Thermalization of inelastic dark matter in the Sun

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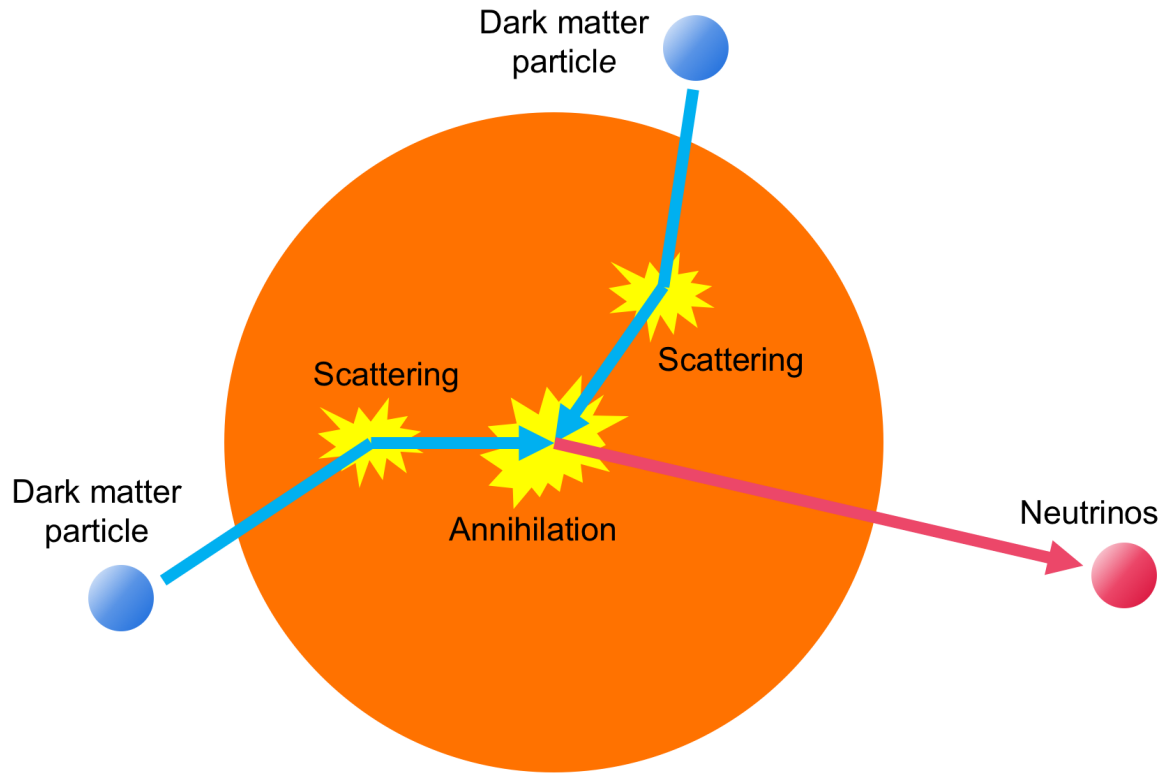
Dark matter in the Sun

Indirect detection: Look for high energy neutrinos from DM annihilation in the Sun

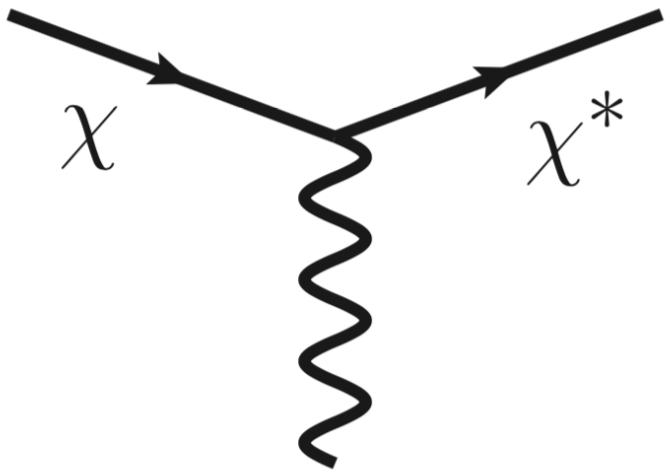
Process in general:

- Capture
- Thermalization
- Annihilation or evaporation



Motivation

Scattering mode:



- Two states separated in mass by

$$\delta = m_{\chi^*} - m_{\chi}$$

$\delta > 0$: endothermic
$\delta < 0$: exothermic

- Altered scattering kinematics

When captured by the Sun

- Does it thermalize? Impacts the annihilation rate
- Enhanced evaporation due to boost in $\chi^* \to \chi$ scattering

Simulate the thermalization process to find out!

The setup

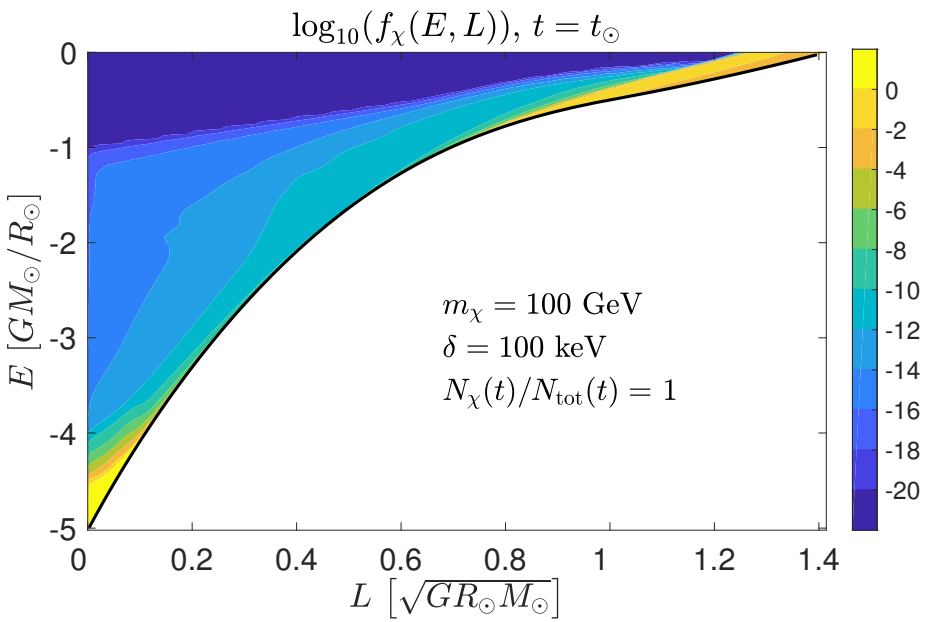
- Discretize DM orbits as states α with definite E_i and L_i
- Numerically calculate:
  - C_α = Capture into state α
  - $\Sigma_{\alpha\beta}$ = Scattering rate from state β to α
- Evolve initial distribution according to

$$\dot{f}_\alpha = \sum_\beta \Sigma_{\alpha\beta} f_\beta \qquad \longrightarrow \qquad \vec{f}(t) = e^{\Sigma t}\vec{f}(0)$$

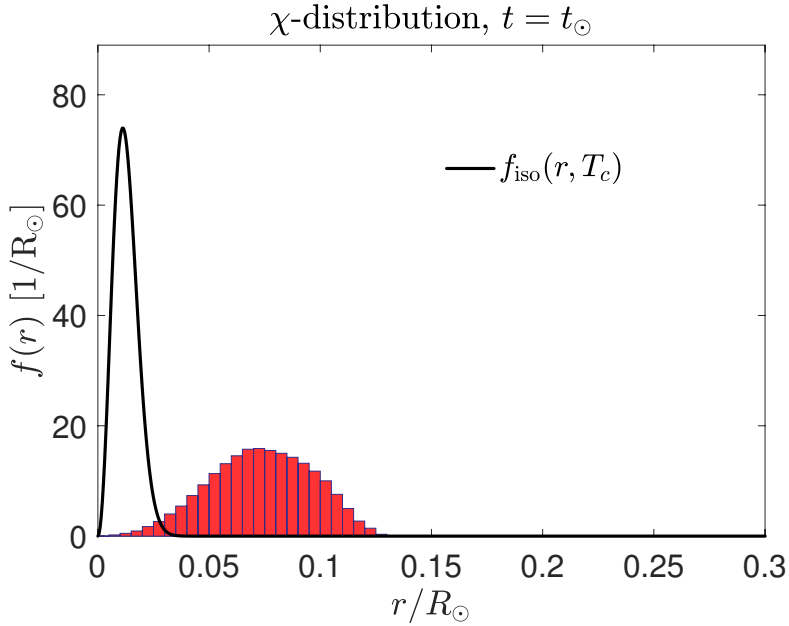
Evolution

Evolving a distribution over a solar lifetime

Distribution of χ at $t = t_\odot$



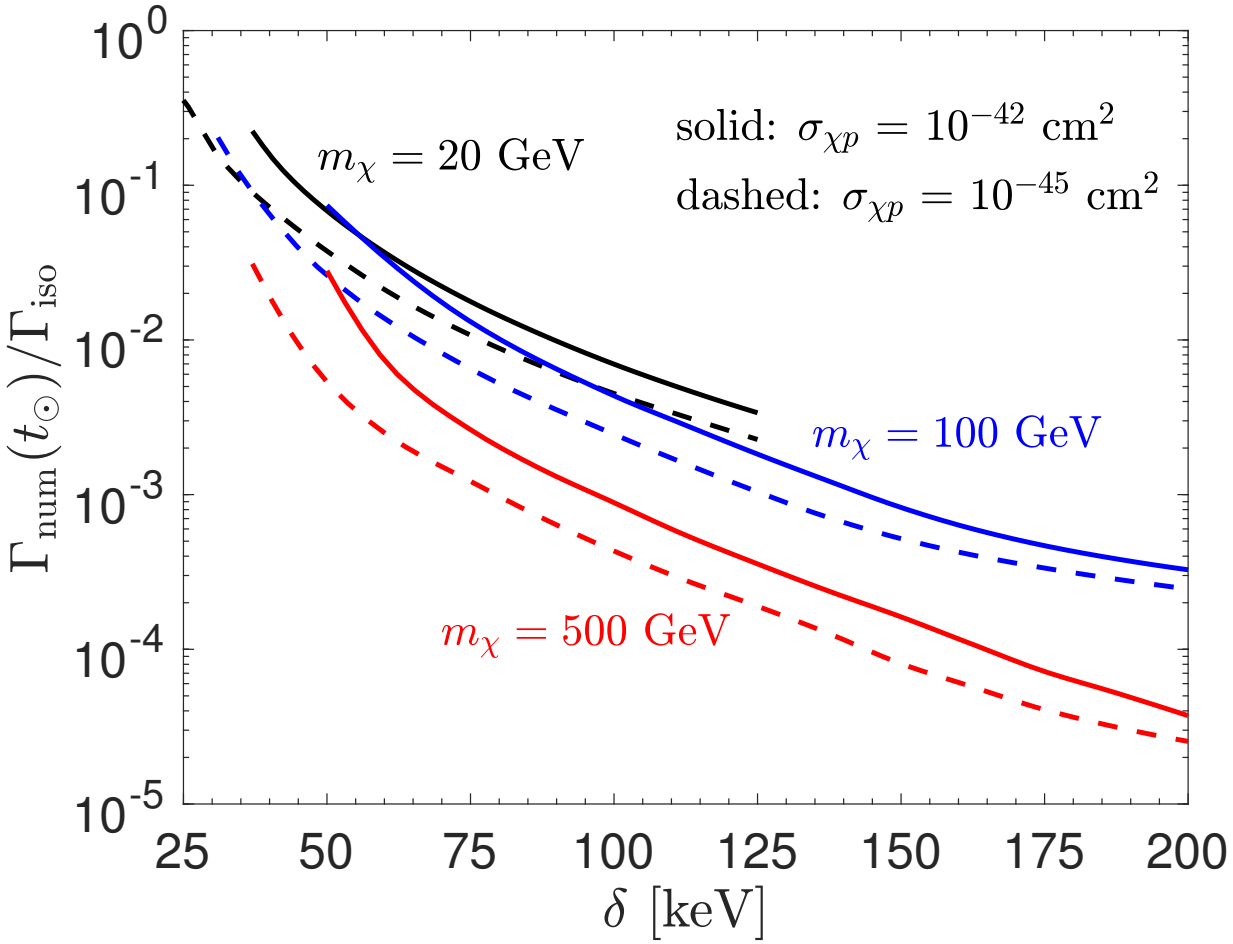
Radial distribution at $t = t_\odot$



- No χ^* survives

Annihilation

Comparing annihilation between thermal and our simulated distributions



Conclusions

1. Dark matter does not thermalize
2. Equilibrium between annihilation and capture not guaranteed
3. No enhanced evaporation due to $\chi^* \to \chi$ scattering

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Thank you!