SCHOOL OF PHYSICS AND ASTRONOMY

PX4310 Project **Session 2017-2018**

MPhys Project **Interim Summary Report**

Project Supervisor: **Paul Clark**

Project Assessor: **Patrick Sutton**

Title: **CO formation in diffuse ISM**

Name: **Gerwyn Jones**

1. Introduction

Star formation has long been a difficult area to research due to the considerably long time-scale of stars. Our project delves into the CO formation in these collapsing clouds that are the birthplace of stars. CO molecules in star formations are incredibly important to astronomers, since the most abundant molecules in large molecular clouds (MC) are hydrogen and are incredibly difficult to observe due to the emission lines from excitation of hydrogen are quickly absorbed by the surrounding dust particles. The second most abundant molecule in MC are CO molecules which when excited, have emission lines which are not absorbed by by dust and therefore can be easily observed from Earth.

Using a package called AREPO (Springel, 2010) we shall investigate to possible problems that are still unsolved in the scientific community, one problem is to investigate whether or not two clouds colliding together can also be the starting points of star formation; the other problem is to investigate whether a simple chemical network similar to that of the chemical network produced by Nelson & Langer (1997) is sufficient for highly taxing numerical simulations; or that a more complicated chemical network similar to that of the chemical network produced by Nelson & Langer (1999) is needed to preserve the accuracies of chemical evolutions in star formation. Answering this question could aid researchers who use simple chemical networks over more complicated chemical networks, not just in star formation but also on the galactic scale.

AREPO is a Moving Mesh code that incorporates both Eulerian and Lagrangian fluid dynamics and through this combination, it provides greater accuracy and more workability compared to Smoothed-Particle Hydrodynamic codes (SPH).

Along with AERPO, the supercomputer Raven is taken full advantage on this project due to the incredibly taxing code that AREPO is.

Currently, both Nelson & Langer (1997) and Nelson & Langer (1999) are the simple and complex chemical networks used in our project.

With the cloud-cloud collisions, we can vary cloud velocity and investigate the differing cloud interaction with increasing velocity.

When using AREPO, the GADGET2 paper (Springel, 2005a) and its user guide (Springel, 2005b) is extremely useful when learning AREPO's many complicated codes. This is due to the fact that both GADGET2 and AREPO are all the creation of one man called Volker Springel, this brings an advantage since all of his codes have an intentionally similar format in which we can change from one code to another much easier.

2. Results

The first process of the project was to be familiarized with the use of Raven and AREPO, from this a simple cloud collapse was made to see how the interactions of molecular clouds as they collapse. From Figure 1 we can see the initial setup of the single cloud where the radius of the cloud was around 11Pc with a number density of 50 cm^{-3} and a temperature of 30K which was based on Clark et al. (2012).

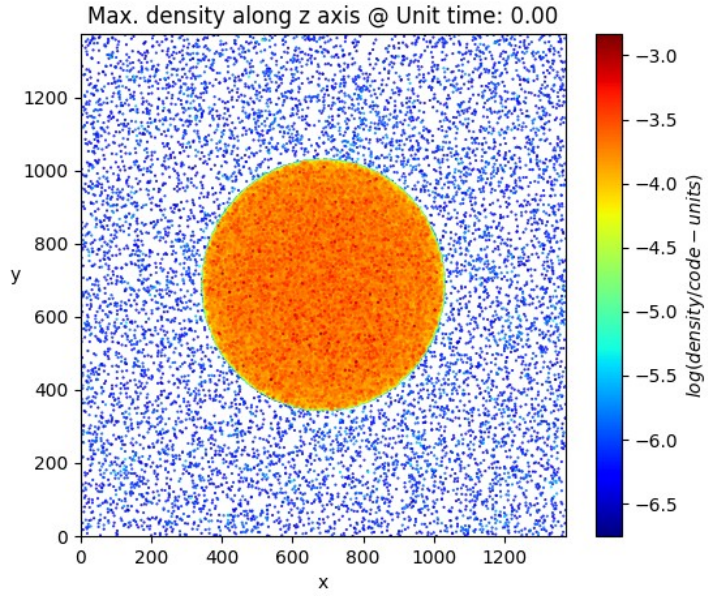

Figure 1 : A molecular cloud with a radius of 11Pc confined to a box with a width of around 50Pc.

After around 5My this cloud has collapsed in on itself as seen in Figure 2, what is noticeable is that the cloud hasn't collapse spherically, but in fact has collapsed asymmetrically and formed filamentary structures which were first detected by André et al. (2010). Note that 5My for this cloud was also the crossing time of the cloud, this is the theoretical time taken for a particle and the edge of the cloud to collapse freely into the centre of the cloud.

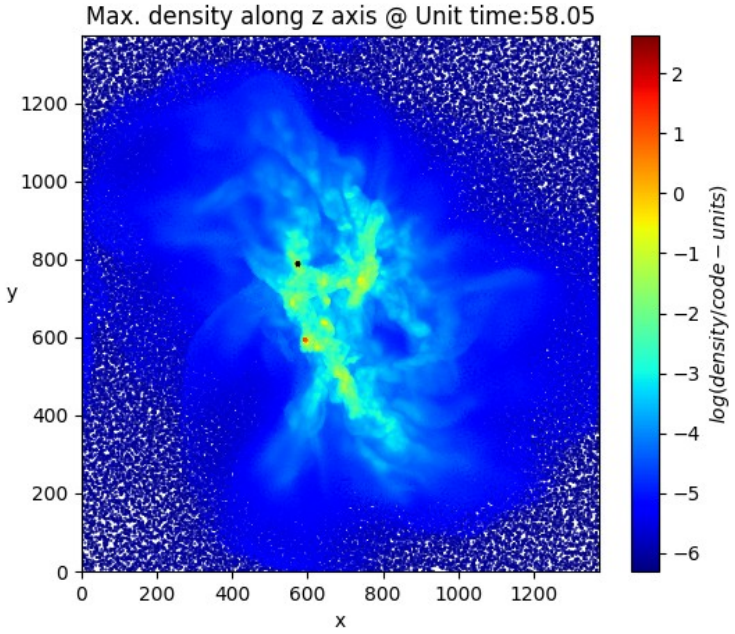

Figure 2 : A molecular cloud during the collapse stage after a period of 5My confined to a box with a width of around 50Pc.

The next process was to begin the cloud collisions, starting at a velocity of 5 Kms^{-1} and using the simpler chemical network of Nelson & Langer (1997) . Using the same radius for both clouds of 9Pc, both with a number density of 50 cm^{-3} and a temperature of 20K, we can see the evolution of the two clouds.

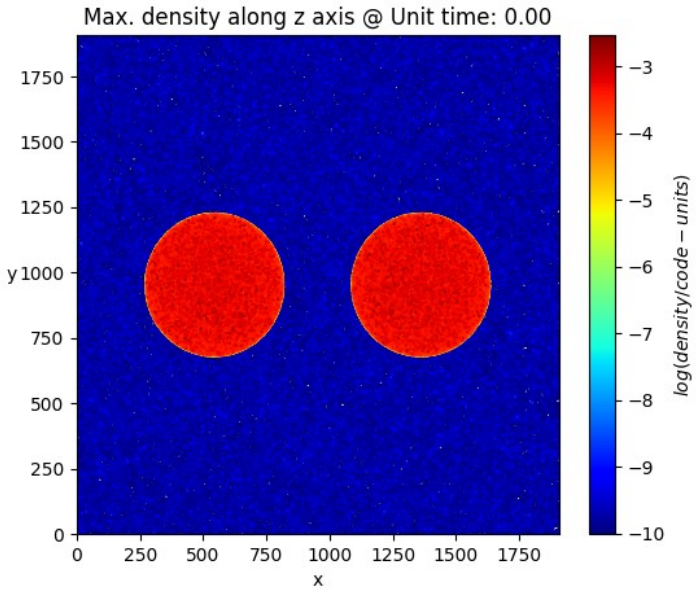

Figure 3 : Two molecular clouds with radius of 9Pc confined to a box with a width of around 62Pc.

After around 2My or around 0.7 T_{cross} we can see that in Figure 4 both clouds have collided with one another.

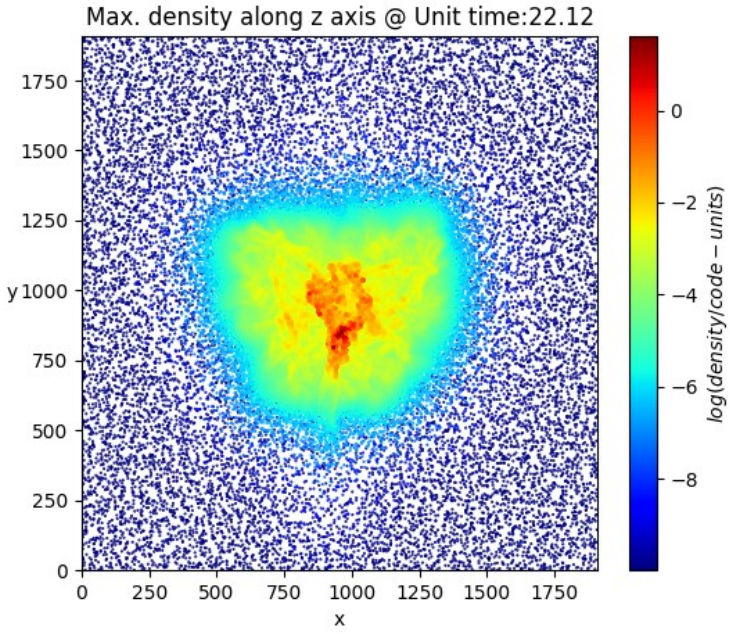

Figure 4 : Two molecular clouds in the process of collision after a period of 2My confined to a box with a width of around 62Pc.

3. Conclusion

To conclude, I have set up my conditions for both problems and I'm currently running the codes which will enable myself to further the solutions to the problems that have been created for the project. Currently the future is still very much open ended and could lead to new problems and new ideas that need answering.

4. References

André, P. *et al.* (2010) ‘From filamentary clouds to prestellar cores to the stellar IMF: Initial highlights from the Herschel Gould Belt Survey’, 518, p. L102.

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