Kinematics of IRDCs

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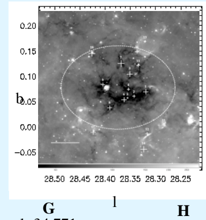
ABSTRACT: **Massive stars and star clusters are thought to form from the densest gas clumps within giant molecular clouds. These reveal themselves by absorption of the diffuse Galactic infrared background, appearing as Infrared Dark Clouds (IRDCs). Studies of IRDCs thus provide information on the initial conditions of massive star and star cluster formation. We study IRDC kinematics using the Galactic Ring Survey of 13CO(1-0) (Jackson et al. 2006). Here we first present properties of a small (nine) cloud sample, including maps of 8 micron intensity, 13CO-derived surface density, average line of sight velocity and momentum. In the dense central regions of the clouds, masses derived from 13CO are about a factor of 3 smaller than those derived from extinction, perhaps because of optical depth effects. We study the radial profiles of enclosed mass, projected rotation axis position angle and ratio of rotational to gravitational energy, beta. We also study a larger sample of 285 IRDCs identified by Simon et al. (2006). We measure the projected rotation axis position angle for each cloud at various radii and compare our results with those of Galactic GMCs (Phillips 1999) and M33 GMCs (Rosolowsky et al. 2003). We also measure beta for these clouds. We find a significant number of clouds rotating in a retrograde sense to the Galactic rotation, perhaps indicating that IRDC formation is driven by turbulent or cloud collision velocities that have been decoupled from Galactic shear, as in the model of Gammie et al. (1991) and Tan (2000).**

Small IRDC Sample

The GRS ^{13}CO(1-0) molecular line survey spans the inner Galaxy from l= 18°-55°. The line data has spectral resolution of 0.2 km/s and angular resolution of 46'' with a sampling of 22''. The ^{13}CO molecular line is a more accurate tracer of the column density of dense gas than the optically thick ^{12}CO line. However, the ^{13}CO line may also become optically thick in the densest gas. Below is a visual catalogue of all 9 clouds in the sample, Rathborne et al. (2006), including a 8μm GLIMPSE image, surface density map, local mean velocity map, linear momentum map, and radial profiles of ^{13}CO intensity mass, position angle, and rotational energy to gravitational energy. The radius, R_{cloud}, was defined as twice the average plane of sky core distance from the mean core position; which defines the cloud center. For example,right figure shows the circular size of cloud C with all the cores located inside of this boundary.



	A	B	C	D	E	F	G	H	I
l	18.882	19.271	28.373	28.531	28.677	34.437	34.771	35.395	38.952
b	-0.285	0.074	0.076	-0.251	0.132	0.245	-0.557	-0.336	-0.475
M_{ext}	251M_o	674M_o	33300M_o	6020M_o	16200M_o	1300M_o	1900M_o	712M_o	382M_o
M_{13CO}	183M_o	216M_o	4000M_o	1910M_o	2480M_o	243M_o	889M_o	345M_o	159M_o
M_v	3270M_o	2190M_o	32300M_o	13700M_o	642M_o	3000M_o	14600M_o	3540M_o	895M_o
R_{cloud}	6.28pc	1.78pc	7.74pc	10.6pc	10.6pc	2.36pc	1.81pc	5.69pc	2.06pc
R_{MSX}	8.2pc	3.0pc	13.6pc	NAN	10.6pc	3.5pc	1.6pc	6.8pc	3.4pc
PA	-4.08°	-42.8°	158°	102°	-134°	166°	-126°	108°	-104°

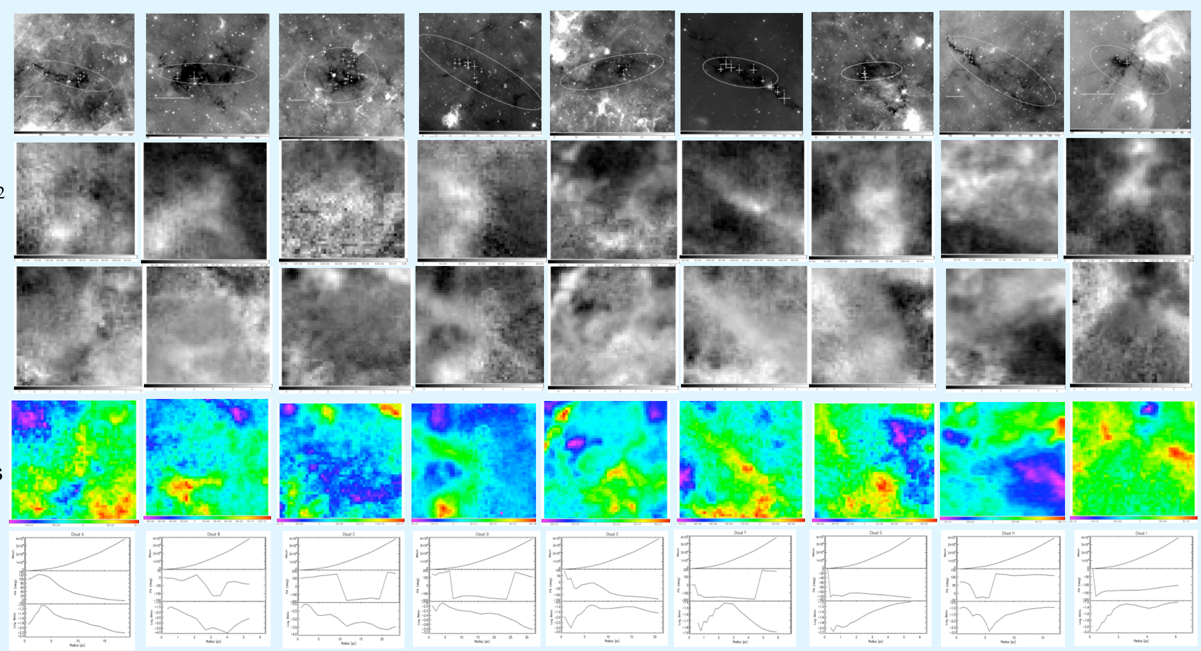
8μm GLIMPSE

Σ_{13CO}: g/cm^2

v: km/s
mean velocity between ±15 km/s

Σ_{13CO}v: M_o km/s

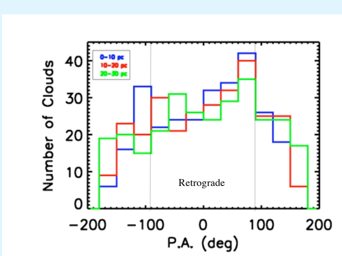
Radial Profiles



Large IRDC Sample

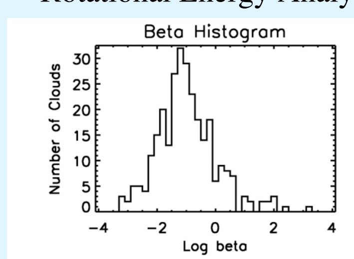
285 Clouds

Direction of Cloud Rotation



Above shows a histogram of position angles defining the direction of cloud rotation projected on the plane of the sky. Using a K-S test we find that our data has a ~4% probability relation with Rosolowsky et al (2003) on the scale of ~20 pc in M33. Also, there is a ~22% probability relation with Phillips et al. on the scale of ~50 pc (1999)

Rotational Energy Analysis



Above is a histogram of β, defined as the ratio of rotational energy to gravitational energy, with bins of dex 0.2° for our large sample at one R_{cloud}. Our analysis peaks at 0.06. This is near agreement with Goodman et al. (1993) with 0.02.

References:
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