1. Introduction

Opening paragraph

Stars form in clouds of molecular hydrogen that are large (hundreds of light years), low density ($\rho \simeq 10^{-24}$g cm^{-3}) , cold ($T \simeq 20K$), and turbulent, with velocities several times the speed of sound, c_s, in the cloud ($c_s \simeq 0.2$km s^{-1}). It is an essential but open problem in astrophysics to uncover the relationship between the properties of a molecular cloud (e.g. density and velocity distributions) and the properties of the stellar population it produces (e.g. star formation rate and mass distribution). The current proposal will measure the relationship between the velocity of a supersonic shock and the distribution of the resulting density fluctuations induced by the post-shock turbulence, $f(\rho)$. This is an essential component in understanding the relation between the velocity distribution in a molecular cloud, which is easy to measure with telescopes, and its potential to form stars, which impacts many aspects of the host galaxy.(Padoan & Nordlund 2002)

Scientific Motivation Molecular clouds are barely held together by gravity. Their gravitational energy, which will cause the cloud to collapse, is balanced by kinetic, magnetic, and thermal energies, which all support against the collapse. Interacting shocks within the cloud cause density enhancements orders of magnitude larger than the mean density of the cloud. Some fraction of these small, dense regions can have large enough gravitational binding energies to decouple from the turbulence, and ultimately become stars. The proposed campaign will examine these post-shock density enhancements.

The fraction of a cloud that can form stars (M_*/M_{total}) can be predicted from the density distribution, $f(\rho)$, as the mass fraction of the cloud above a critical density, ρ_c;

$$M_*/M_{total} = \int_{\rho_c}^{\infty} \rho f(\rho) d\rho. \tag{1}$$

Similar calculations can give predictions for the star formation rate and mass distribution of the stellar population. The critical density ρ_c is the density at which gravity overtakes the other forces. With this campaign, we will measure the full density distribution, $f(\rho)$, by way of the integrated column density distribution using the techniques of (cite Federrath). Since $f(\rho)$ is set primarily by the underlying turbulence, our proposed campaign will give a direct window on the relationship between the properties of a star forming cloud and the stellar population it may form.

It is straightforward to show, analytically and numerically, that supersonic, isothermal turbulence will produce a lognormal density distribution $f(\rho)$;

$$f(\rho) = \frac{1}{\rho\sqrt{2\pi\sigma_{\ln\rho}^2}} e^{-\frac{(\ln\rho-\mu)^2}{2\sigma_{\ln\rho}^2}} . \tag{2}$$

Here μ and $\sigma_{\ln\rho}$ are the mean and variance of $\ln\rho$. One very useful feature of this distribution is that the width of the distribution, $\sigma_{\ln\rho}$, is simply determined by the velocity variance

$$\sigma_{\ln\rho}^2 = \ln\left(1 + b(\sigma_v/c_s)^2\right) ., \tag{3}$$

where σ_v is the velocity variance and c_s the speed of sound. This can be extended to gas that is adiabatic or with external heating and cooling sources, which tends to result in a similar distribution, but with excess tails to higher or lower density, depending on the compressibility of the gas relative to isothermal. The utility of this relationship, which is well established numerically *citations*, is that it predicts the density distribution only using the velocity variance. This has two primary consequences. First, the velocity variance is relatively easy to measure with radio telescopes, using Doppler shift of emission lines. Second, it makes prediction of the formation of stars as straight forward as the application of Equations 3, 2, and 1. Our proposed campaign will examine and verify the validity of Equations 2 and 3.

REFERENCES

Padoan, P. & Nordlund, Å. 2002, ApJ, 576, 870