Molecular Clouds – c. 2000!

Object	Size Scale	Mean Density of Emitting Volume	Typical Method for Observing	Gas Kinetic Temperature	Magnetic Field Strength	Means of "Support"	Comments
Giant Molecular Cloud (GMC)	100 pc	10^2 cm^{-3}	^{12}CO spectral line observations (mm-wavelength).	20-100 K	5-20 μG	**M=K**, sometimes =**G**, sometimes > **G** (many pieces of cloud may be unbound or transient) $K_{non\text{-}thermal} >> K_{thermal}$	Large-scale distribution is correlated with H I density peaks.
Dark Cloud	10 pc	10^3 cm^{-3}	Apparent in visual extinction, ^{13}CO spectral line observations, and far-IR emission from dust.	10-30 K	10-40 μG	**M=K**, sometimes =**G**, sometimes > **G** (outer parts of cloud may be unbound or transient) $K_{non\text{-}thermal} >> K_{thermal}$	Found in "complexes" within GMC's. A complex may easily harbor tens of sites of star formation.
Dense Core (and/or Bok Globule) a.k.a. "Low-mass Cores"	0.3 pc	10^4 cm^{-3}	NH_3 and/or CS spectral line observations. Peaks of visual extinction.	10-15 K	not well known; probably ~40 μG	**G** ≥or≅ **K** and sometimes = **M**, (**G** >**K** implies collapse) $K_{non\text{-}thermal} \cong K_{thermal}$	•May contain region of infall at "center." •Lifetime ~ 10^7 yr. •Often associated with one or a handful of "embedded" young stellar objects.
"Disk"	<<1000 AU	>>10^5cm^{-3}	Evidence is primarily spectroscopic+new HST images. Some radio interferometric evidence.	may have strong radial dependence	unknown	centrifugal, magnetic	Presumably the analog of the a true "protosolar nebula."

"Molecular" Outflow	up to several pc	10^2 cm^{-3}	Spectral lines show excess red-shifted and blue-shifted emission with bipolar spatial distribution.	found where ambient T~10-50 K	unknown	"Driven" by jets? See below.	Distinction between "jets" and "outflows becoming less apparent.
"Optical" Jet	1000-10,000 AU	usually, only "ionized" density can be measured directly	Spatially mapped in optical-wavelength lines of ionized species. Apparent in near-IR observations, especially vibrationally excited H_2.	hard to differentiate "shocked" gas temperature from "pre-shock" gas temperature	unknown	Modern "theory": Jets, which emanate from star/disk system embedded deep within a dense core, "drive" outflows in momentum-conserving fashion.	•Dynamical time scale for jets and outflows is of order 10^5 years, but real time scale is hard to measure if jets are episodic. •Infall and Outflow likely occur simultaneously.

Symbols used in the table

K=total kinetic energy; $\mathbf{K}_{\text{thermal}}$ =thermal kinetic energy; $\mathbf{K}_{\text{non-thermal}}$=non-thermal kinetic energy; $\mathbf{K}^2 = \mathbf{K}_{\text{non-thermal}}^{\ 2} + \mathbf{K}_{\text{thermal}}^{\ 2}$

M=magnetic energy

G=gravitational potential energy

Notes: These numbers are only rough approximations. The "definitions" of various categories of clouds is somewhat arbitrary, and are often based primarily on how each type of cloud is observed. The "filling factor" for gas in any type of cloud may be quite low, so that calculating the mass of a cloud by substituting the density and size listed above into $M = 4\pi R^3 n m_{avg}/3$, where R is the size scale, and n is the number density of particles of mass m_{avg}, may overestimate true mass.

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