The Magnetic Field in the Star-Forming Regions of the Perseus Molecular Cloud

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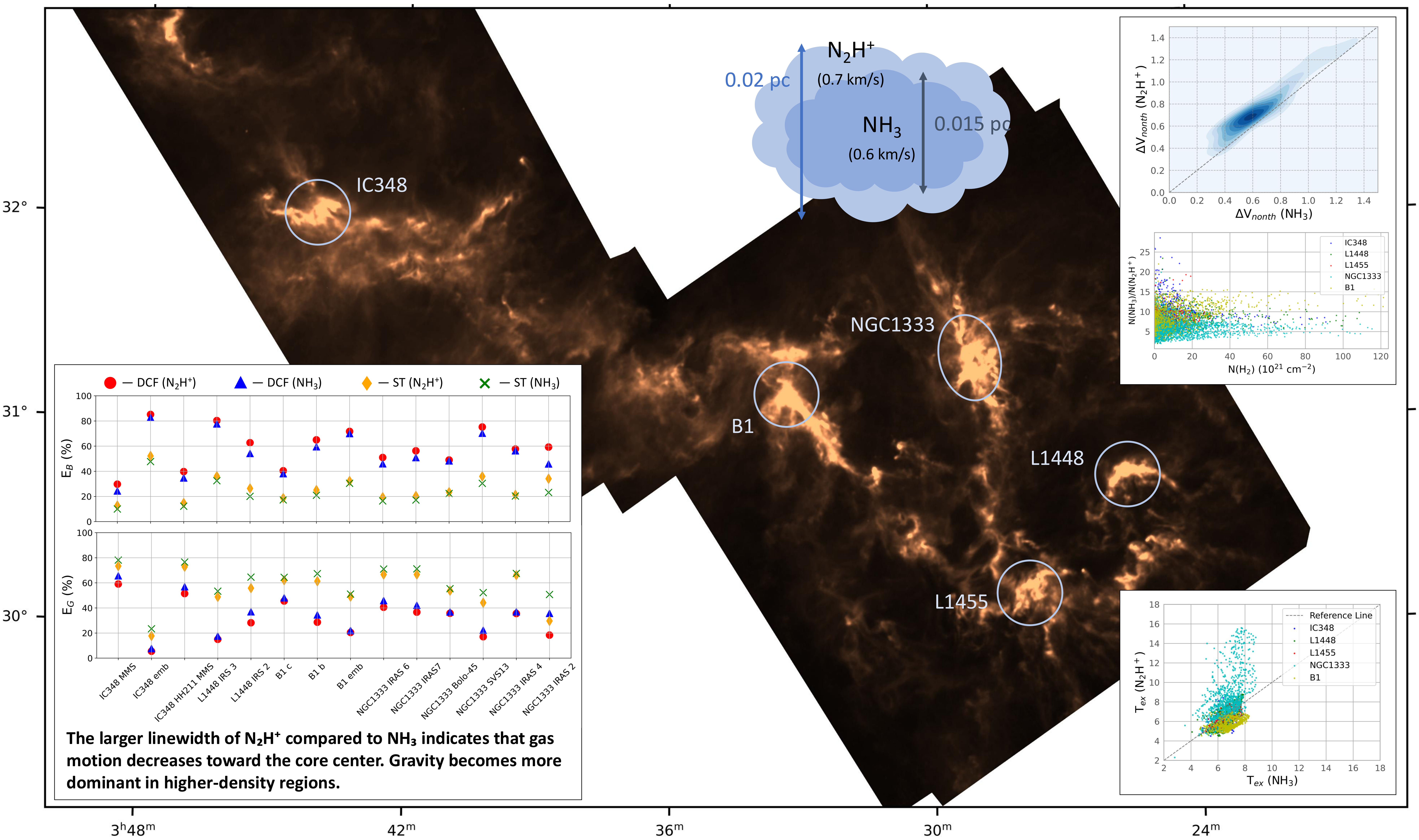
Abstract

We estimated the magnetic field strength in the star-forming regions IC348, L1448, L1455, NGC1333, and B1 within the Perseus molecular cloud using the Davis-Chandrasekhar-Fermi (DCF) method and modified approaches. The plane-of-sky magnetic field strengths calculated with the DCF method were consistently higher than those obtained using the modified methods. We also calculated the mass-to-flux ratio, which transitions from subcritical in filaments to supercritical in cores. To assess the relative importance of magnetic fields, gravity, and turbulence, we estimated the magnetic, gravitational, and kinetic energies of the cores. Comparing the distributions of NH_3 and N_2H^+, we found that NH_3 traces denser core regions. Moreover, the energy fractions show that gravitational energy is higher in these NH_3-traced regions. **These findings align with the ambipolar diffusion model, suggesting that magnetic fields weaken while gravity becomes increasingly dominant toward the core centers.**



The larger linewidth of N_2H^+ compared to NH_3 indicates that gas motion decreases toward the core center. Gravity becomes more dominant in higher-density regions.

Plane-of-sky Magnetic Field Strength

Calculate the magnetic field strength by DCF (Davis 1951; Chandrasekhar & Fermi 1953) and ST methods (Skalidis & Tassis 2021):

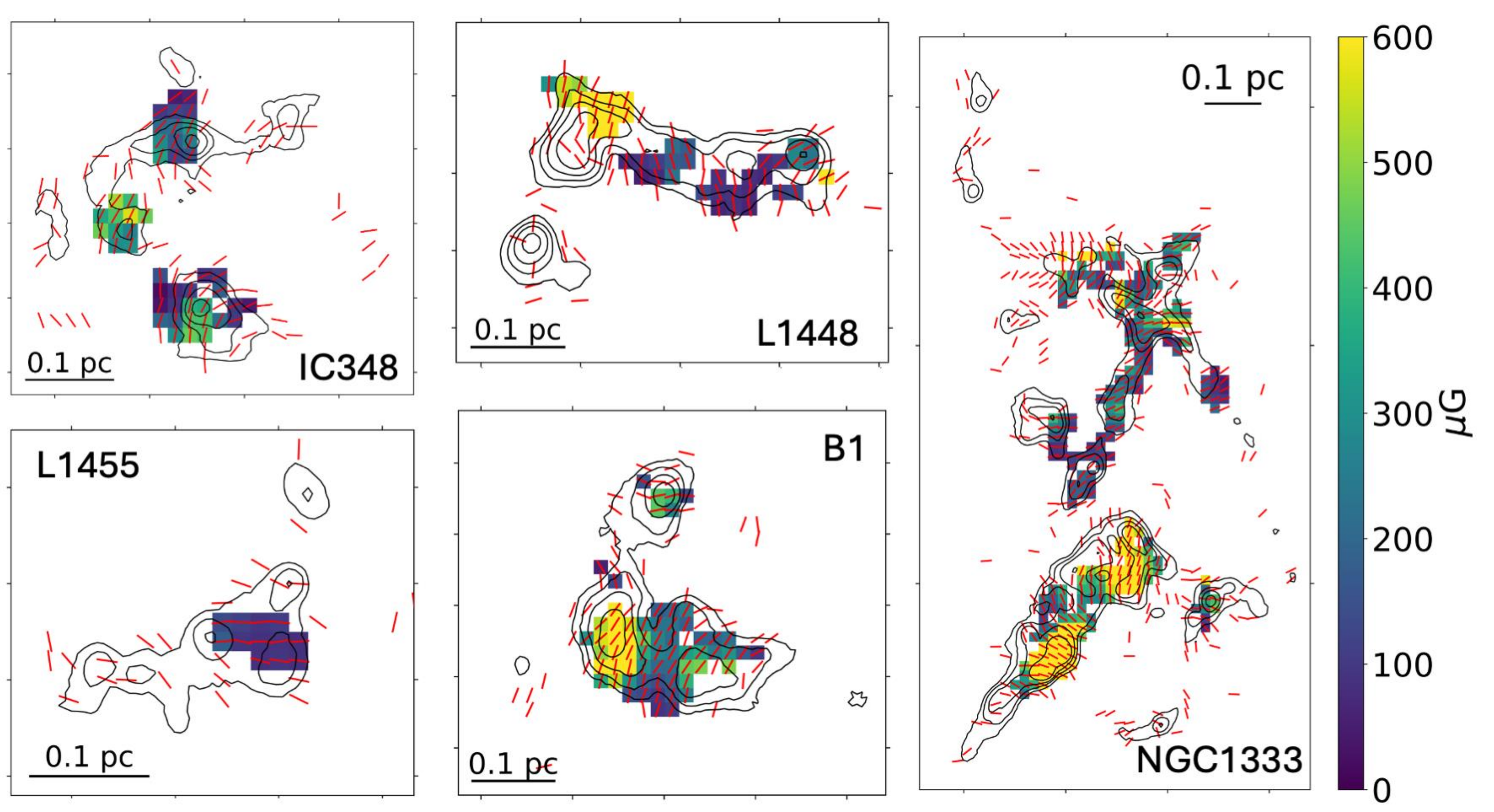
$$B_{pos} = Q\sqrt{4\pi\rho}\frac{\sigma_v}{\sigma_\theta} \approx 9.42\sqrt{n(H_2)}\frac{\Delta V}{\sigma_\theta} \quad (DCF)$$

$$B_{pos} = \sqrt{4\pi\rho}\frac{\sigma_v}{\sqrt{\sigma_\theta}} \approx 1.76\sqrt{n(H_2)}\frac{\Delta V}{\sqrt{\sigma_\theta}} \quad (ST)$$

Based on the numerical simulations, Chen et al. (2022) proposed that the peak of the $B_{pos,\,DCF}$ distribution in log space can better represent the magnetic field strength.

- **Angular dispersion** measured from 850 μm polarization data observed by JCMT
- **Velocity dispersion** measured from NH_3 (1,1) observed by GBT and N_2H^+ J=1-0 observed by NRO

		unit	IC348	L1448	L1455	NGC1333	B1
N_2H^+	$B_{DCF,pos}$	μG	302 ± 37	422 ± 69	169 ± 31	618 ± 42	402 ± 34
	$B_{ST,pos}$	μG	127 ± 13	158 ± 16	88 ± 13	240 ± 12	171 ± 12
	B_{peak}	μG	-	-	-	203	252
NH_3	$B_{DCF,pos}$	μG	245 ± 127	317 ± 150	106 ± 46	508 ± 199	349 ± 137
	$B_{ST,pos}$	μG	103 ± 38	120 ± 28	55 ± 12	199 ± 40	149 ± 30
	B_{peak}	μG	125	-	-	202	194



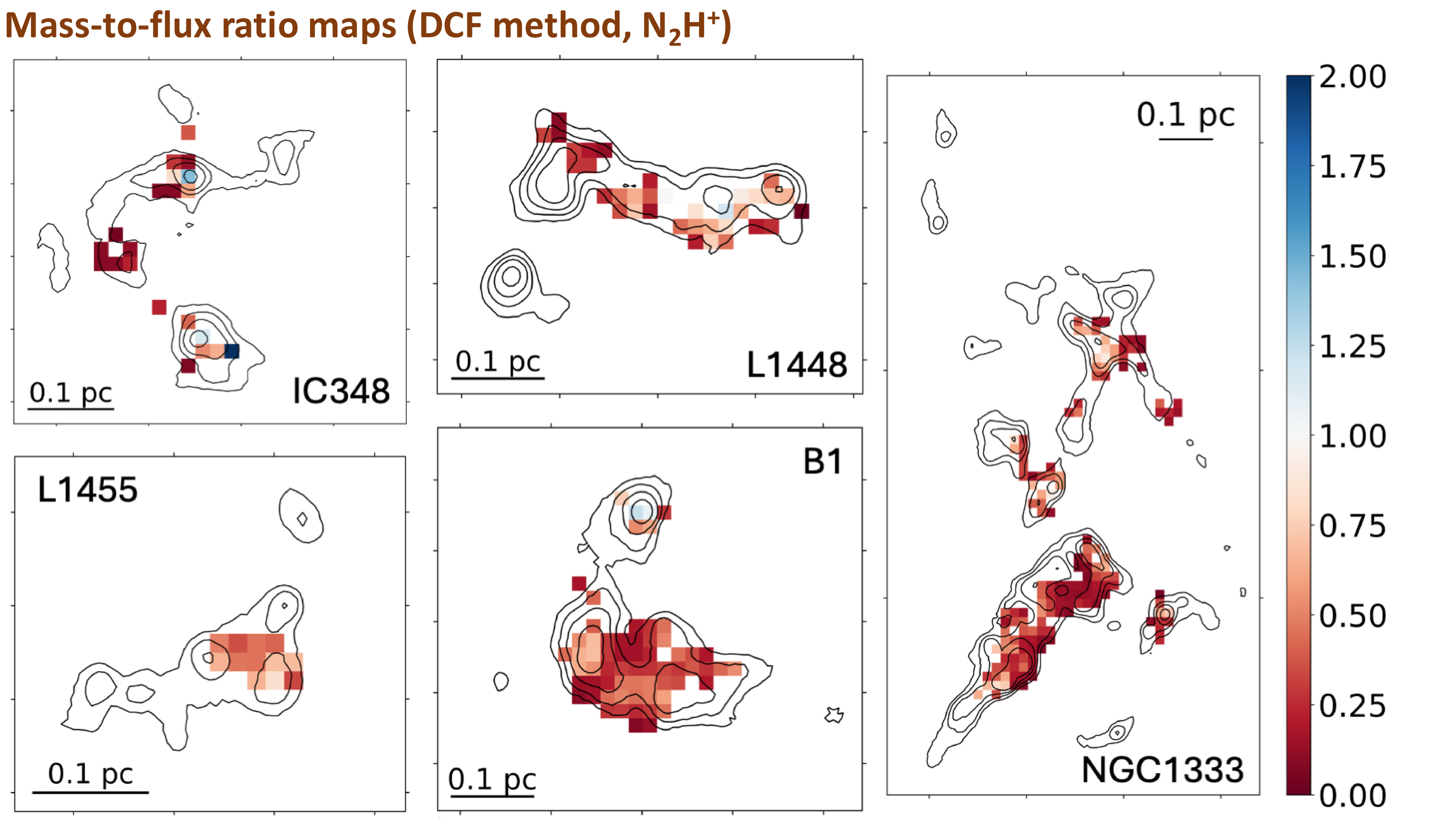
Mass-to-Flux Ratio

The mass-to-flux ratio (Crutcher, 2004): $\lambda \equiv \frac{(M/\Phi)_{obs}}{(M/\Phi)_{crit}} = 7.6 \times 10^{-21}\frac{N(H_2)}{B}$

$\lambda < 1$ → magnetically subcritical → magnetic pressure can support the cloud

$\lambda > 1$ → magnetically super-critical → gravitational collapse

Mass-to-flux ratio maps (DCF method, N_2H^+)



Mass-to-flux ratio maps (DCF method, NH_3)