The formation and evolution of GMCs in galaxies

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Overview

- Introduction
- Formation of molecular clouds
- Evolution within galaxies
- Conclusions
Hierarchical density structure in molecular clouds

- Not homogeneous, but highly structured
- Stars embedded in dense cores

Emission line maps of the Rosette Molecular Cloud (Blitz 1987)

Formation of cold gas embedded in warm diffuse gas
Cloud formation: shock-induced

Shock-induced formation

Inutsuka & Koyama (2006)
Van Loo et al. (2007, 2010)

e.g. shocks and winds sweeping up material

• Similar processes as in flow-driven model; thermal instability of ISM, dynamical instabilities
• Can explain different cloud morphologies e.g. filamentary, head-tail,…

• Study isolated magnetised warm diffuse cloud ($\beta \approx 1$) interacting with shock

W3 GMC (Bretherton 2003)
Dynamical evolution: 3D parallel

Parallel shock

![Geometry](image1.png)

![Phase diagram](image2.png)

⇒ Rapid condensation at boundary
Dynamical evolution: 3D perpendicular

Perpendicular shock \( \sim 90^\circ \)

Geometry

Phase diagram

\[
\log(p/k) \quad \log(n)
\]

⇒ Condensation along equilibrium curve
Cloud properties:

large differences between parallel and oblique/perpendicular

- Oblique/perpendicular → HI clouds; Parallel → molecular clouds
- Ideal conditions ($\beta < 1$) for MHD waves to produce large density contrasts
Substructure

Effect of increasing resolution: overall the same but more detail

Also, non-uniform initial conditions will produce more structure
GMCs in galaxies

Galactic star formation hierarchy

Global simulations of galaxy, but, by extracting local regions, GMC evolution can be followed to subparsec scale.

Current hydrodynamic simulations contain
- Self-gravity
- Radiative cooling
- Thermal feedback

Future developments:
- Magnetic fields (ideal & non-ideal)

Butler, Tasker & Tan (in prep.)
See Mike Butler’s poster (B1)
Conclusions:

- Magnetically-dominated clouds form due to thermal instability and compression by weak or moderately-strong shocks
- Magnetic field geometry determines whether molecular/atomic
- The time-lag between cloud and core formation is short

Future work:

- Including self-gravity in the models
- The effect of multiple clouds and cloud-cloud collisions
- Global galaxy simulations with magnetic fields