The Interstellar Medium and Star Formation Process in the Andromeda Galaxy

Andreas Schruba
Max-Planck-Institut für extraterrestrische Physik
The CARMA Survey of Andromeda

Today’s largest (0.1 deg²) Interferometric Survey of CO(1-0) on Cloud Scale (20 pc x 1 km/s)
1. Where is the Molecular Gas in a ‘normal’ Spiral?

2. What are the Properties of Molecular Clouds?

3. Is there Concordance of Cloud Properties?
Where is the Molecular Gas in a Spiral?

... a 3D cloud-scale view of CO(1-0) in Andromeda

SCHRUBA+ (IN PREP)
Where is the Molecular Gas in a Spiral?

... a 2D cloud-scale view of CO(1-0) in Andromeda

SCHRUBA+ (IN PREP)
Where is the Molecular Gas in a Spiral?

... PDFs of CO Pixel Brightness

~ 0.23 dex  Log width ~ 0.26 dex  ~ 0.33 dex

Most emission at low intensity (signal-to-noise) and thus often missed.

Hughes+13; Gratier+12

Data at Common Resolution of 50 pc x 5 km/s
A Thick Disk of (diffuse) Molecular Gas

M31: cumulative emission around local HI velocity

76% of flux within ~40 km/s ⇒ LOS dispersion ~18 km/s ... but M31 highly inclined

Velocity Dispersion of HI and CO in 12 spirals at low inclination

Line Width of HI and CO comparable => Evidence for thick disk of diffuse H$_2$
Mass Spectrum of Molecular Clouds

... as described by truncated power-law

Cloud mass spectrum steeper in low-density then high-density environments, ... but cloud samples contain only ~50% of total mass, rest in diffuse phase

Colombo+13; Gratier+12; Wong+11; Rosolowsky+05; Heyer+01
Surface Density of Molecular Clouds

... mass vs. radius for Milky Way and nearby SF galaxy clouds

![Graph showing surface density vs. radius for different types of galaxies and molecular clouds.](image)
Turbulence of Molecular Clouds

... line width vs. radius for Milky Way and nearby SF galaxy clouds
Turbulence of Molecular Clouds

... concordance of properties (ie offsets) of neighboring clouds?
Concordance of Cloud Properties?

avg cloud properties ($\sigma^2/l$) for neighboring clouds

500 pc
Concordance of Cloud Internal Properties?
Concordance of Cloud-to-Cloud Motions?

Median: 2.44 km/s
Mad: 5.80 km/s

Non-Circular Velocity [km/s]

-15.0 -12.5 -10.0 -7.5 -5.0 -2.5 0.0 2.5 5.0 7.5 10.0 12.5 15.0

Right Ascension

00°45'15"
0°
44°45'
30°
Concordance of Cloud-to-Cloud Motions?
A Short Summary

1. Evidence of diffuse molecular gas in thick disk
2. Molecular Clouds don’t have uniform properties
3. Neighboring Clouds have uncorrelated properties