

The dynamics and star-forming potential of the massive Galactic centre cloud G0.253+0.016

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The Galactic Centre Infrared Dark Cloud G0.253+0.016



Credit: Hubblesite

The Galactic Centre Infrared Dark Cloud G0.253+0.016

Projected 45pc from the Galactic Centre

Cold dust temperature: ~18 - 30 K

Dense: 2 x 10⁴ - 6 x 10⁵ cm⁻³

High mass: $0.8 - 7 \times 10^5 M_{sun}$

However... minimal evidence for ongoing star formation



Longmore+ 2012

SMA and IRAM 30m Observations



 $\nu \sim 218.9$ and 230.9 GHz (1.3 and 1.37mm) Angular resolution ~4 x 3" (~0.15 pc) Spectral resolution: 1.1 kms⁻¹ Line **and** Continuum observations



 $\nu ~\sim 217.3$ and 233.0 GHz Angular resolution $\sim 12''$ ($\sim 0.5~pc$) Spectral resolution: 0.3 kms^{-1} Line observations

The density structure of G0.253+0.016



SMA 230.9 GHz or 1.3mm dust continuum emission

Combined SMA and scaled SCUBA 450 μm dust emission

Column density PDF



PDF has no power-law tail No indication of gravitational collapse or star formation

Column density threshold for star formation

Is there a density threshold for star formation which applies to all clouds? (e.g. Lada+2010, Heiderman+2010)

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G0.253+0.016 should produce ~40 YSOs with >15 M_{sun} which are not observed (see Kauffmann+2013)

Can turbulence explain SFR~0?

Virial Mass:
$$M_{\rm vir} = \frac{5R\sigma_v^2}{G\alpha_{\rm vir}}$$

For a bound cloud or core with radius R: $N_{th} \propto M_{vir}/R^2 \propto \sigma_v^2$

Can turbulence explain SFR~0?

Scaled threshold column density by ratio of σ_v^2 :

$$N'_{th} = N_{th} \left(\frac{\sigma_{\rm Brick}}{\sigma_{\rm Gal.disk}}\right)^2 - \frac{14 \text{ km/s}}{2.5 \text{ km/s}}$$
$$N'_{th} = 0.75 \text{ g cm}^{-2}$$

But still expect 10 YSOs >15 $M_{sun}!$

Can turbulence explain SFR~0?

Scaled threshold column density by ratio of σ_v^2 :

$$N'_{th} = N_{th} \left(\frac{\sigma_{\text{Brick}}}{\sigma_{\text{Gal.disk}}} \right)^2 \underbrace{\sim}_{2.5 \text{ km/s}} 14 \text{ km/s}}_{2.5 \text{ km/s}}$$

But still expect 10 YSOs >15 $M_{sun}!$

Other aspects... background/average density, evolution?

SMA Detected Lines



Detected lines:

SiO, CH₃OH, HNCO, SO – Shock tracers 12 CO, 13 CO, C¹⁸O – Diffuse gas tracers H₂CO – Dense gas tracer, temperature probe

Temperature from H₂CO



 $n \sim 10^4 - 10^5 \text{ cm}^{-3}$ T ~ 100s of K

(see Mills & Morris 2013 and Rodriguez-Fernandez+2001)



Evidence for Cloud Collisions





Black: CH₃OH Green: ¹³CO

Evidence for Cloud Collisions





Black: CH₃OH Green: ¹³CO

Evidence for Cloud Collisions

Black: CH₃OH Green: ¹³CO



Are super star clusters formed by cloud collisions? (Fukui+ 2013, Higuchi+2014)



log density