Progress Report for AST130036 "A Study of Colliding Flows and Feedback in Star Formation"

Adam Frank, Jonathan J. Carroll-Nellenback, Baowei Liu,
Martín Huarte-Espinosa, Jason Nordhaus, Shule Li

April 15, 2014

1 Summary of Scientific Discoveries

Our allocations of AST130036 was 3.5 million SUs on Kraken. The allocations will be ended on June 30, 2014. As of April 15, 2014, we used 80% of our allocation to do high resolution simulations on colliding flows. Over the tenure of the last proposal we have carried out studies leading to 3 papers [Carroll et al, 2014, Li et al, 2014, Kaminski et al, 2014] . We have also begun studies of magnetized colliding flows with shear.

Below is a summary of our accomplishments

1.1 Summary of Scientific Discoveries

- We completed a high resolution study of hydrodynamic self-gravitating converging flows with realistic cooling properties to explore the effect of heterogenties on the formation of molecular clouds [Carroll et al, 2014]
- We began a low resolution study of MHD self-gravitating converging flows with realistic cooling focusing on the effect of field tension and initial shear on the formation of bound cloud complexes.
- We completed studies of the effect of ambient gas (either static or supersonic) on the collapse of pre-existing clouds. In particular we completed the first high resolution studies of triggered star formation to track the formation of a star and a surrounding accretion disk ([Li et al, 2014, Kaminski et al, 2014])

2 Accomplishments of Computational Plan

In [Carroll et al, 2014] we studied the evolution of flow-driven cloud formation with and without substructure in the flow. Our goal was to explore how pre-existing heterogenities would alter the ability of converging flows to drive post-shock regions into gravitational collapse. We compared two extreme cases, one with a collision between two smooth streams, and one with streams containing small clumps. Our analysis showed how structured converging flows lead to a delay of local gravitational collapse ("star formation"). Thus, more gas has time to accumulate, eventually leading to a strong global collapse, and thus to a high star formation rate.

New low resolution studies of the effects of magnetic fields and shear on these flows has laid the ground work for the current proposal. Our initial work shows that the presence of shear in the colliding flows leads to the generation of substantial vorticity which alters the creation of dense proto-clouds. Magnetic field tension restricts motion lateral to the field lines which can either enhance or destabilize local structures depending in the shear angle.

In [Kaminski et al, 2014] we studied the effects of the ambient gas on the collapse of pre-existing cloud cores. In particular we explored how either a dense ambient gas or a passing supersonic flow could drive stable Bonner Ebert spheres into gravitational collapse. Using our code's sink particle capacities we modeled the collapse past the point of the formation of a condensed object (a star). For non-rotating clouds we found robust triggered collapse and little bound circumstellar material remaining around the star. When we added initial cloud rotation we observed the formation of disks around the star which then interact with the post-shock flow. Our results indicated that these circumstellar disks are massive enough to form planets and are long-lived, in spite of the ablation driven by post-shock flow ram pressure. We also tracked the time evolution of the accretion rates and particle mixing between between the ambient wind and cloud material.

3 Publications and Reports that Result from XSEDE support

Publications related to this project are ([Carroll et al, 2014] ([Li et al, 2014]) and ([Kaminski et al, 2014])

References

Carroll, J.J., Frank, A., & Heitsch, F. 2014, ApJ accepted eprint arXiv:1304.1367.

Li, S., Frank, A., & Blackman, E. G. 2014, submitted to MNRAS, "Triggered Star Formation and Its Consequences"

Kaminski, E., Frank, A., Carroll, J., Myers, P. 2014, ApJ accepted, "On the role of ambient environments in the collapse of Bonnor-Ebert spheres" eprint arXiv:1401.5064