Physics 224: Paper Discussion 6
Winter 2020

McKee & Ostriker 1977:

- Since 1977, there have been a new class of SN discovered that are 10-100 times more luminous than typical Supernovae. I am unable to find a predicted rate of SLSn per galaxy, however, if they are numerous, what kind of effect would these have in this model of the ISM?
- On page 151, when discussing anisotropy, the authors state that if the radius of the SNR exceeds the scale height, it will blow out of the galaxy. What about more intermediate cases? I.e. gas density drops off with height above the disk, so would a SNR with a radius near the scale height be elongated in that direction?
- The results of this paper are under the assumption that all ISM phases are roughly in pressure equilibrium. But from later studies we know turbulent heating/cooling make the pressure-density distribution much broader. How would the results from this paper be affected if this effect is also considered?
- Figure 2 features a super nova blast wave disrupting the warm regions of clouds it comes in contact with, one of the cores is just about to be engulfed and we can see it being distorted. Depending on the sound speed of the warm gas could this disruption propagate to other neighboring clouds that have not been engulfed by the supernova yet? Or is the speed of the the blast wave just much faster than the sound speed of the warm gas?
- It seems like the Sedov were wrong in a number of ways. The paper references that solution a number of times and each time the differences between the papers results and Sedov's results were very different. So a couple questions come of this. What is the Sedov solution? Why is it being compared here? Was it implemented widely before this paper? What did it get wrong? Are any of its solutions still applicable?
- The two phase model was introduced by Field, Goldsmith and Habing was succesful in explaining a lot of observational phenomena. This shows that it certainly has solid underlying physics behind it. Does that mean that the three phase model must, in some limit, approach the results of the two phase model or are these models fundamentally incompatible and competing in nature, and as such, manifest in different regimes when it comes to time and length scales?
- I might have missed this in the paper, is this model the best explanation for galactic outflows observed in star-forming galaxies?

- This paper replaces the theory put forth by Field, Goldsmith, and Habing (1969) that the ISM is composed of two phases due to cosmic ray heating: cold dense clouds embedded in a warm diffuse medium. This paper puts forth a three-phase model primarily due to supernovae explosions. Does the previous model match better in cases with a smaller rate of supernovae? Also, why is cosmic ray heating ignored in this paper?

- When calculating the volume filling fraction of the SNRs in our galaxy, the authors adopt the SNR density of 1e-13 per cubic parsec per year. This number is obviously extremely important in the model; however, I am struggling to find out how it was estimated.

- The authors mention that they ignore locations associated with active star formation, like molecular clouds or Stromgren regions. How does the analysis change if these regions are included?

- they claim that the phases are all in rough pressure equilibrium, how does this work with the idea that a supernova explosion has blast waves that move though these phases. doesn't turbulence cause pressure to become non equilibrium? and on this note, how does this assumption effect their calculations where they say the phases evolve adiabatically in pressure equilibrium? did you find any thing in researching their methods that would indicate issue with this?

Walch et al. 2015:

- First, external gravitational potential (a global effect) plays important role in the structure of the ISM gas. Specifically, in the initial evolution of the gravitational collapse. If the simulations included an estimate of the gravitational potential due to Dark Matter, do you think this would delay or accelerate the collapse? What effect on the scale height of the mid-plane ISM structure? Secondly, the radius for a supernovae event is defined when the sphere envelops 800 solar masses? This value of mass is relatively large compared to typical the typical masses of stars that explode. I am confused as to why this specific number is chosen and how it relates to a star efficiency rate.

- On page 454 the authors state they assume a constant metallicity and dust-to-gas ratio. Would metal enrichment and dust destruction from these supernovae have any significant effects on this study over the time scales analyzed?

- The author concluded that the resulting ISM from peak-driving models are not consistent with observations, and that only models with more SNe exploding in low-density gas match better with observations. I wonder if peak-driving SN positions were commonly used in simulations? Since SN explosions occur in the very late stage of their evolution, I would expect that most of the gas around them already been formed into stellar structures, and thus there shouldn't be high-density clumps nearby. What is the rationale for using the peak-driving assumption?

- The paper found supernovae rate and position had a significant impact on the molecular cloud, but used the same thermal energy and mass for each supernovae and only one case investigated two types of supernova. How could including different types of supernovae affect the results? Also, the paper didn't investigate other forms of feedback. Have the details of different feedback mechanisms within molecular clouds been studied since this paper and what are their impacts?

- They mention that "we do not follow star formation self-consistently, we have to choose a SN rate for our simulations" but over their simulated time larger stars could be born and die and lead to a sort of feedback process? Would these large stars not form in these clouds?

- It's interesting that none of the distribution of densities in figure 20 are log-normal and they provide an explanation that the ISM is neither coherent nor isothermal. They recommend caution or fitting mixtures of log-normals and power laws. Is this now standard practice?

- I know very little about galaxy simulations or supernova observations. That being said, is there a way observationally or by simulation to determine the time and space distribution of super novas that could be used to favor one of the distributions used in this paper?

- I don't quite understand the argument in section 8.2 for why a higher SN rate causes a lower volume filling factor of the hot gas. Even if there are larger outflows, why does this reduce the volume filling factor?

- The authors mention that in different cases, the H_2 mass fraction changes, and the CO changes in proportion to this. Do they make assumptions about the relative ratio between the two molecules, using Milky Way conditions? Are these simulations useful in figuring out what other dynamics could play a role in variations between the ratio of these two molecules (such as magnetic fields, etc)?

- This question is about the "driving" schemes, i.e. how supernovae are distributed in the simulation (section 3.3). I appreciate that star clusters will have multiple coeval massive stars that are likely to explode at nearby points in space/time. The authors use a special driving scheme ("clustered random driving") to account for that. Outside of clusters, I would intuitively expect this correlation to invert, since supernovae explosions will disrupt the star formation in their vicinity, thereby reducing the likelihood of another supernova at a nearby point in space/time. However, the driving schemes used outside of star clusters do not appear to account for any correlations between different explosions. Is this simply a limitation of the model or is there a good reason why this correlation can be neglected?

- I think its really interesting that the dense molecular gas results are so gravity dependent but the formation of the dense gas is heavily dependent on the magnetic fields, but they dont change the evolution on a whole just set timescales. it is interesting to consider how the self gravity timescale and the magnetic field dense gas formation timescales might compare to one another. is there a scenario where very dynamic magnetic fields from some source could disrupt this?