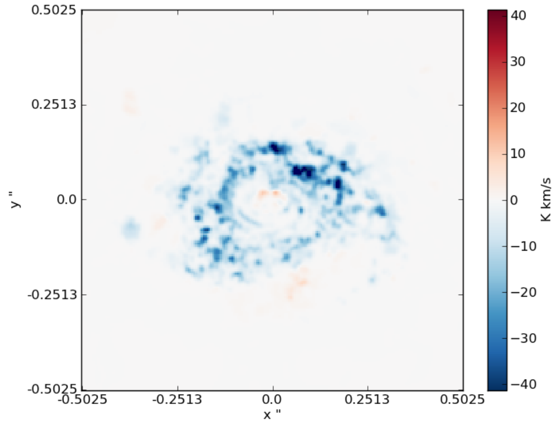


Figure 27. C18O 3-2 45 deg Continuum subtracted mom0

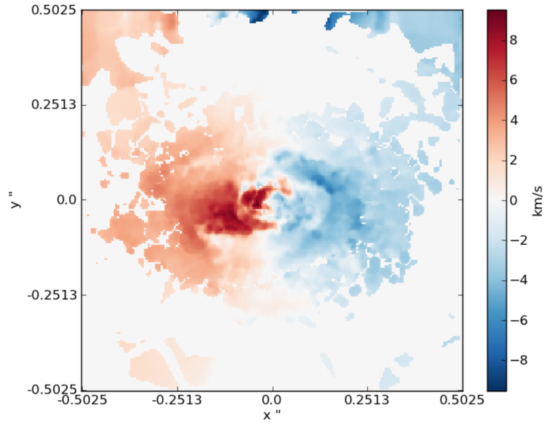


Figure 28. C18O 3-2 45 deg mom1map

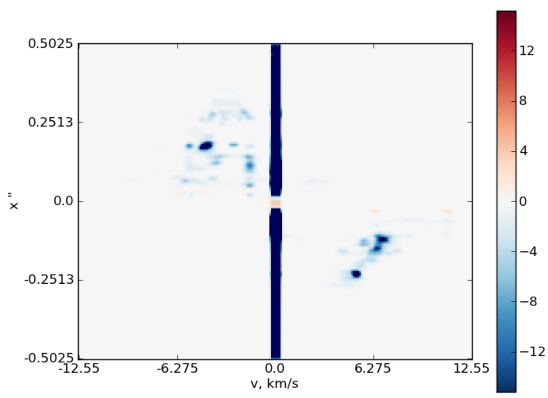


Figure 29. C18O 3-2 45 deg PV through centre

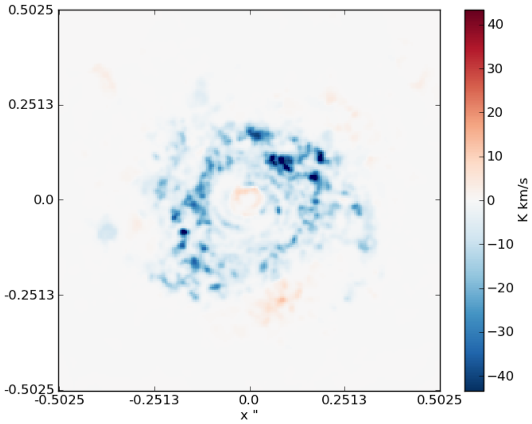


Figure 30. C18O 3-2 60 deg Continuum subtracted mom0

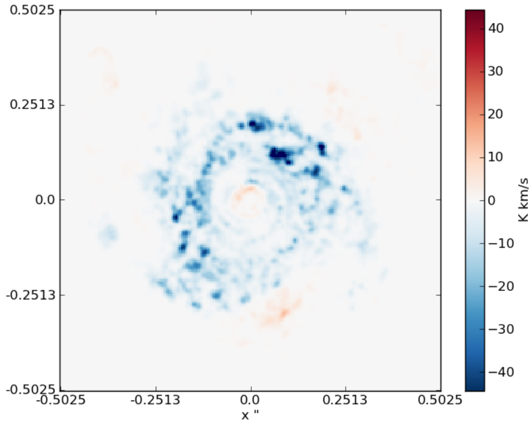


Figure 33. C18O 3-2 75 deg Continuum subtracted mom0

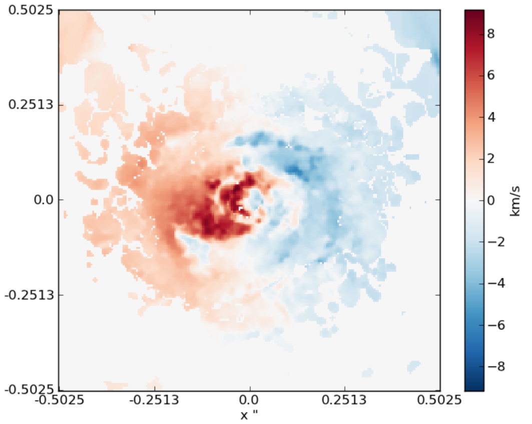


Figure 31. C18O 3-2 60 deg mom1map

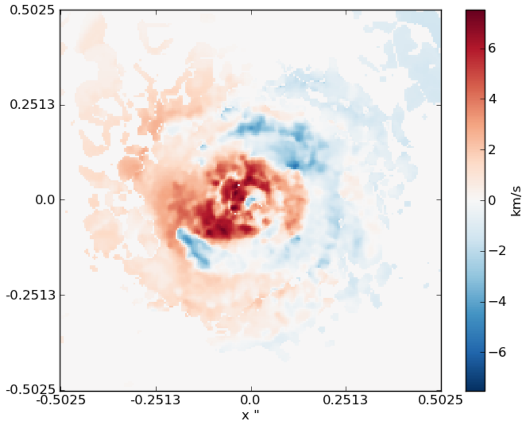


Figure 34. C18O 3-2 75 deg mom1map

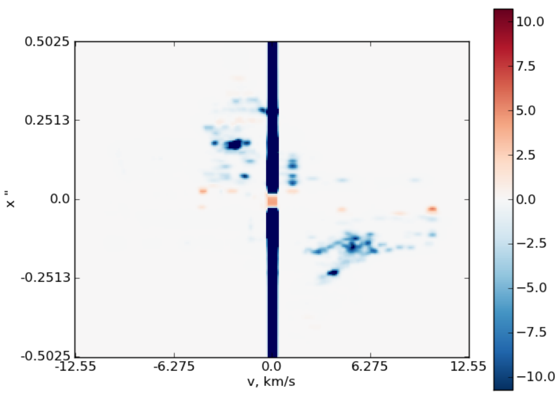


Figure 32. C18O 3-2 60 deg PV through centre

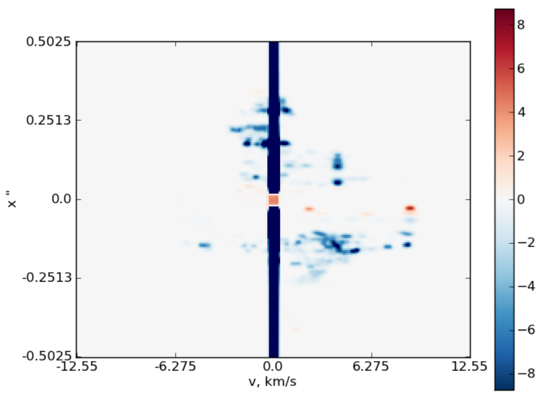


Figure 35. C18O 3-2 75 deg PV through centre

deg 75 deg

Figure showing different transitions of the same molecule (e.g. CO(1-0), ...(7-6) , OCS, H2CO) for same inclination but in different disks (Boley et al. and the smooth disk)

4 ALMA PREDICTIONS

- current status (Cycle 1) - Figure OCS + C18O + H2CO + HNO/CS/ - final status - Figure

5 CONCLUSIONS

note that all speices show up in absorption and some show a little bit of emission around the edges of the disc OCS is good for showing up spiral structure without being able to resolve it. enevelope only contaminates the central plusminus 500 m/s or so

ACKNOWLEDGMENTS

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