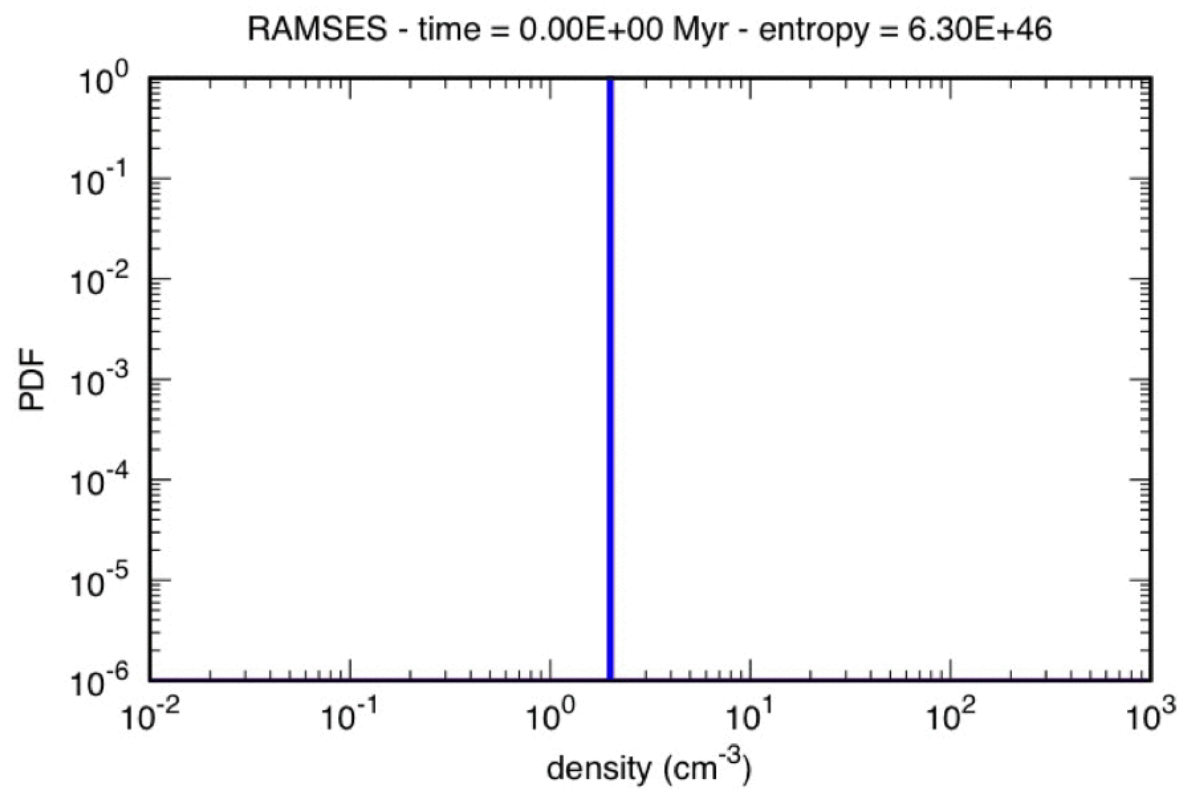
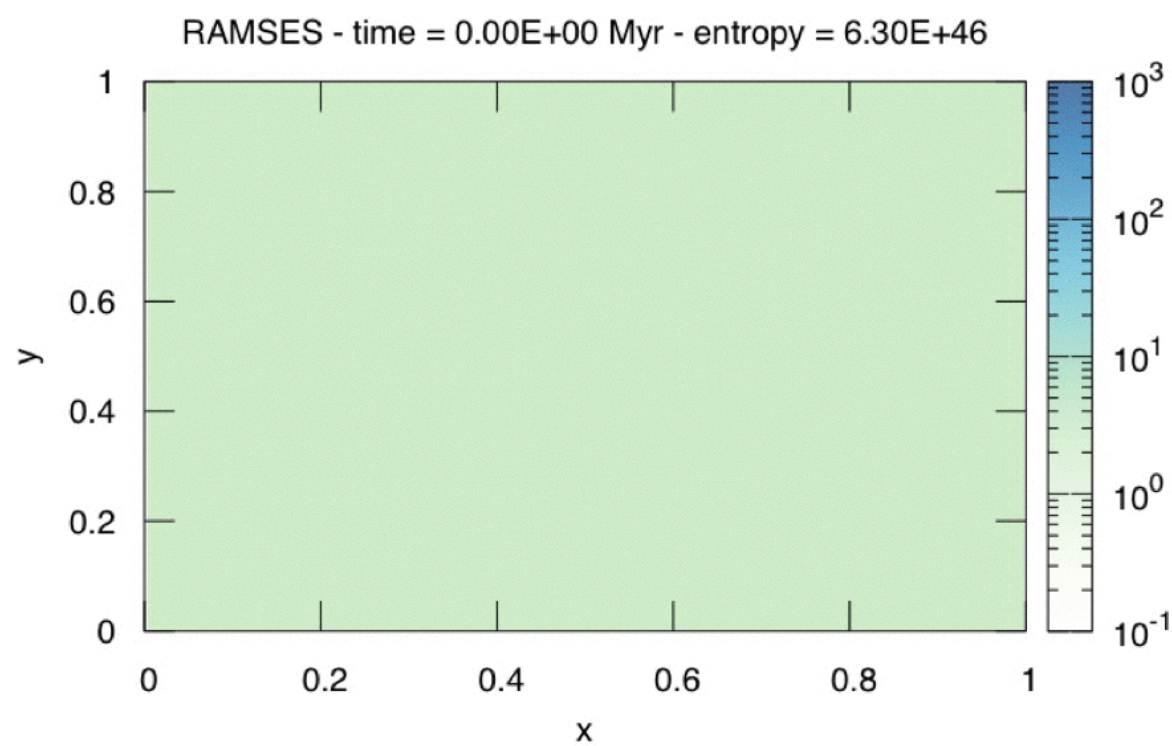
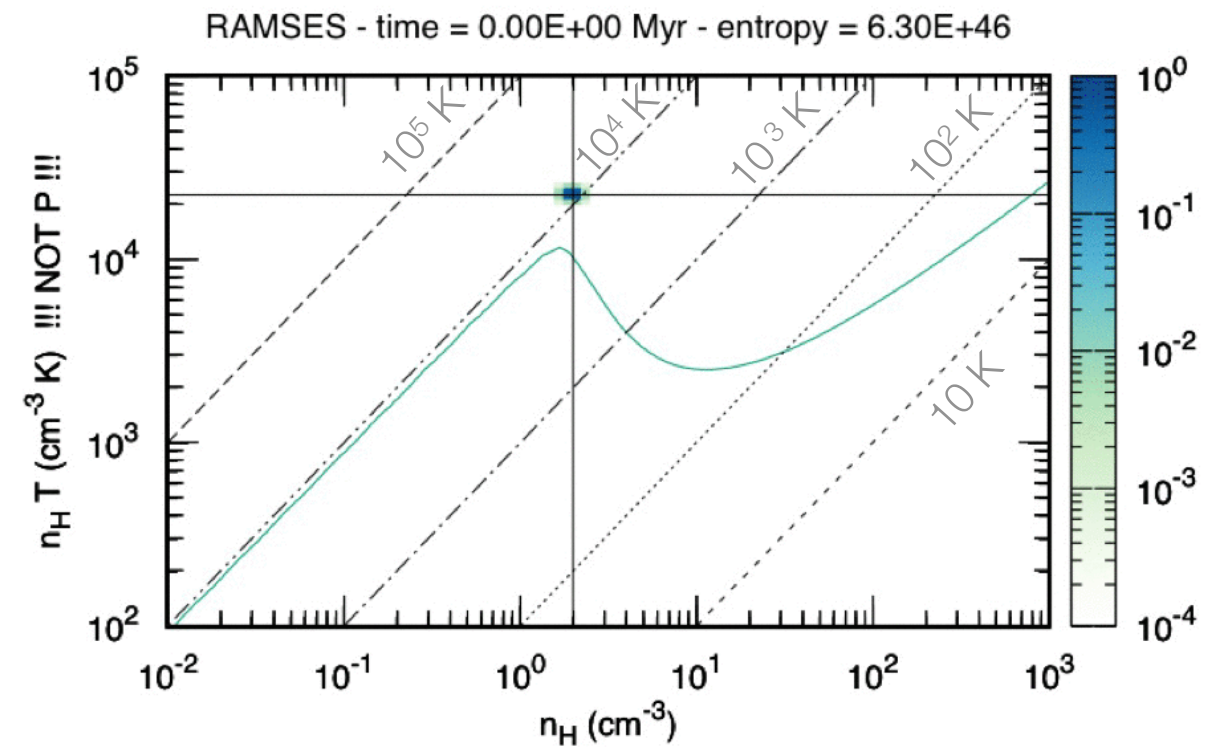
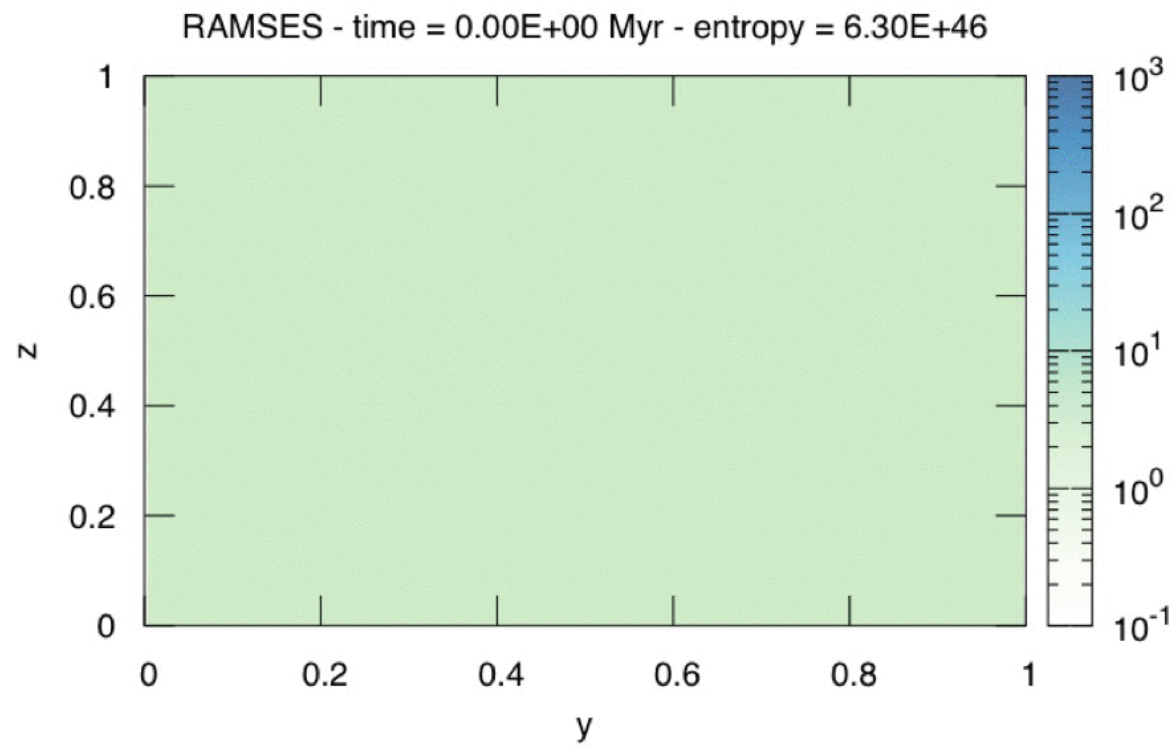


Modeling shocks in the WNM

B. Godard, F. Boulanger,
A. Lehmann, G. Pineau des Forêts

Thermal instability and turbulence



Goals

- physics of interstellar shocks in the context of phase transition
Warm Neutral Medium (WNM) → Cold Neutral Medium (CNM)
- parametric study : magnetic field, velocity, density
- study out-of-equilibrium effect, recombination scales
- observable quantities ?
Faraday rotation, H α emission
[Bracco et al. \(2020\)](#)

Numerical method

Paris-Durham shock code

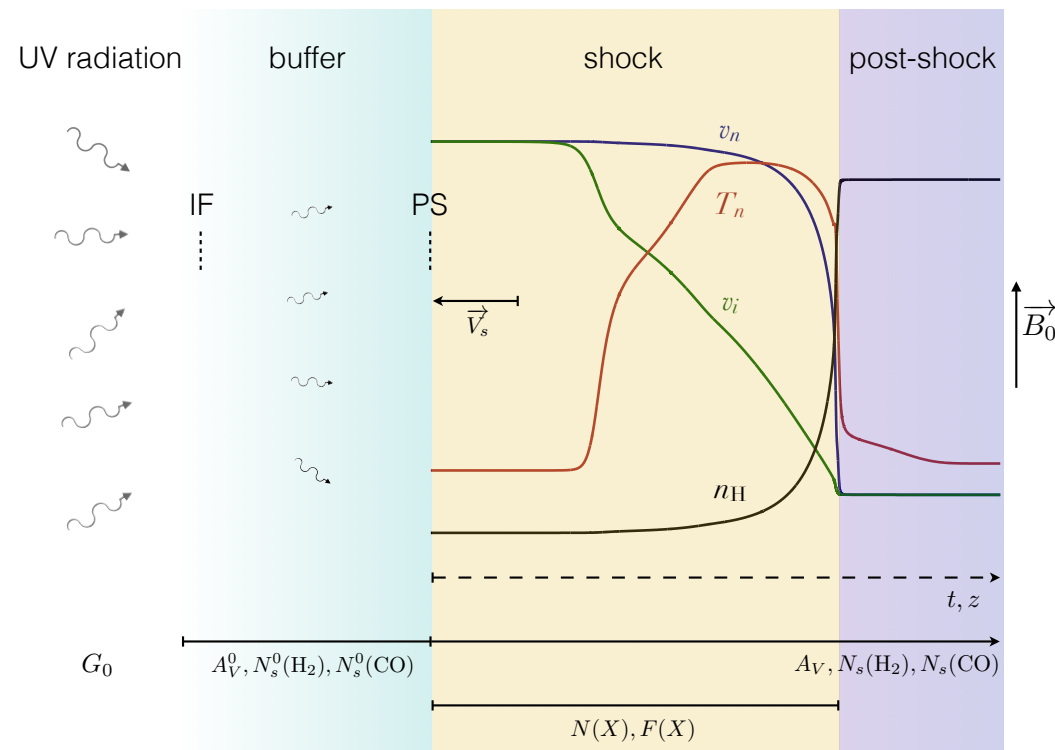
- steady-state shocks
- 1D plane parallel geometry
- ultraviolet radiative transfer
- treatments of microphysical processes
dust, chemistry, pumping

standard model

- J-type shock
- $V_S = 50 \text{ km s}^{-1}$
- $n_H = 0.3 \text{ cm}^{-3}$ [Wolfire et al. \(2003\)](#)
- $G_0 = 1$ [Mathis et al. \(1983\)](#)
- $B_0 = 1 \text{ } \mu\text{G}$ [Frick et al. \(2001\)](#)

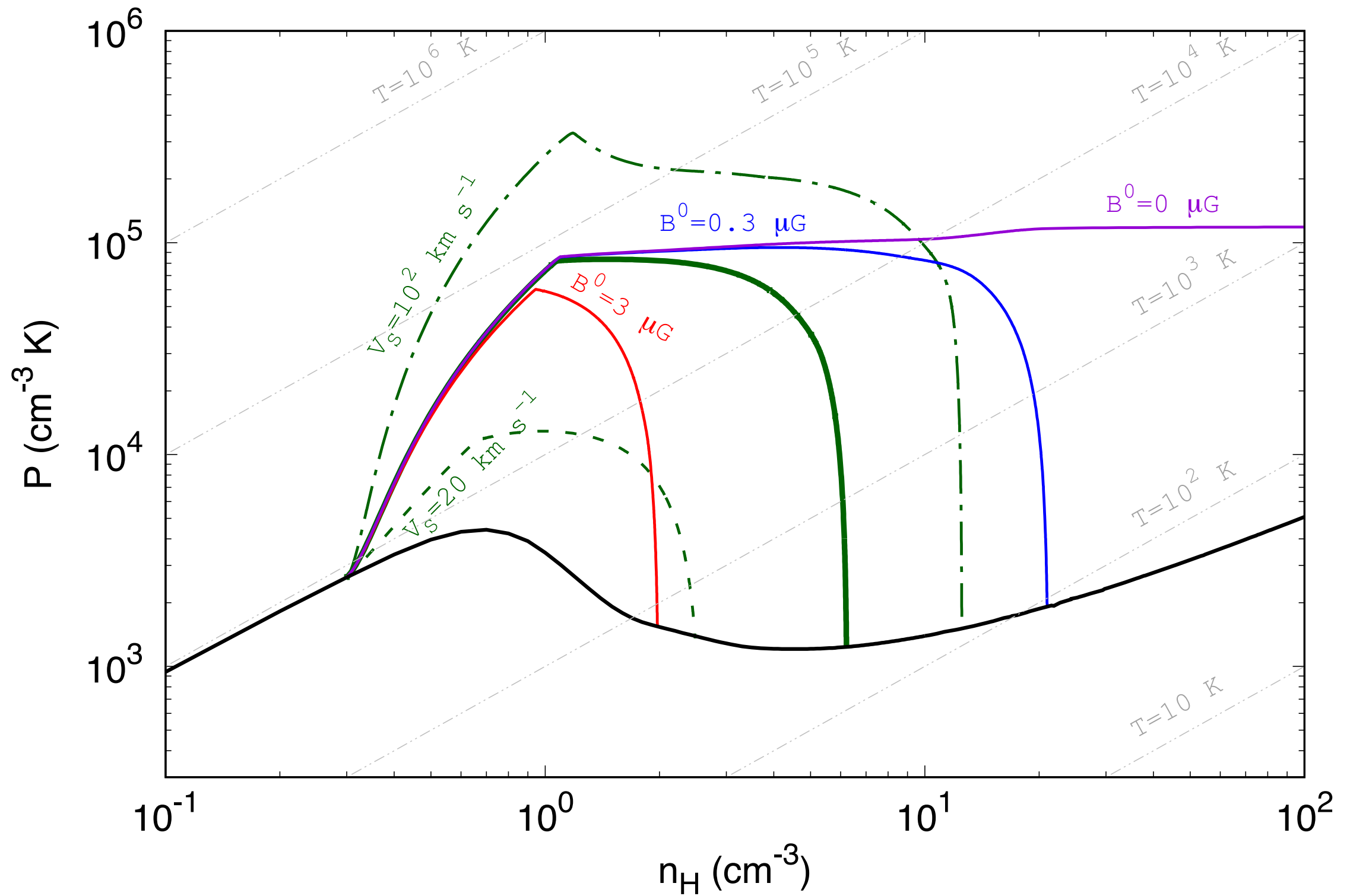
grid of models

- $n_H = 0.05 - 1 \text{ cm}^{-3}$
- $B_0 = 0.1 - 10 \text{ } \mu\text{G}$
- $V_S = 10 - 100 \text{ km s}^{-1}$

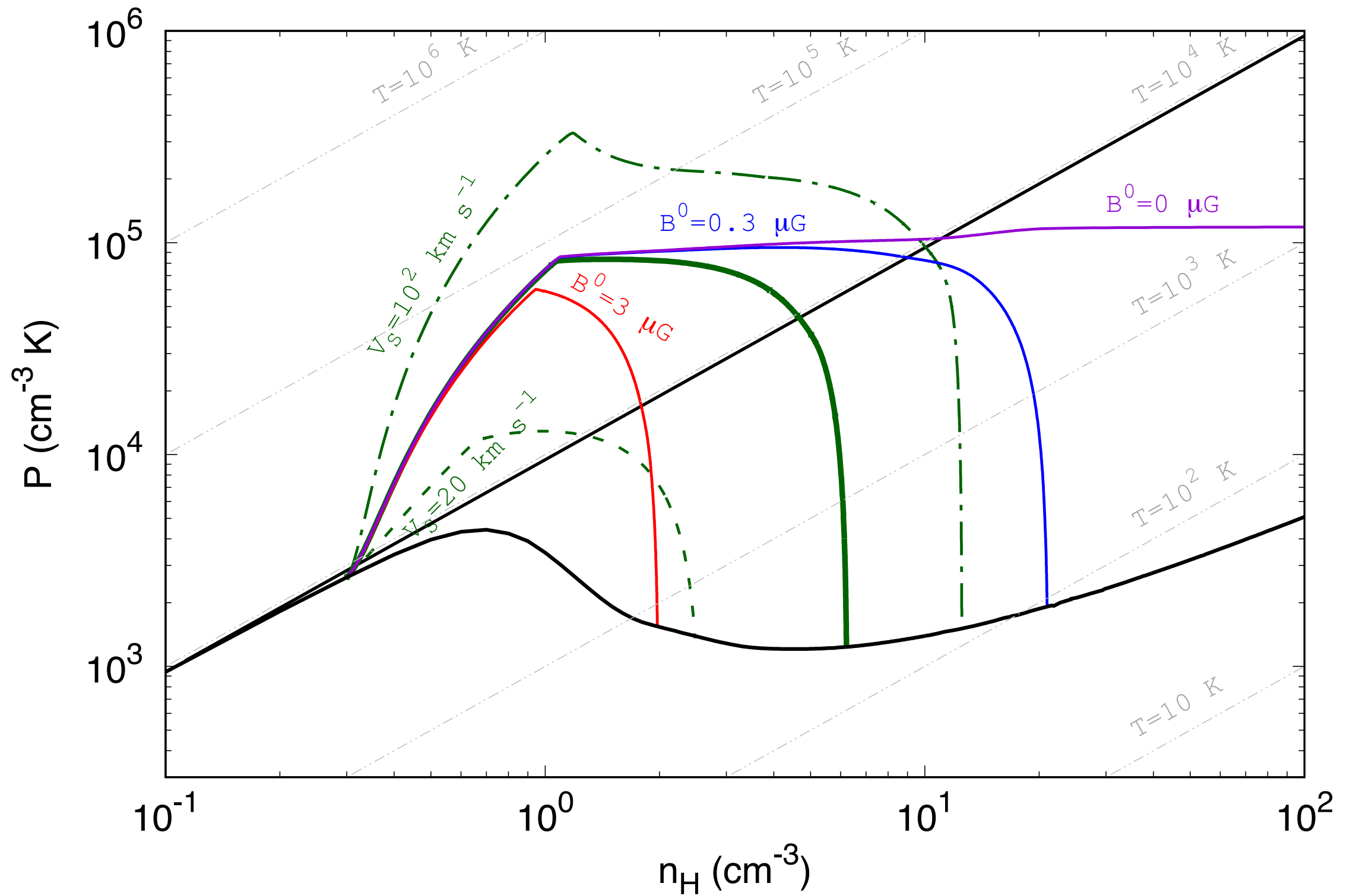


[Godard et al. \(2019\)](#)
[Tabone et al. \(2020\)](#)
[Lehmann et al. \(2020\)](#)

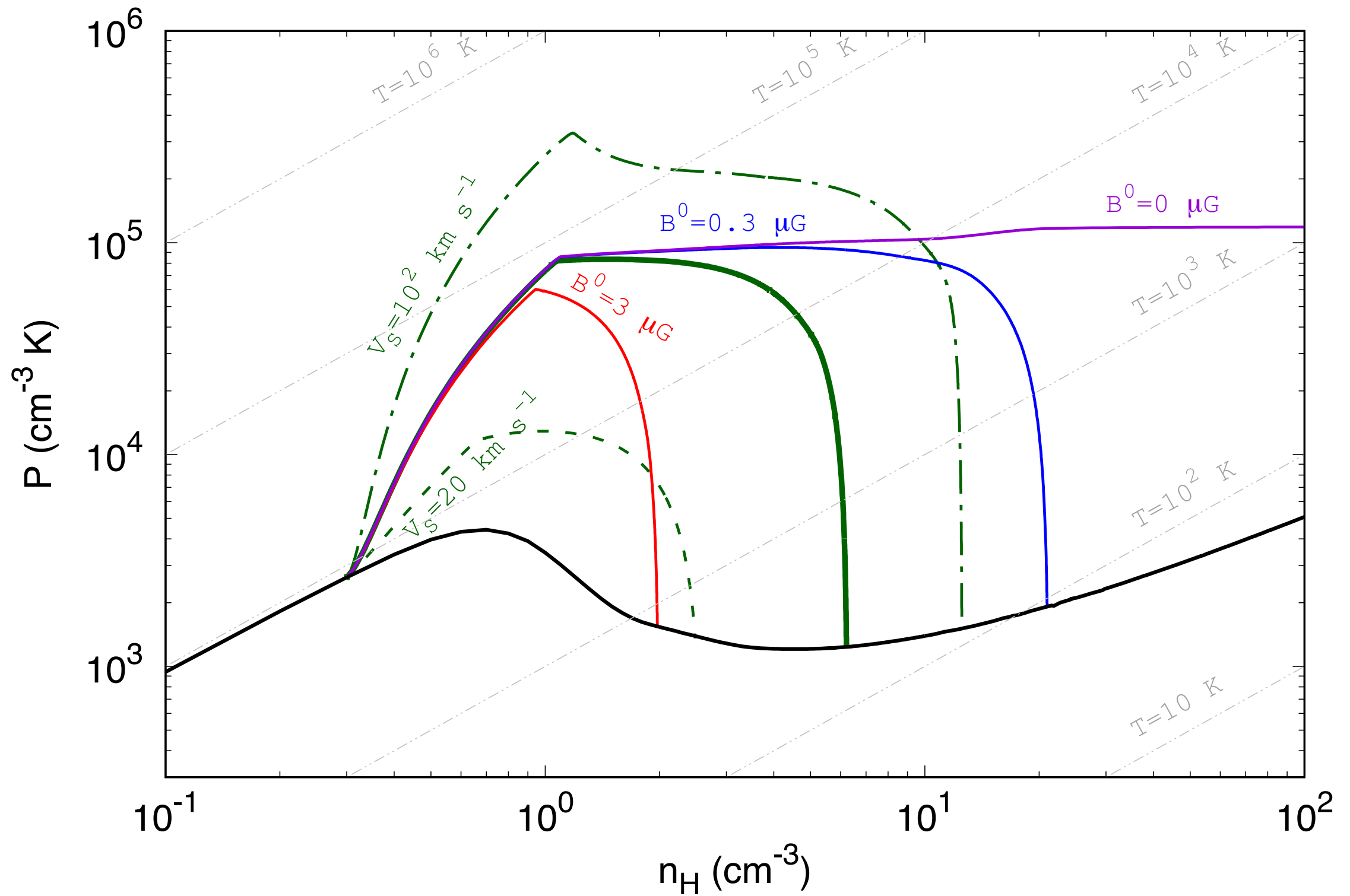
Trajectories of WNM shocks



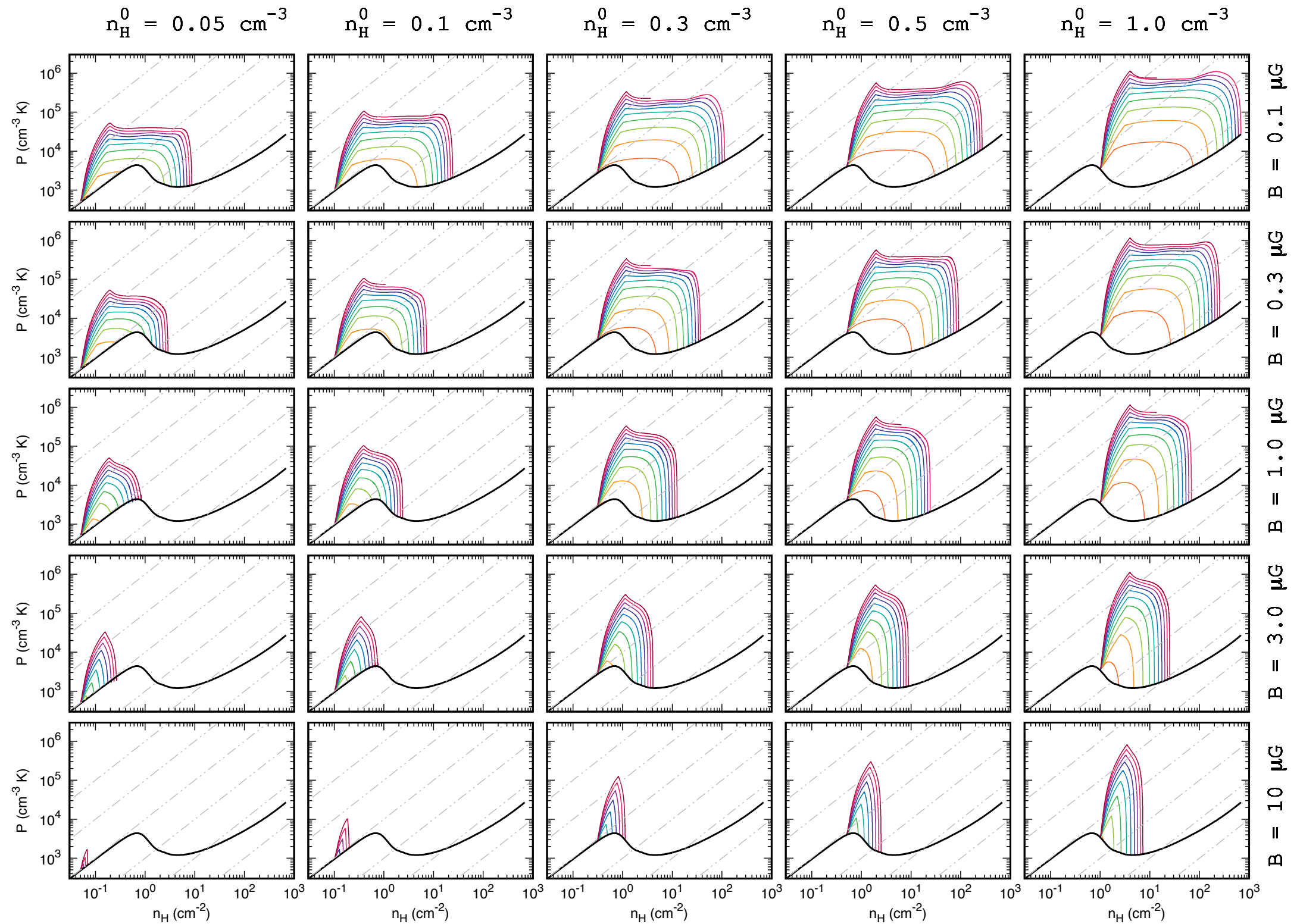
Trajectories of WNM shocks



Trajectories of WNM shocks

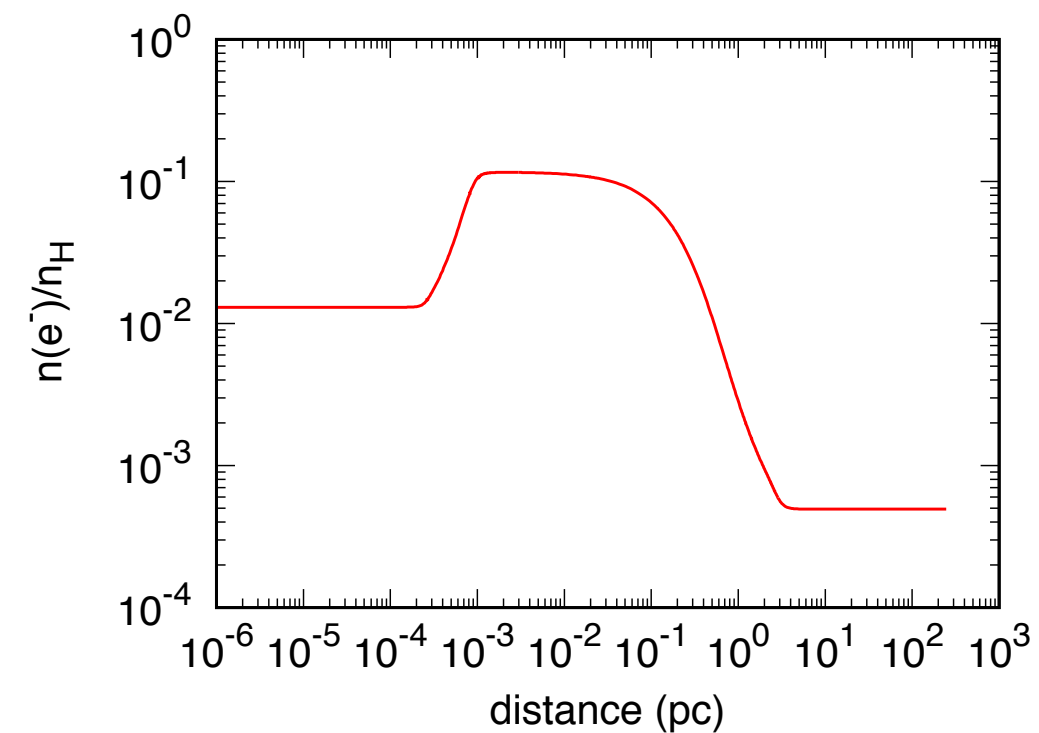
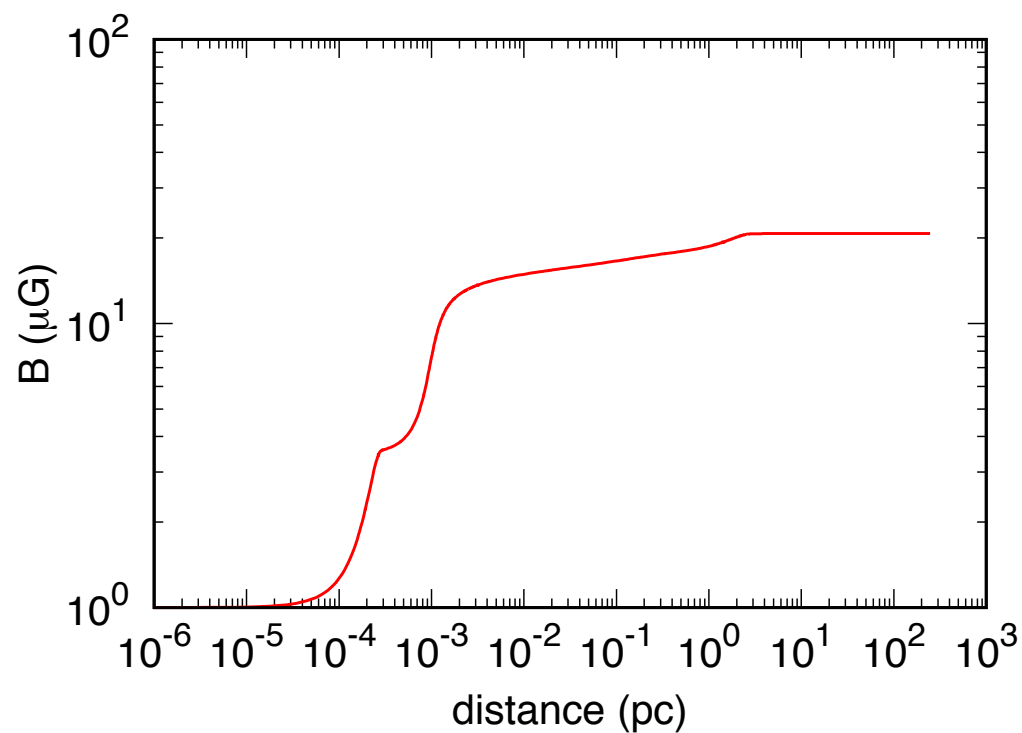
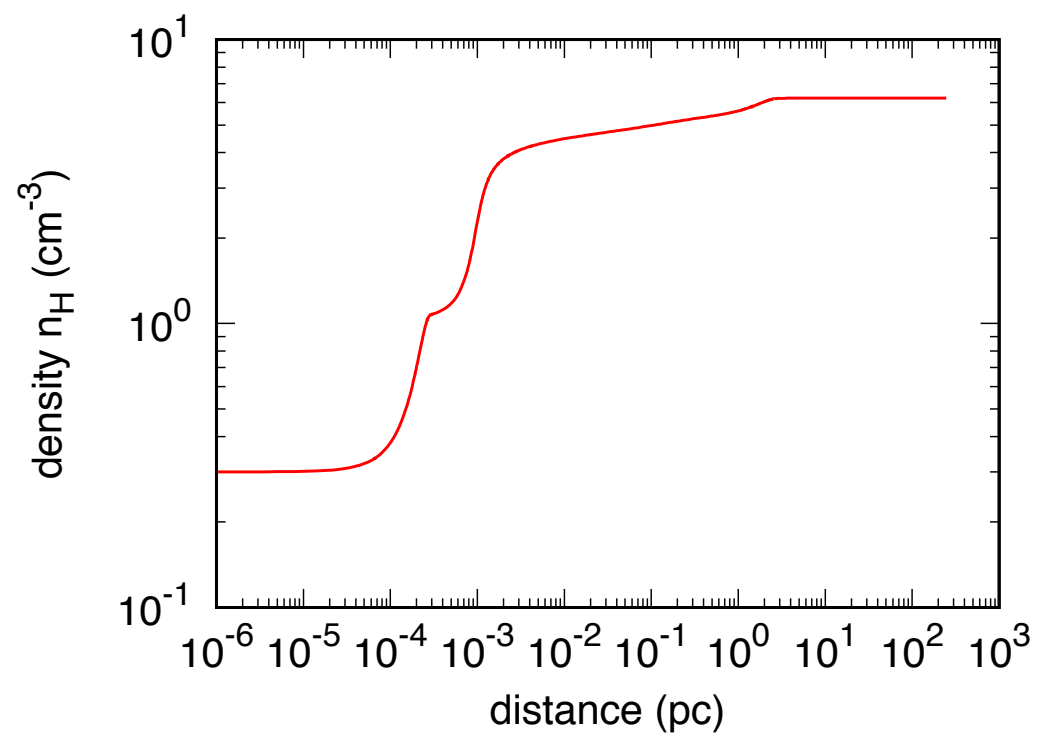
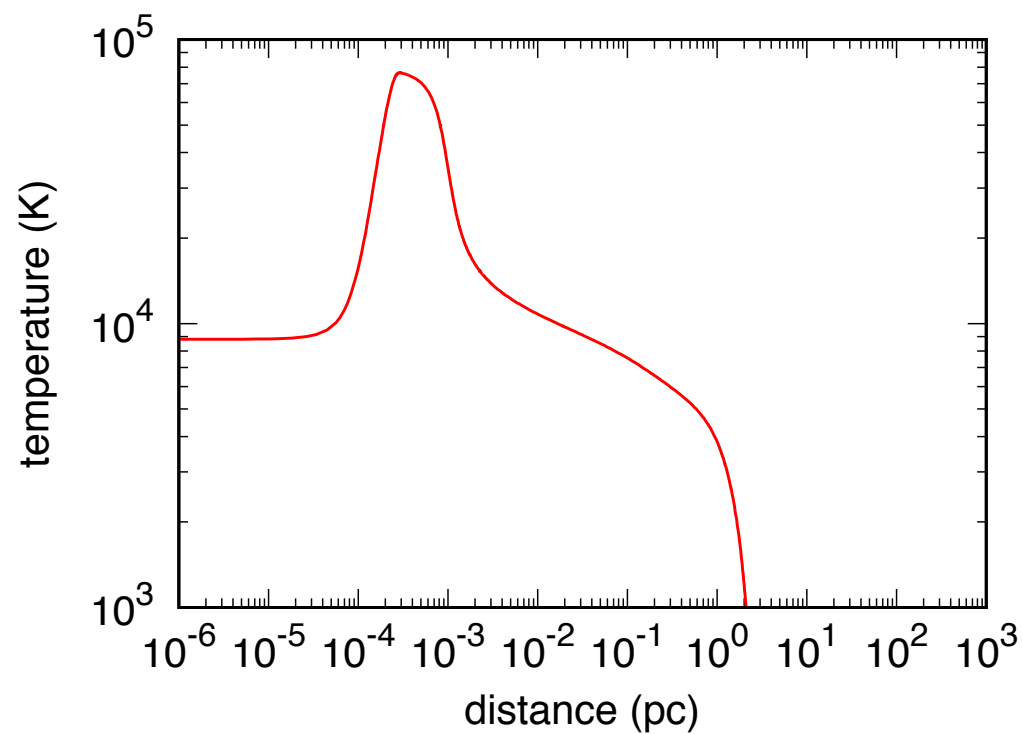


Trajectories of WNM shocks



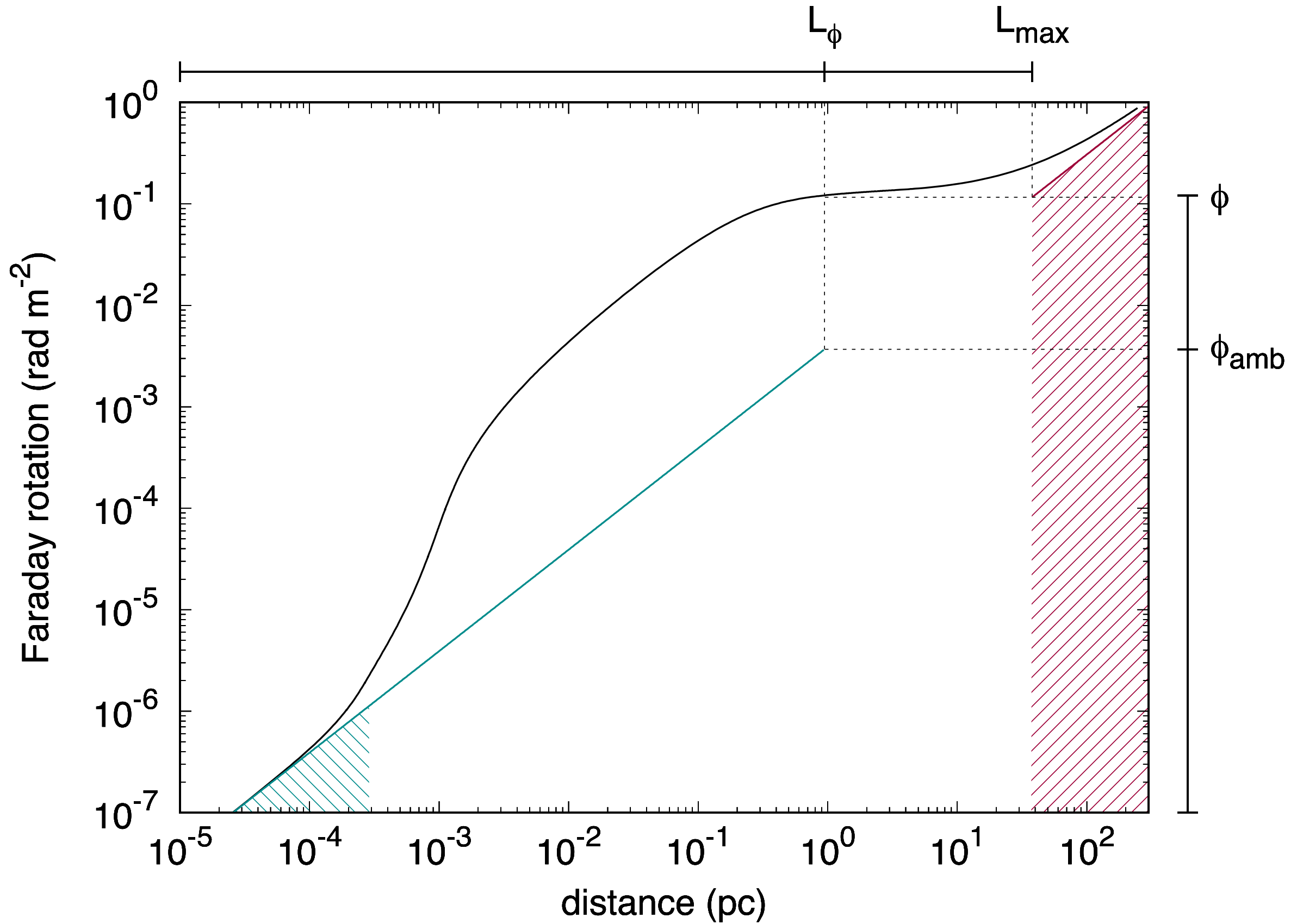
phase transition \longrightarrow $V_S \geq 40 \text{ km s}^{-1} \left(\frac{B^0}{1 \mu\text{G}} \right) \left(\frac{n_{\text{H}}^0}{0.3 \text{ cm}^{-3}} \right)^{-3/2}$

Shock profiles

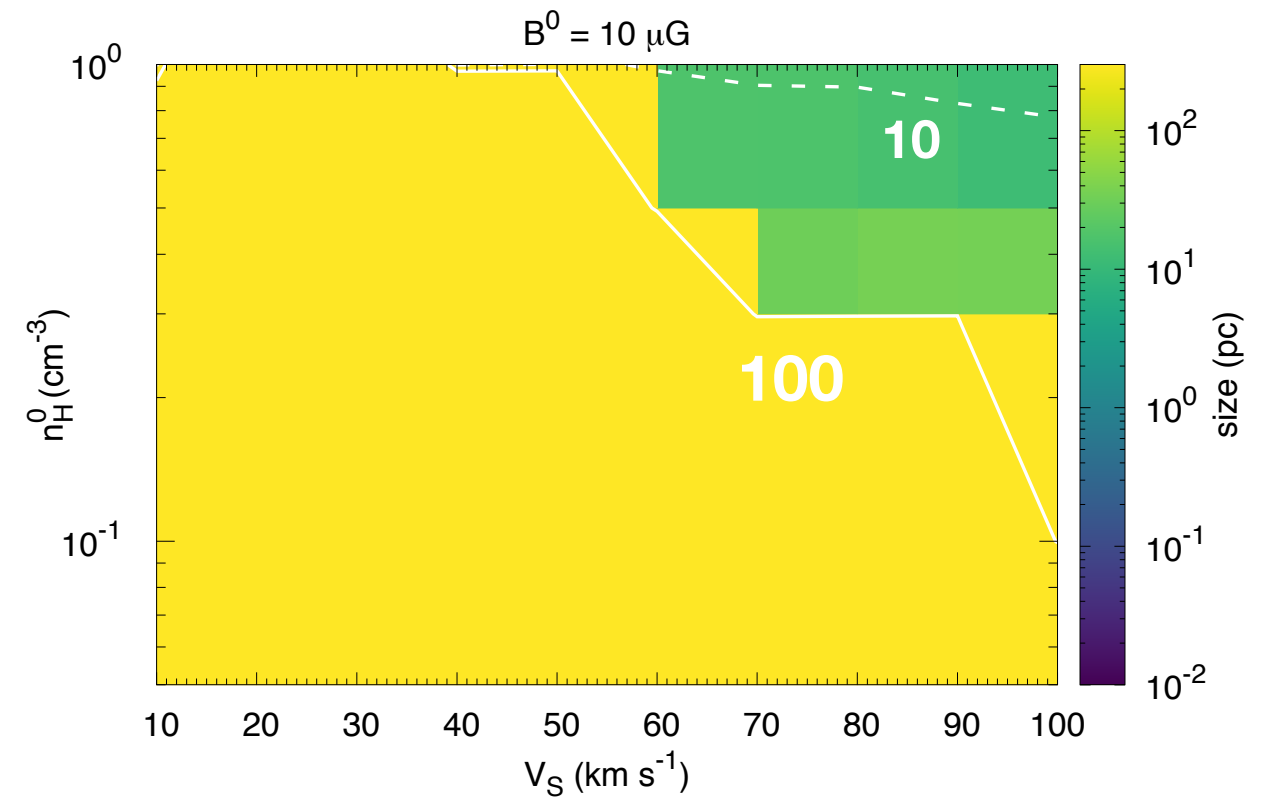
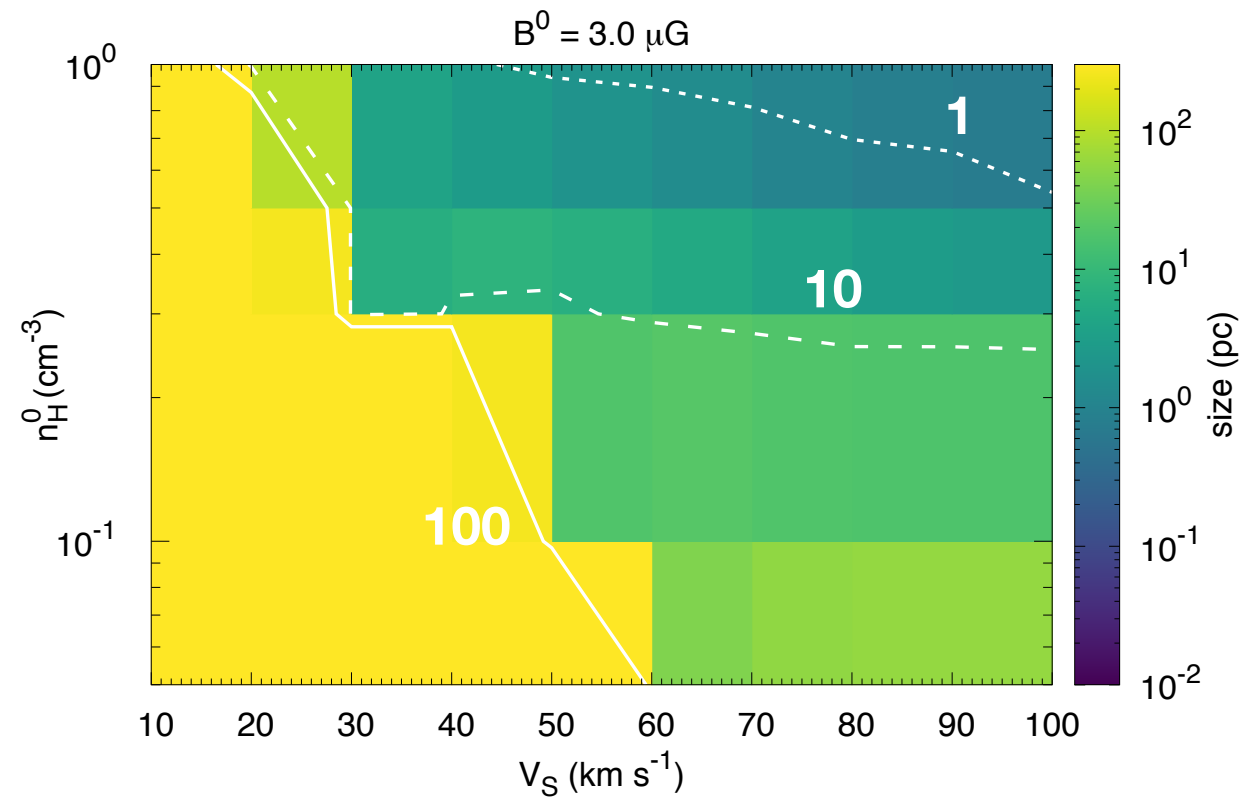
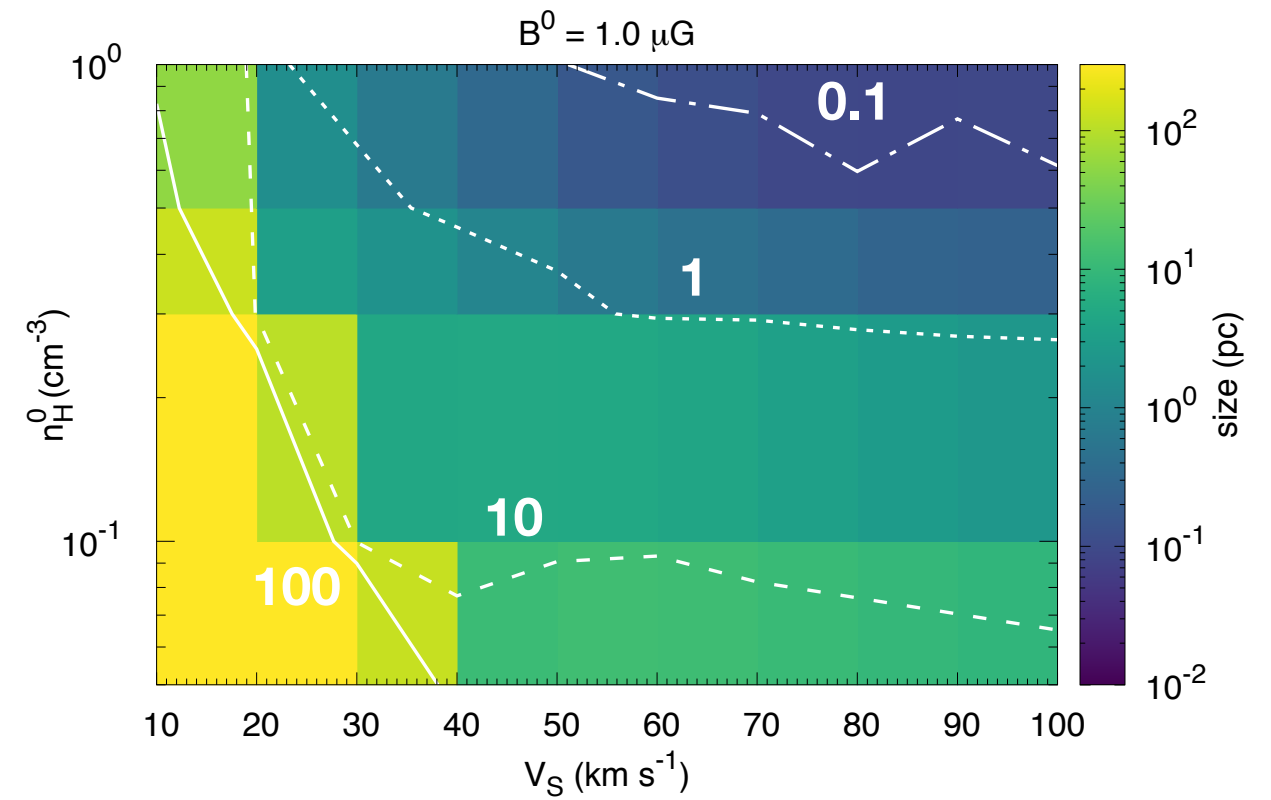
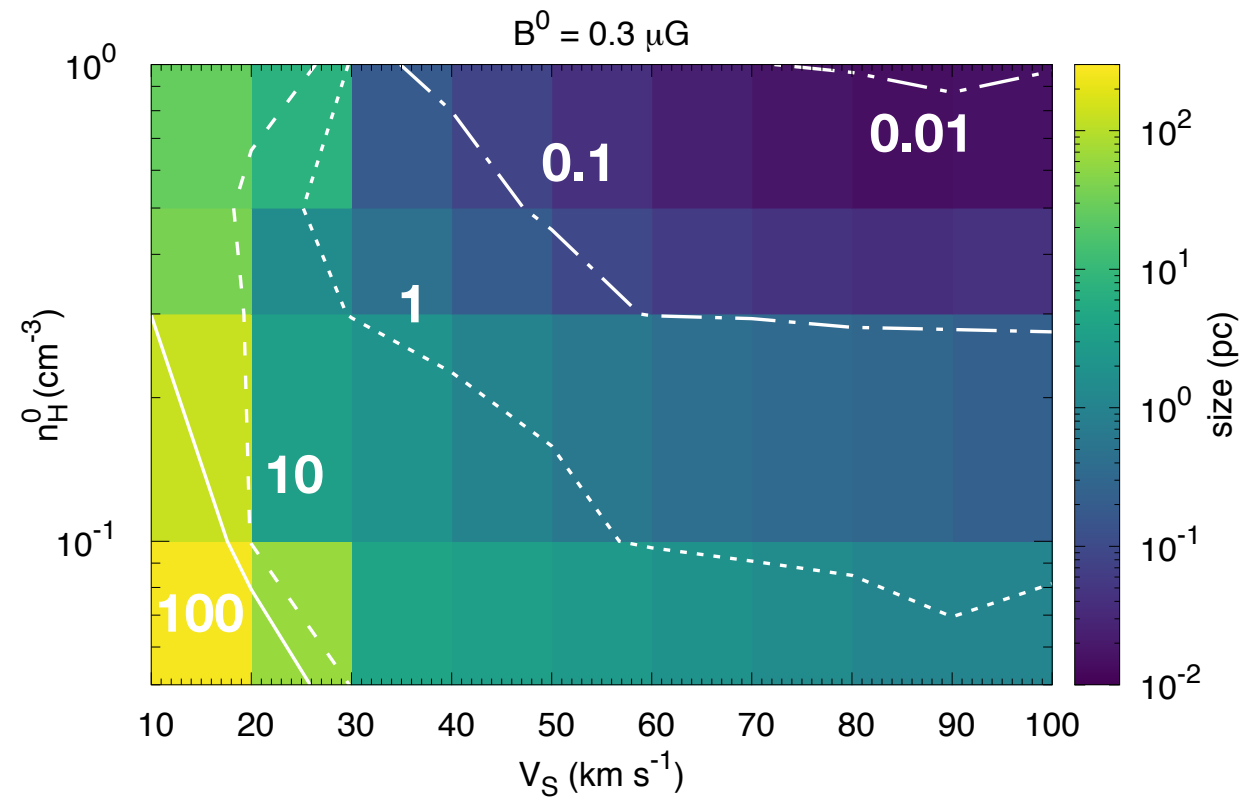


Rotation measure $\longrightarrow \phi = 0.81 \text{ rad m}^{-2} \int_0^{L_\phi} \frac{n(e^-)}{\text{cm}^{-3}} \frac{B_{||}}{1 \mu\text{G}} dl$

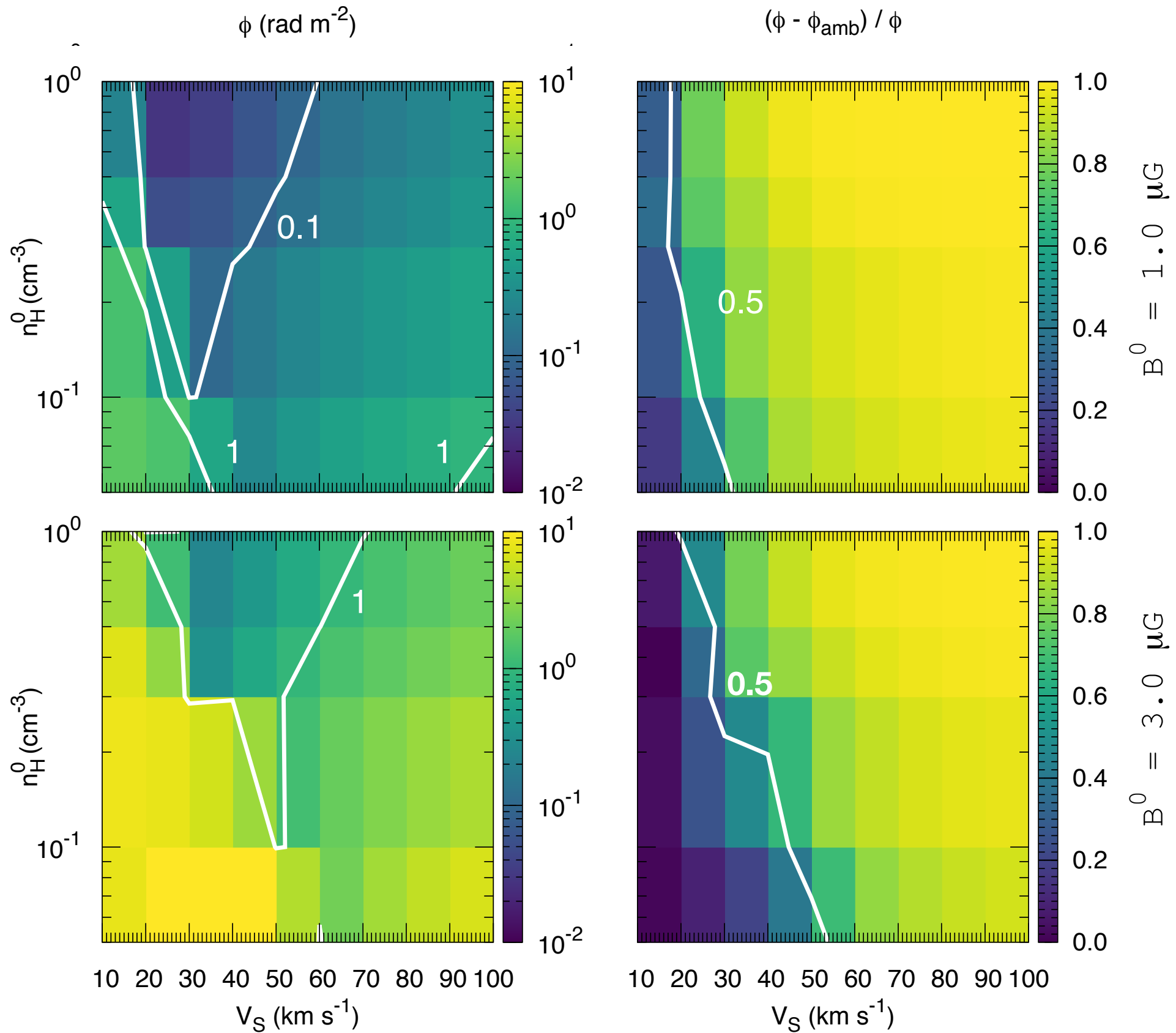
Integration scale L_ϕ



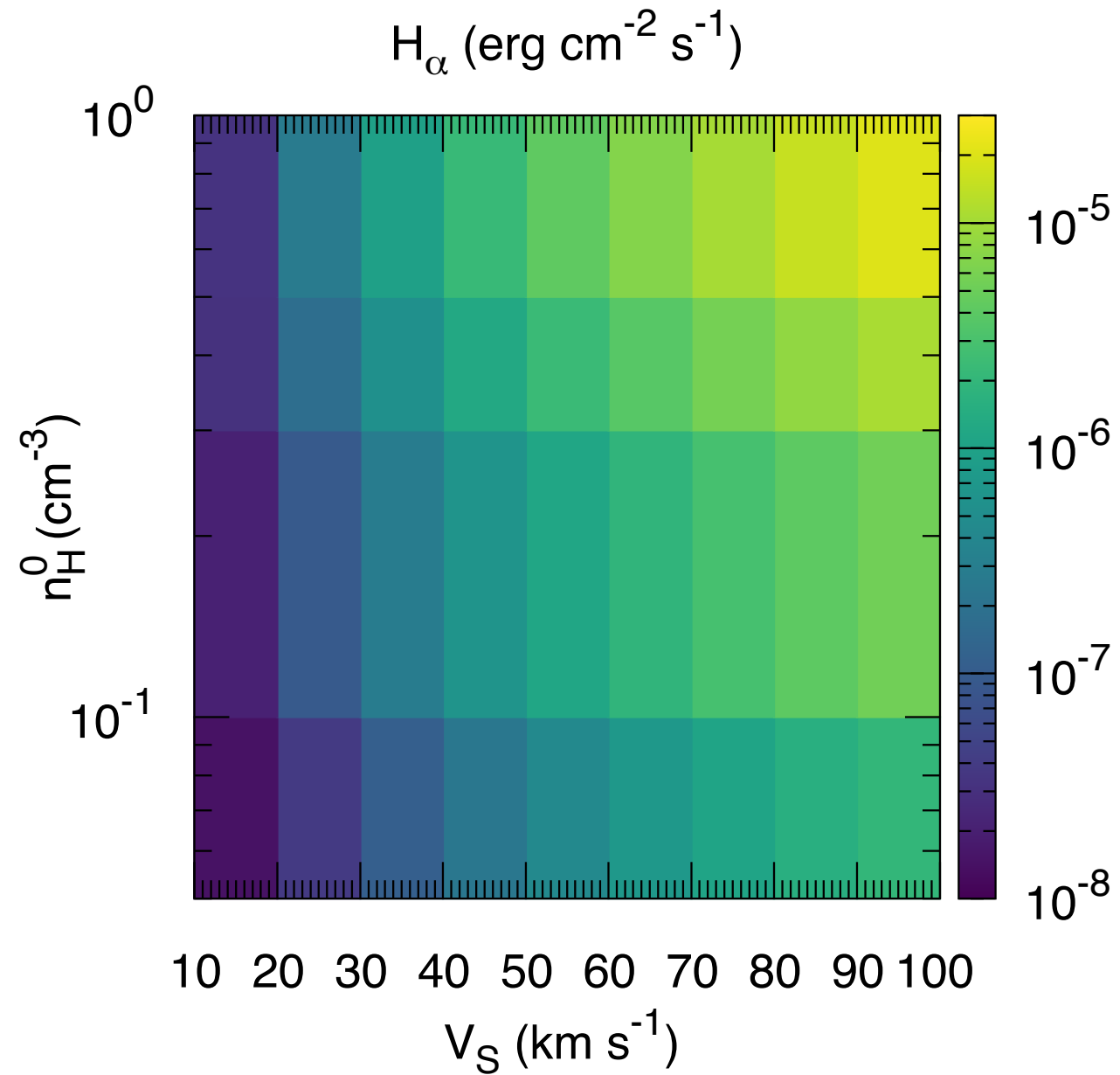
Integration scale L_ϕ



Faraday rotation



H α emission



$$\Rightarrow \frac{I(\text{H}\alpha)}{\frac{1}{2}\rho V_S^3} \sim 3 \times 10^{-2}$$

Lehmann et al. (2020)

Conclusions

- J-type shocks in WNM induce phase transition

1D model $\rightarrow V_S \geq 40 \text{ km s}^{-1} \left(\frac{B^0}{1 \mu\text{G}} \right) \left(\frac{n_{\text{H}}^0}{0.3 \text{ cm}^{-3}} \right)^{-3/2}$

postshock is supported by magnetic pressure

shock trajectory almost analytical

- J-type shocks in the WNM produce Faraday rotation

$\sim 0.1 - 1 \text{ rad m}^{-2}$ over distances ~ 0.1 to 10 pc

- J-type shocks in the WNM produce H_α emission

reprocessing of mechanical energy

$$\frac{I(\text{H}_\alpha)}{\frac{1}{2}\rho V_S^3} \sim 3 \times 10^{-2}$$

On-going work

- exploration of C-, CJ, and C*-type shocks
 - impact on phase transition
 - impact on observables
- geometric model for the computation of ϕ
 - caustics, inclination along the line of sight
- out-of-equilibrium initial conditions
 - e.g. electronic fraction
- identification of other tracers
 - FUV, NUV lines & continuum