Physics 224: Paper Discussion 4
Winter 2020

Tielens & Hollenbach 1985:

- They mention the different heating and cooling mechanisms differing from the surface as you go deeper into the cloud, but don't really mention the direction of the flux and I'm unsure as to why that is the case? They are dealing with areas that have a much higher flux than typical and I'd expect the directionality of that flux to have a bigger impact.

- It is interesting, in figures 8a and 8b, that a drop in CI cooling corresponds to an maximum heating by CO and a large drop in CII heating. The authors do state that the carbon transitions are of "prime importance". Compared to the other species, the heating and cooling curves do not appear to show the balancing behavior. Is this an early indicator that Carbon is an important population in dust (PAHS)? (I hope this question makes sense)

- It's interesting that only less than 1% of FUV flux contribute to gas heating, while it is still the dominant heating source throughout the ISM of a galaxy. However, the author states that both an increase of FUV flux and decrease of electron density would decrease the efficiency of photoelectric heating. Then why do the OI, CI, CII lines show similar variations in Figure 10 and 11? I would expect their intensities to increase with densities and decrease with the incident FUV field.

- The paper mentions that almost all the FUV radiation is absorbed and re-emitted by dust. Are there any reasonable scenarios where the dust density is low enough that this changes significantly, and more of the radiation is available for the gas-phase elements? How would that affect the model they present?

- The paper discusses how photoelectric efficiency increases as you go deeper into clouds due to increased density. Since the efficiency rises when dust is more negative, you should also see in increase efficiency due to the fact that there are fewer FUV photons deep in clouds. Can we comment on the relative contributions of these two efficiency boosts, or is the density dominant?

- This paper states "the C II 158 μm line intensity in the possible best fit model, which has a lower dust-to-gas ratio than the standard model, is in much better agreement with the observations." But they state afterward that equally good fits can be obtained by tilting the slab or choosing a normal gas-to-dust ratio combined with a gray FUV dust opacity. and that they cannot rule out the possibilities and in fact these might all be operating at once. Do you have any ideas after researching this paper which of these mechanisms might also be important beside the one considered in their model?

- So is this paper effectively looking at the impact of FUV outside the Stromgen sphere? For the other cases (neutral shells around planetary nebulae, bright-rimmed molecular clouds, reflection nebulae, regions around protostars, and the center of the Galaxy, and to global studies of external galaxies.) all have FUV sources but no stromgen sphere? Why is that?

- There are a number of interesting things (in my opinion) that happen in the shell or on the surface of the molecular clouds. CI lies on the surface of the clouds and H2 is in vibrationally excited states. Do we know how thick the edges are? Put another way, how quickly does the transition from cloud to outside the cloud happen?

- CO is often used as a tracer of H2 in the ISM, since the latter is considerably harder to detect. Is it possible to use the model in this paper to develop a better H2/CO conversion technique than the usual assumption of a constant ratio between the two?

- Based on the cooling mechanism presented in this paper, which cooling mechanism dominates regions in the Orion complex? I wanted to make a connection with the previous homework

- I assume the calculations in this paper are now done using simulations - is this something CLOUDY could do, and how accurate have these 35 year old results proven to be?

- I'm having trouble understanding the picture for where the photodissociation region is relative to the HII region. Can you have a photodissociation region existing as a shell around an HII region?

Field, Goldsmith & Habing 1969:

- The authors state that the ionization rate is tied to the energy density W and W appears to be a key variable that effects the predictions of the phase H temperature. How could the analysis change with the inclusion of high energy cosmic rays? What makes the contribution of high energy cosmic rays to the ionization rate negligible?

- An estimate of the scale height of the galaxy is presented (160 pc) without any reference to the spiral structure of the Milky Way. I would expect the scale height inside the arms to be noticeably different to that between the arms. How can the procedure in the paper be improved to include this variation? E.g., can the on-arm/off-arm differences be fully incorporated in the assumed heating and cooling parameters or would the model require additional physics?

- On page L153 the authors note that "Ellis and Hamilton argue against the existence of discrete clouds..." Is the work by Redfield (discussed earlier this quarter) contradictory to this claim? How would the introduction of discrete clouds alter this work and it's conclusions?

- How well does the assumption regarding the ambient cosmic ray energy hold up to newer observations and/or simulations?

- Why does the model consider only cosmic ray heating? Are UV photons supposed to be a more dominant heating source than low-energy cosmic rays? How are later 21-cm observations comparing to the model prediction?

- In this paper, they discuss using the equipartition field of 3uG, and utilizing the depletion factors their model agrees well with observations. They claim the depletion factors are quite unknown and they use a static average magnetic field. Do you think this is valid in the ISM since the depletion regions can have depletion factors that vary quite a bit and the magnetic field can also vary quite a bit.

- When discussing the morphology of the clouds formed in the model, the authors discuss how the minimum and maximum size for clouds are set, but say there is no preference for cloud shape or size beyond these factors. Is this still the case, or is there some distribution for cloud size based on different factors in the ISM? If it is a flat, even distribution, how much does that depend on the assumptions they make earlier in the paper about cosmic ray density, temperature, etc.?

- They included magnetic field in their calculation but with the large variance in magnetic fields is there a regime where that dominates compared to the pressure of the clouds.

- We now know that there are more than two phases of interstellar gas, what role does cosmic ray heating play in these more complex phases?
- Is it possible to tell how far away the source of a detected cosmic ray is? Also, how feasible would it be to detect cosmic rays originating from events at super high redshift (like explosions of PopIII stars)?
- Why is pressure defined as (n+n_e)*T and not just n*T?