The external component: surrounding matter as an agent in star formation

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How does an external matter distribution effect a molecular cloud?

Recent analytical studies have demonstrated that the media surrounding a molecular cloud can importantly alter the gravitational potential to which it is subject, and contribute to its collapse or disruption (Ballesteros-Paredes, 2006; Gómez et al. 07). We sudy three cases where this effect can be important.

1. Dark matter halos as a whole
2. Dark and barionic matter perturbations
3. Tidal influence from the Galaxy

Internal gravitational energy

$$E_{grav} = \frac{1}{2}\int_V \rho_{cloud}\phi_{cloud}dV$$

External gravitational energy

$$W_{ext,i} = -\int_V x_i \frac{\partial \phi_{ext}}{\partial x_i}\rho_{cloud}dV,$$

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- Torres R. M., Loinard L., Mioduszewski A. J., Rodríguez L. F., 2007, ApJ, 671, 1813
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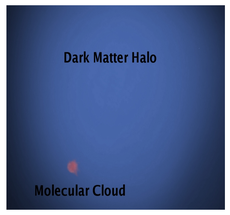
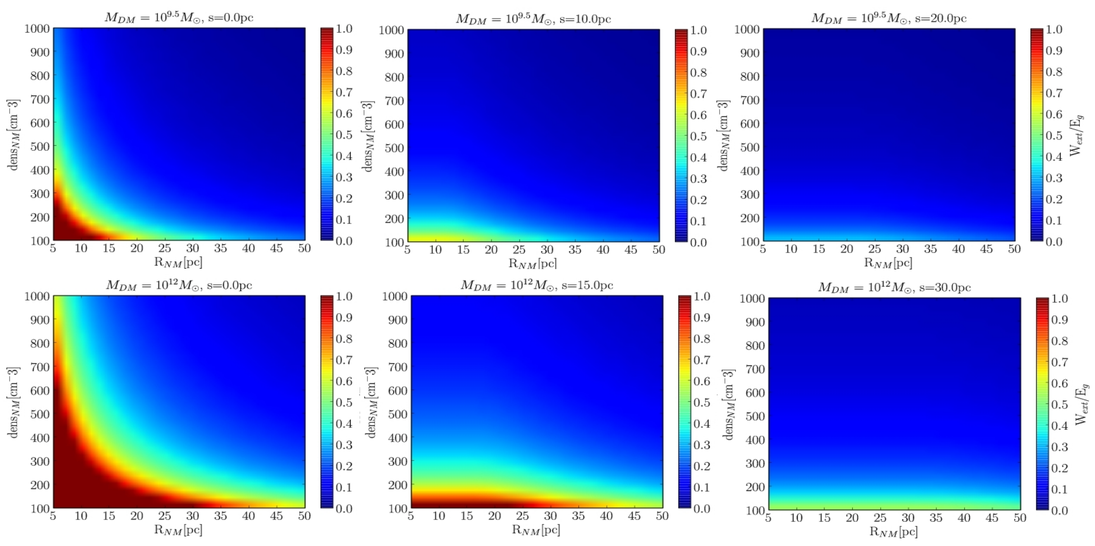
The dark matter contribution

HALO

Constant density molecular cloud embedded in a NFW dark matter distribution.



The halo extended potential is felt by the cloud and contributes as an external agent.
Two very different length scales are involved: the cloud and the halo.



The halo profile is important only for clouds in galaxy centers and contributes to deplete their gas.

PERTURBATION

The presence of a molecular cloud perturbs the otherwise homogeneous dark matter background, which in turn alters the potential felt by the cloud and contributes to its collapse.

Cloud with Plummer density profile

$$\rho_P = \frac{3M}{4\pi a^3}\left(1+\frac{r^2}{a^2}\right)^{-5/2}$$

Homogeneous and isotropic dark matter background:

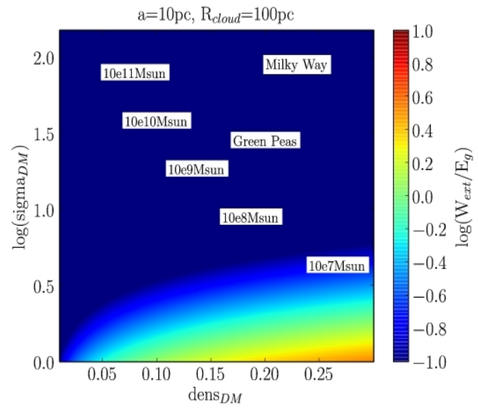
constant density ρ_0
constant velocity dispersion σ

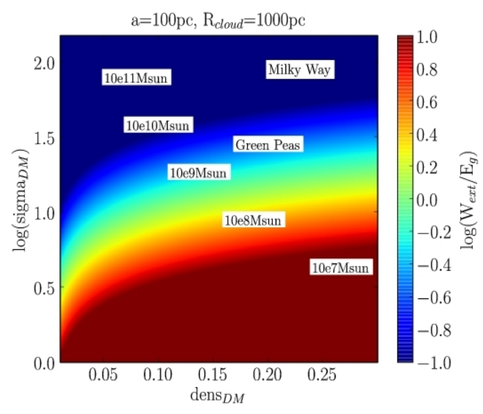
External to internal energy ratio

$$\frac{W_{ext}}{E_g} = -1.8025\left(\frac{a}{10pc}\right)^2\left(\frac{\rho_0}{M_\odot pc^{-3}}\right)\left(\frac{\sigma}{kmsec^{-1}}\right)^{-2}\frac{f_{ext}(R/a)}{f_g(R/a)}.$$

SIMULATIONS IN PREPARATION

The interrelation with dark matter is relevant for big clouds in small galaxies. Could explain starbursts in Green Peas.

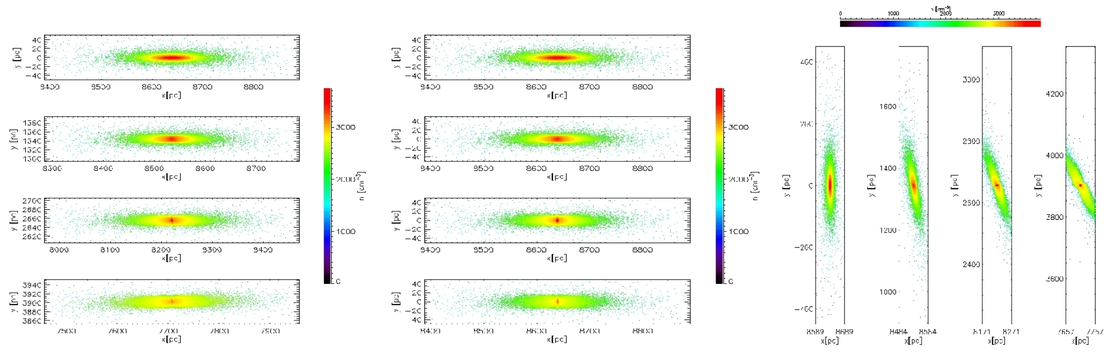




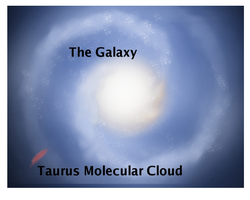
Tidal forces from the Galaxy: Taurus molecular cloud

An oblate ellipsoidal Plummer spheroid resembling Taurus molecular cloud is embedded in an Allen-Santillán (1991) Galactic potential for the Galaxy, which will cause an external potential energy.
Two different alignments of the cloud with respect to the Galaxy are considered and a cloud without any external potential for comparison.

t = 0 Myr
t = 6 Myr
t = 12 Myr
t = 17 Myr

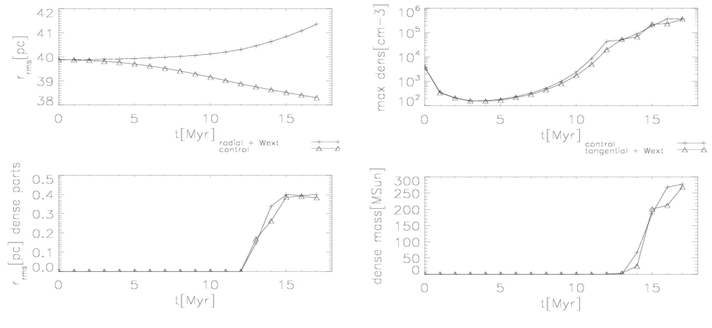


Radial + Wext. | Control (no external potential) | Tangential + Wext.

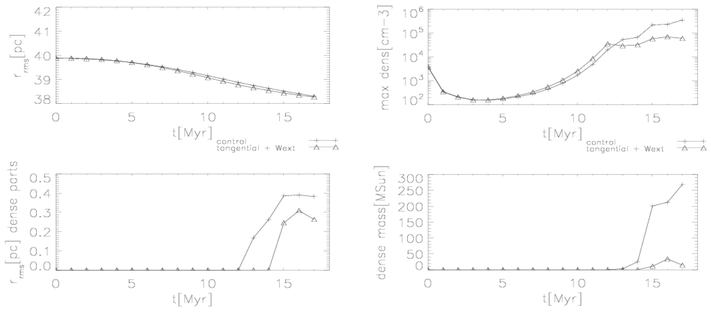


HI-RES SIMULATIONS STILL RUNNING!

A radially aligned cloud is globally disrupted



A tangential cloud still collapses



The tidal forces from the Galactic mass distribution clearly cause global disruption of the cloud, specially for radial alignment.