Winds and Radiation in Unison
A New 1D Feedback Model for Cloud Dissolution
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El Escorial 14.6.2017

1) What is the main feedback force on cloud scale?
2) What is the minimum star formation efficiency needed to destroy molecular clouds?
3) Coupled or not: How much radiation is escaping?
Why do we worry about feedback?

- Star formation rate too high
- Star clusters too bound
- IMF is wrong

Klessen & Burkert 2001
What is stellar feedback?

- Supernovae
- Stellar Winds
- Radiation:
  - Radiation pressure
  - Thermal feedback
- Photochemistry

UNDERSTANDING ONLINE STAR RATINGS:

- ★★★★★ [HAS ONLY ONE REVIEW]
- ★★★★★ EXCELLENT
- ★★★★☆ OK
- ★★★☆☆ CRAP
The Life of a Molecular Cloud

Gravity

Star Formation

Supernova Explosions

Stellar Winds

Radiation
The model
(for massive clouds)

Rahner, Pellegrini,
Glover, Klessen subm.
(arXiv:1704.04240)
The model
(for massive clouds)

(See Draine11, Martinez Rahner, Pellegrini, Glover, Klessen subm. arXiv:1704.04240)
1) Dominating Feedback

\[ F_{\text{ram}} = F_{\text{wind}} + F_{\text{SN}} \]
\[ = M_w v_w + M_{\text{SN}} v_{\text{SN}} \]

\[ F_{\text{rad}} = F_{\text{direct}} + F_{\text{indirect}} \approx f_{\text{abs}} \frac{L_{\text{bol}}}{c} (1 + \tau_{\text{IR}}) \]

\[ F_{\text{grav}} = \frac{GM_{\text{sh}}}{R^2} \left( \frac{M_* + M_{\text{sh}}}{2} \right) \]

Integrated over cloud lifetime:

\( \Omega_{\text{rad}} > 0.5 \) radiation pressure

\( \Omega'_{\text{rad}} > 0.5 \) radiation pressure

(If hot gas pressure excluded)

Rahner, Pellegrini, Glover, Klessen subm. (arXiv:1704.04240)
2) Minimum star formation efficiency

- Minimum star formation efficiency increases with increasing mass.

Rahner, Pellegrini, Glover, Klessen subm. (arXiv:1704.04240)

Kim+16

Minimum star formation efficiency increases with increasing mass.
3) Escape fractions

- Escape fractions show variability
- Generally higher for low metallicity

Solar metallicity

As in Howard+17

Low metallicity (15% solar)

$10^5$, low dens

$10^5$, high dens

$10^6$, low dens

$10^6$, high dens

Rahner, Pellegrini, Glover, Klessen subm. (arXiv:1704.04240)
Summary

● 1D code modeling cloud expansion including winds, SNe, radiation pressure, gravity and shell structure

● Feedback from radiation and winds/SNe is interconnected

● There is not the one main source of feedback. When? How massive is the cloud? How dense? How massive is the star cluster?

● Minimum star formation efficiency increases with cloud mass (5% - 15% for dense $10^5 - 10^7 M_\odot$ clouds)

● Photon escape fractions are strongly time-dependent (e.g., peak at ~5 Myr)