How to choose your tooth fairies ?

Astrophysicist: How about a 10^{16} G magnetic field ?

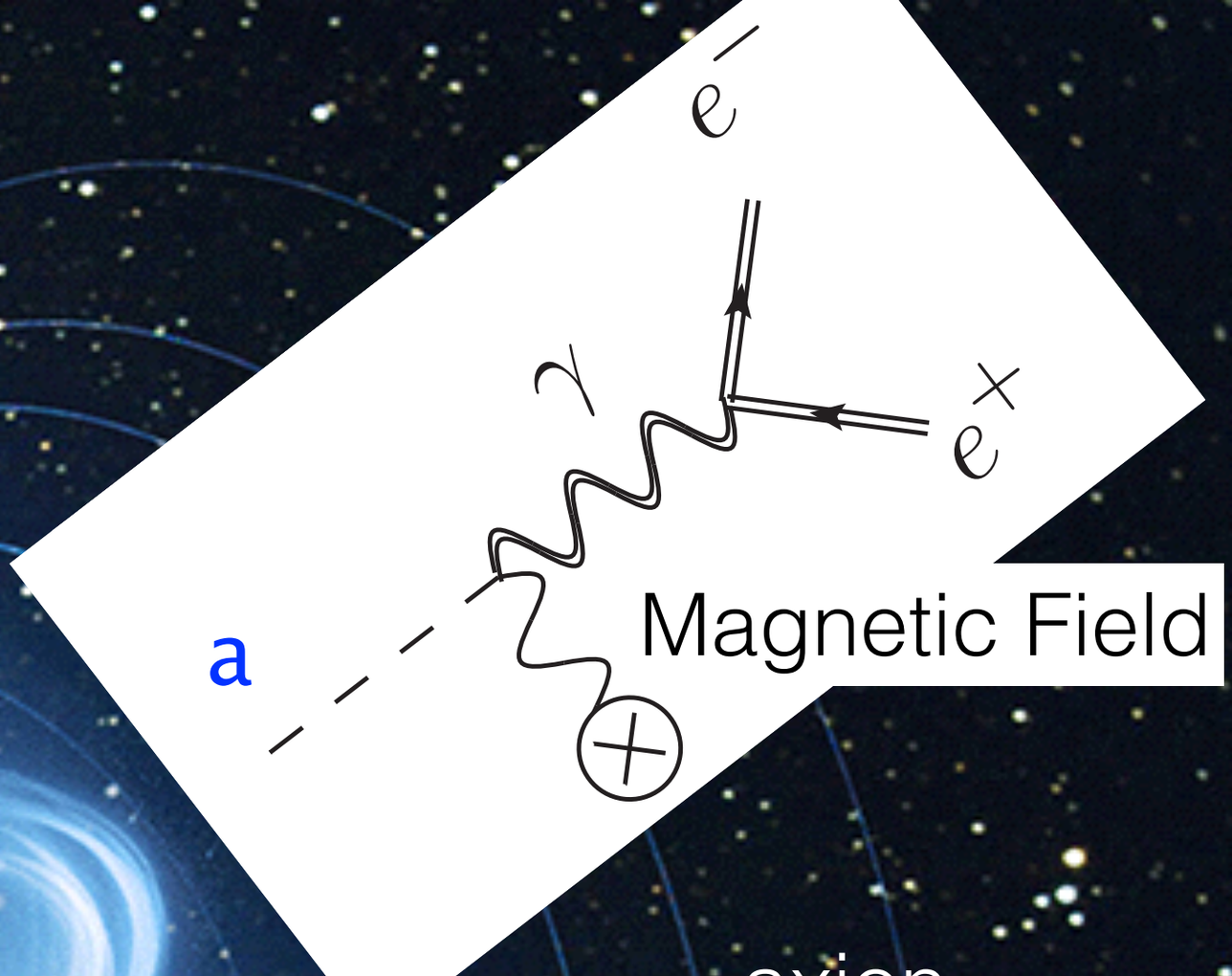
QCD Theorist: Could I have an axion please ?

Neutrino physicist: I have 3, one more please and can make it a sterile ?

Axions & Magnetic Fields in Supernova and Mergers

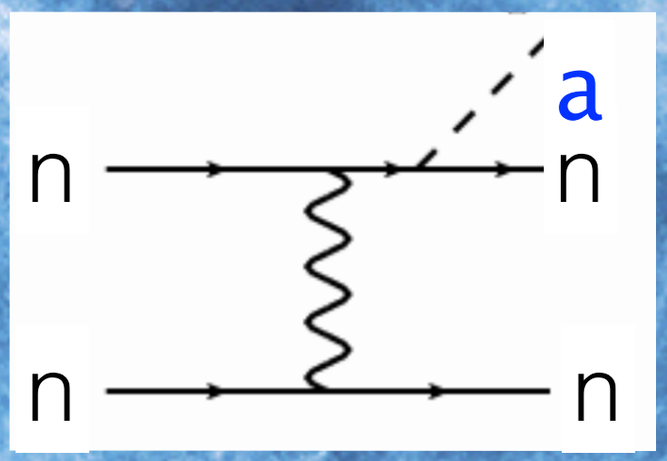
Sanjay Reddy,Bridget Bertoni, Ermal Rrapaj

Institute for Nuclear Theory,
University of Washington



axion
energy deposition
at low density

$$\frac{dE}{dt} \approx L_a \times \frac{\langle \lambda_a \rangle}{R}$$



axion
production
in the core

Supernova Neutrino Signal Constrains Axion Couplings

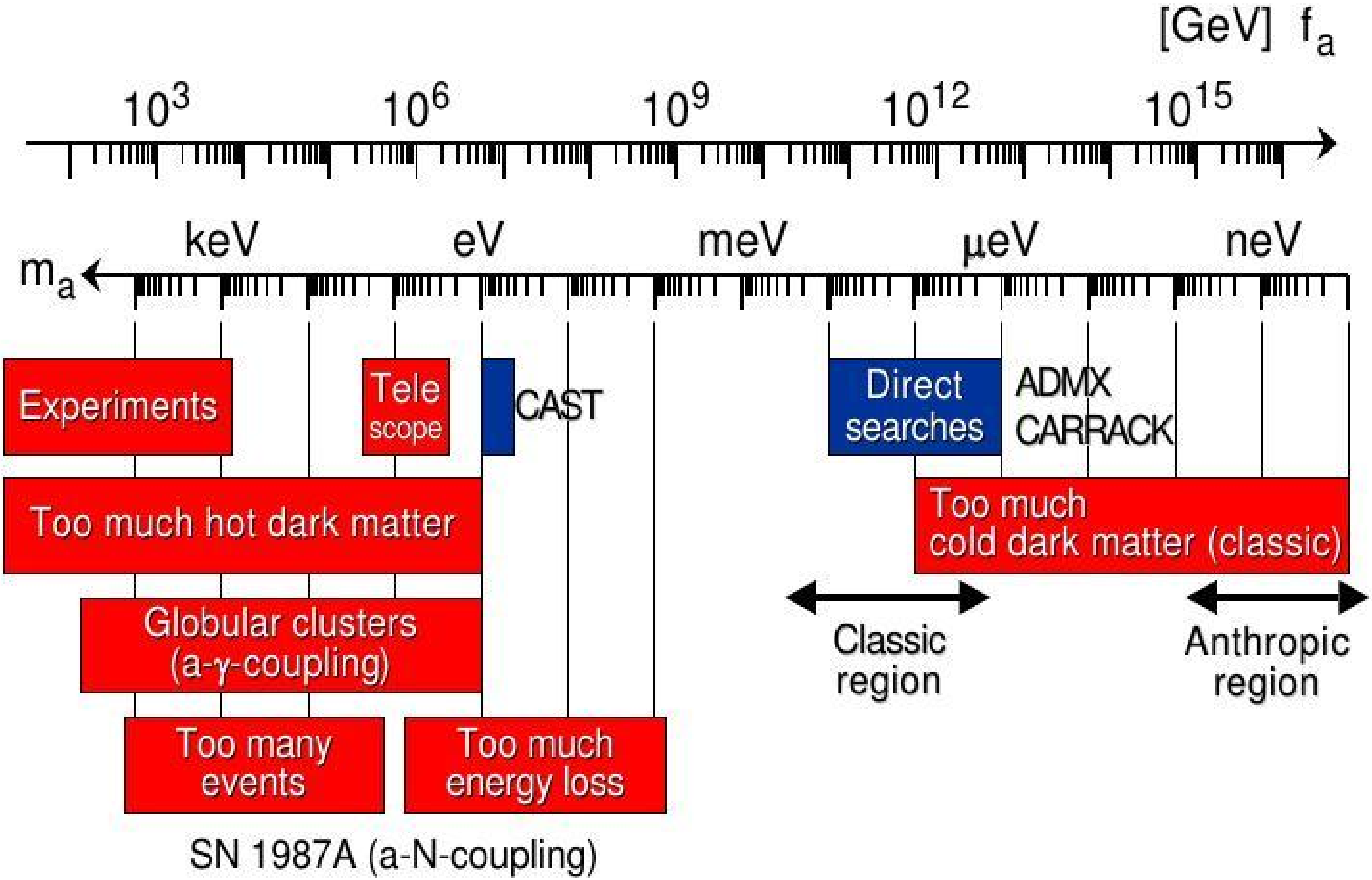
Raffelt, …

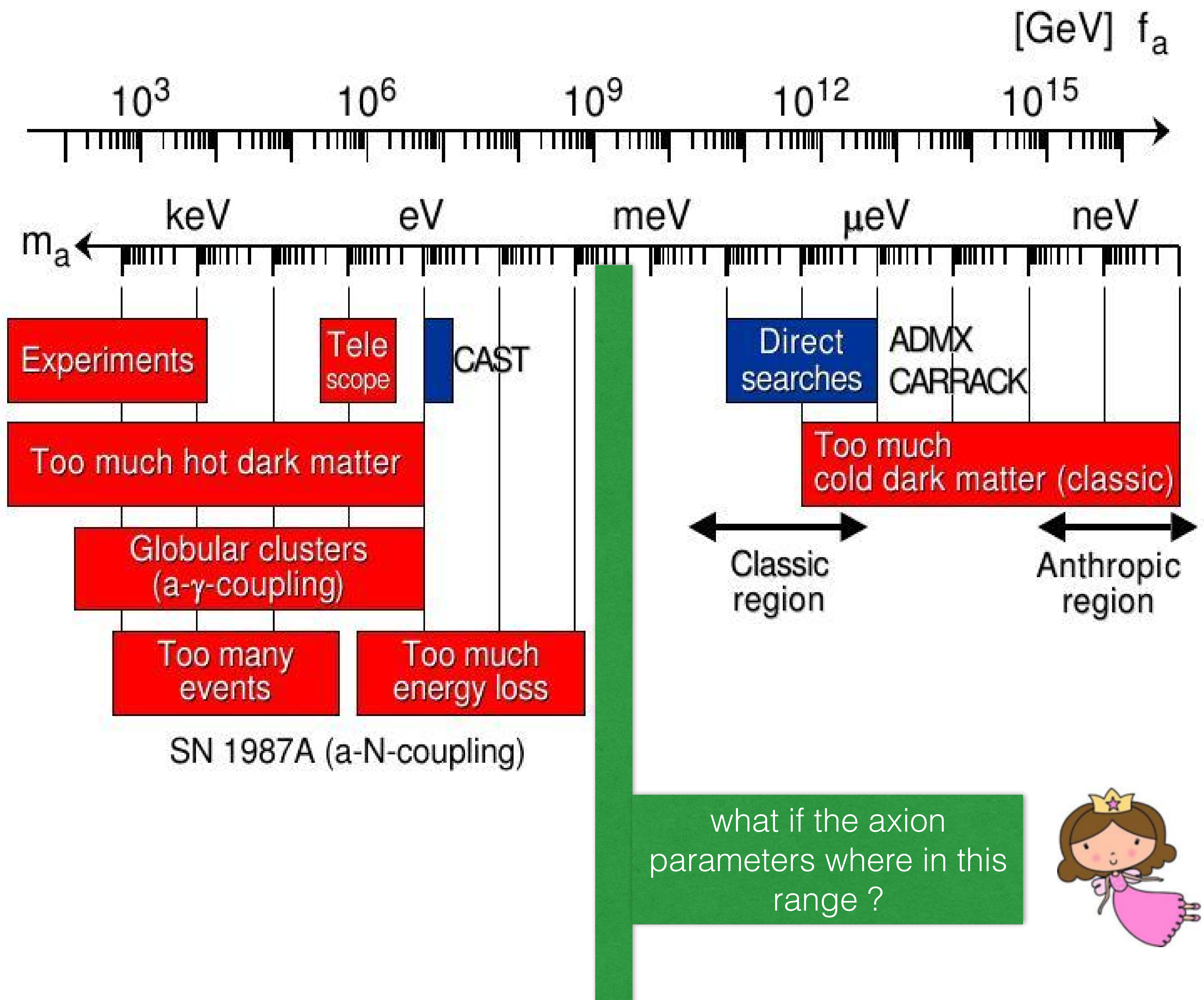
$$\varepsilon_a(r) = g_{aNN}^2 \frac{T^4}{4\pi^2 M_N}\Theta(\xi)$$

$$= 3.4 * 10^{19} \ \frac{\text{erg}}{\text{g s}} \left(\frac{g_{aNN}}{10^{-9} GeV^{-1}}\right)^2 \left(\frac{T}{30 MeV}\right)^4$$

Axion nucleon and axion-photon couplings are approximately related to one energy scale - the Peccei-Quinn scale: f_a

$$L_{ajj} = \frac{C_j}{2f_a}\,\bar{\Psi}_j \gamma^\mu \gamma_5 \Psi_j \partial_\mu a \qquad\qquad g_{a\gamma\gamma} = \frac{\alpha}{2\pi f_a}\left(\frac{E}{N} - \frac{2}{3}\,\frac{4+z}{1+z}\right)$$


[GeV] f_a
10^3
10^6
10^9
10^{12}
10^{15}
keV
eV
meV
μeV
neV
m_a
Experiments
Tele scope
CAST
Direct searches
ADMX
CARRACK
Too much hot dark matter
Too much cold dark matter (classic)
Globular clusters (a-γ-coupling)
Classic region
Anthropic region
Too many events
Too much energy loss
SN 1987A (a-N-coupling)



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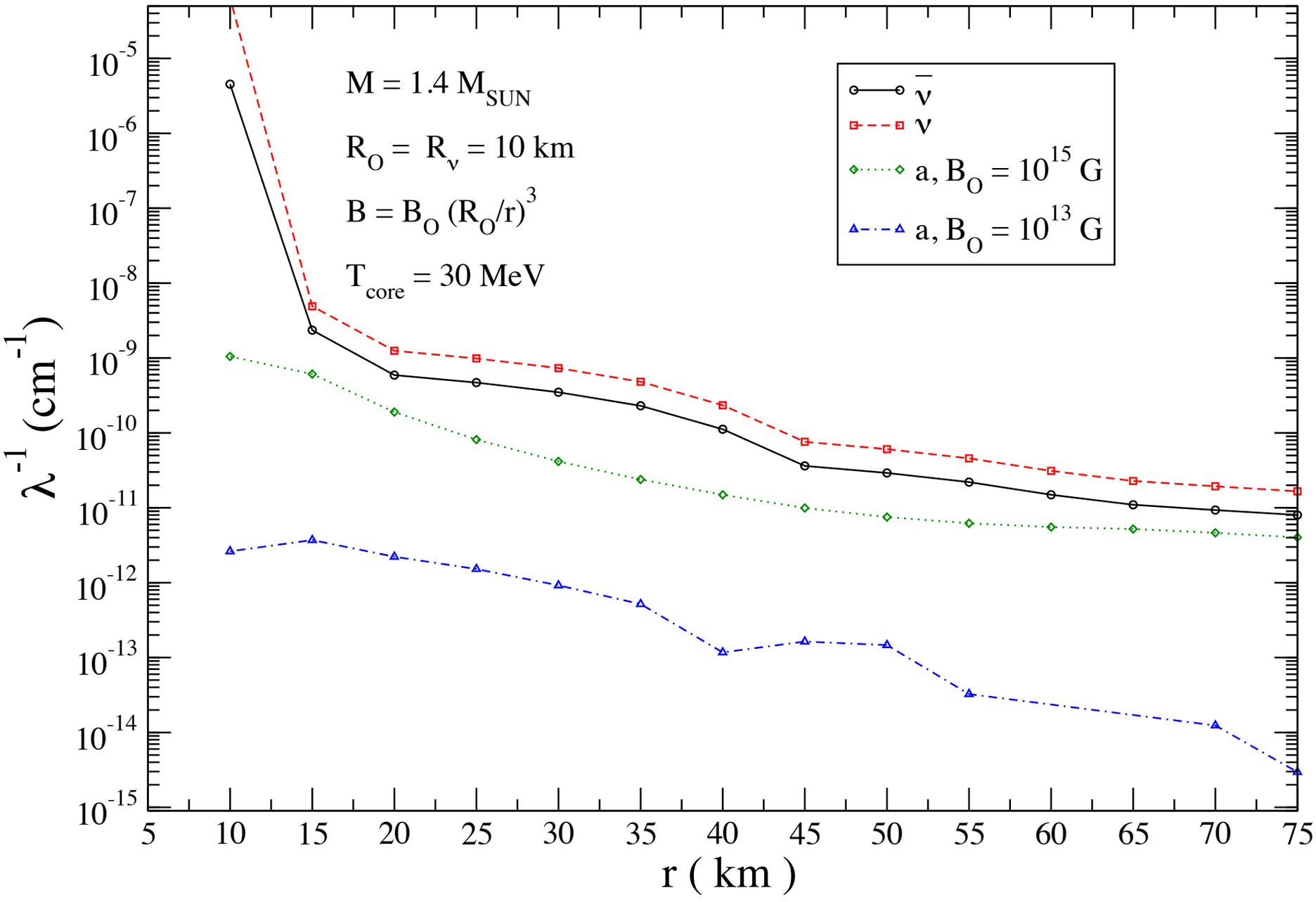
what if the axion parameters where in this range ?

Mean Free Path: In the vicinity of the magnetar

$$\lambda_a(\omega_a) \approx 10^{10}\mathrm{cm} \times \left(\frac{10^{-10}\ \mathrm{GeV}}{g_{a\gamma\gamma}}\right)^2 \times \frac{10^{15}\mathrm{G}}{B} \times \frac{90\ \mathrm{MeV}}{\omega_a}$$

Axion energy deposition is independent of the local density.



This could have implications for:

1. Nucleosynthesis
2. Supernova mechanism
3. Supernova neutrino spectrum
4. GRBs and afterglows (x-ray Plateau?)