Unraveling the nature of GRBs progenitors though neutrinos

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WHAT?

- Could we distinguish the central remnant of LGRBs by observing neutrinos?

WHY?

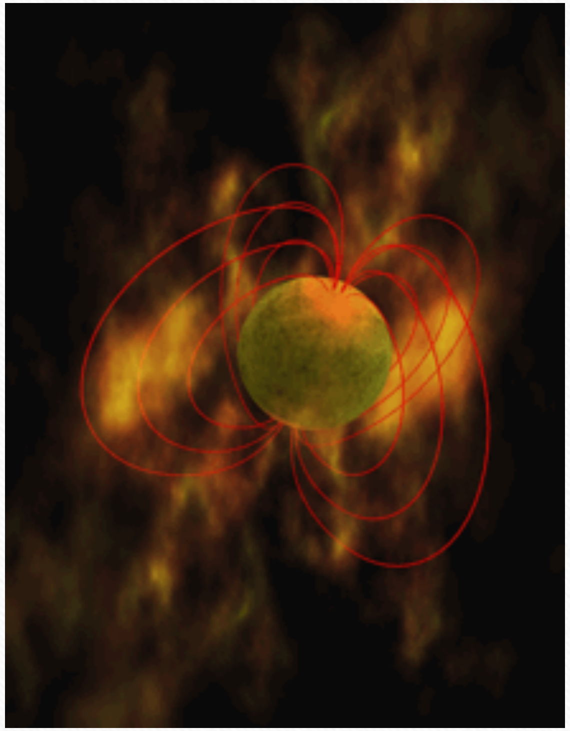
- Neutrinos provide information about the medium they pass through by having a small effective cross section.
- We want to study the possible scope of neutrinos in future detectors. (Neutrino Astronomy)

HOW?

- We study the propagation and oscillation of neutrinos in a medium with strong magnetic contribution associated with a newly born magnetar/neutron star asuming that they are progenitors of LGRBs

Gamma-Ray Bursts

- Long Gamma-Ray Bursts
- t>2seconds (Kouveliotou+1993)
- Collapsar model
  - Precursor: NS
    - Neutron star $B \sim (10^{12}\ \mathrm{G})$
    - Magnetar (Bernardini+13) $B \sim (10^{14} - 10^{15}\ \mathrm{G})$
  - Black hole (main emission)



Neutrino production mechanisms

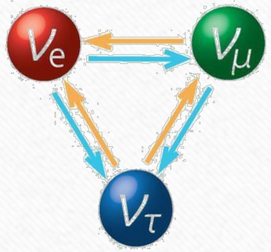
Dominated by thermal processes

- pairs annihilation ($e^+ + e^- \rightarrow \nu_x + \bar{\nu}_x$),
- plasmon decay ($\gamma \rightarrow \nu_x + \bar{\nu}_x$),
- photo-neutrino emission ($\gamma + e^- \rightarrow e^- + \nu_x + \bar{\nu}_x$),
- positron capture ($n + e^+ \rightarrow p + \bar{\nu}_e$),
- electron capture ($p + e^- \rightarrow n + \nu_e$),

$$\approx (4\ \nu_e, 3\ \nu_\mu, 3\ \nu_\tau)$$

Neutrino Oscillation

- 3 neutrino flavors (e, μ, τ)
- 9 allowed transitions
- 6 are independent



Vacuum: $P_{\alpha\beta}(E_\nu, L, \theta, \Delta m^2)$

known

Matter:

$P_{\alpha\beta}(E_\nu, L, \theta, \Delta m^2) +$ **Veff**

Medium

Neutrino potential on a magnetized fireball

$$V_{\text{eff}} \propto (B, T, \mu, \varphi)$$

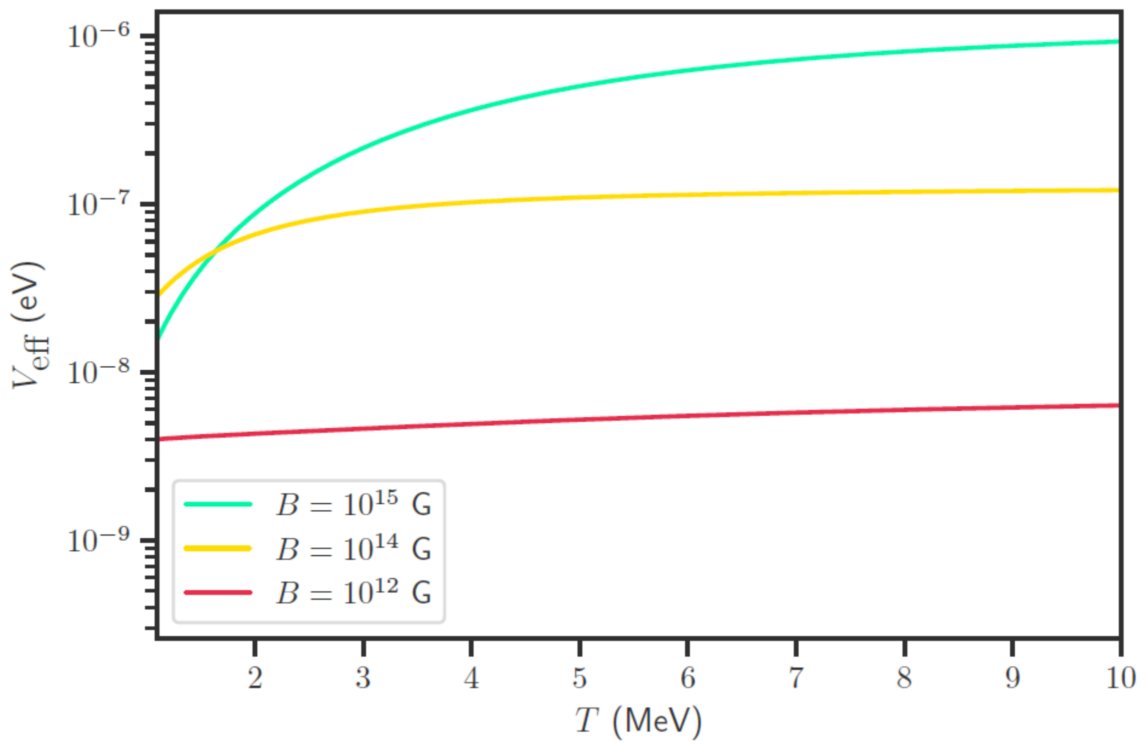
(Fraija, N., 2014)

- Moderate magnetic field

  $$B = 10^{12}\ \text{G}$$

- Strong magnetic field

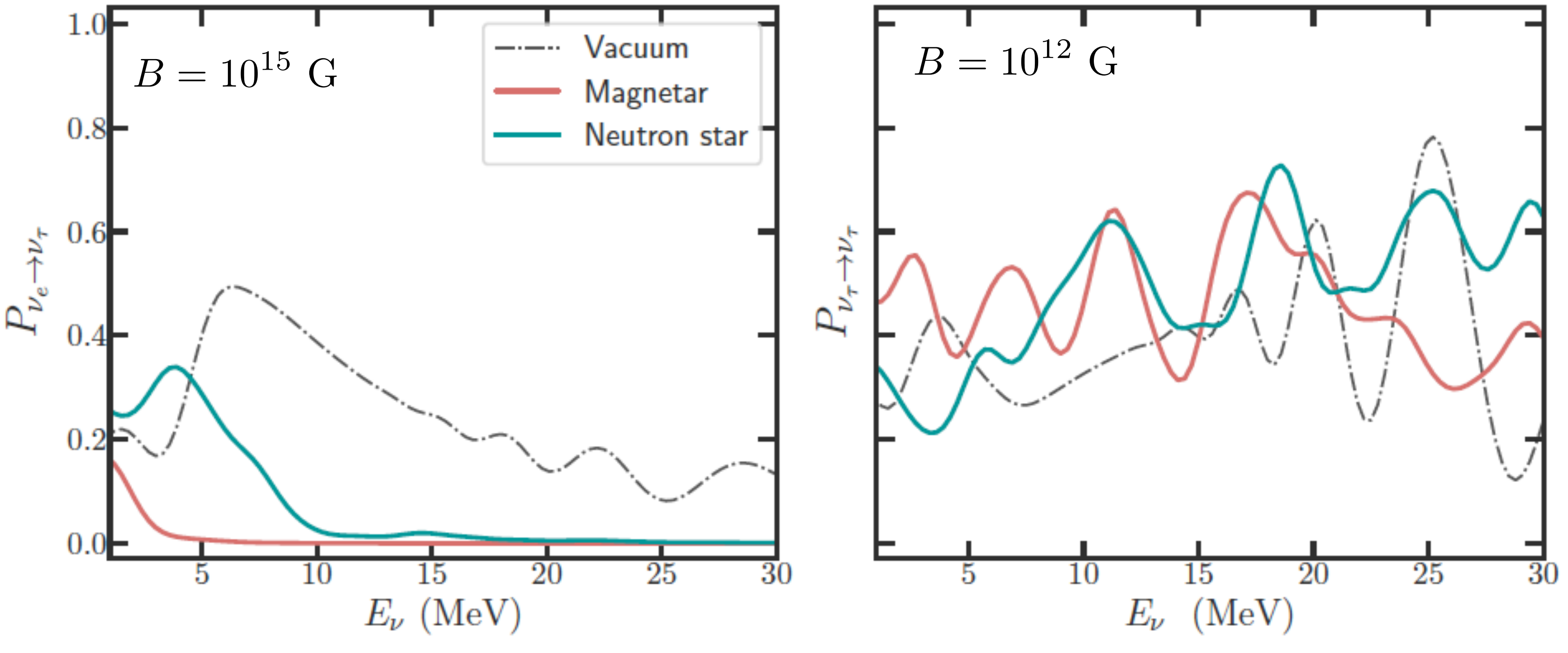
  $$B = 10^{15}\ \text{G}$$



(Morales, G. and Fraija, N., 2021, in prep.)

CASE 1 : Magnetar scenario **CASE 2: Neutron star scenario**

- Here we show only two probabilities in both media and compare them with the vacuum

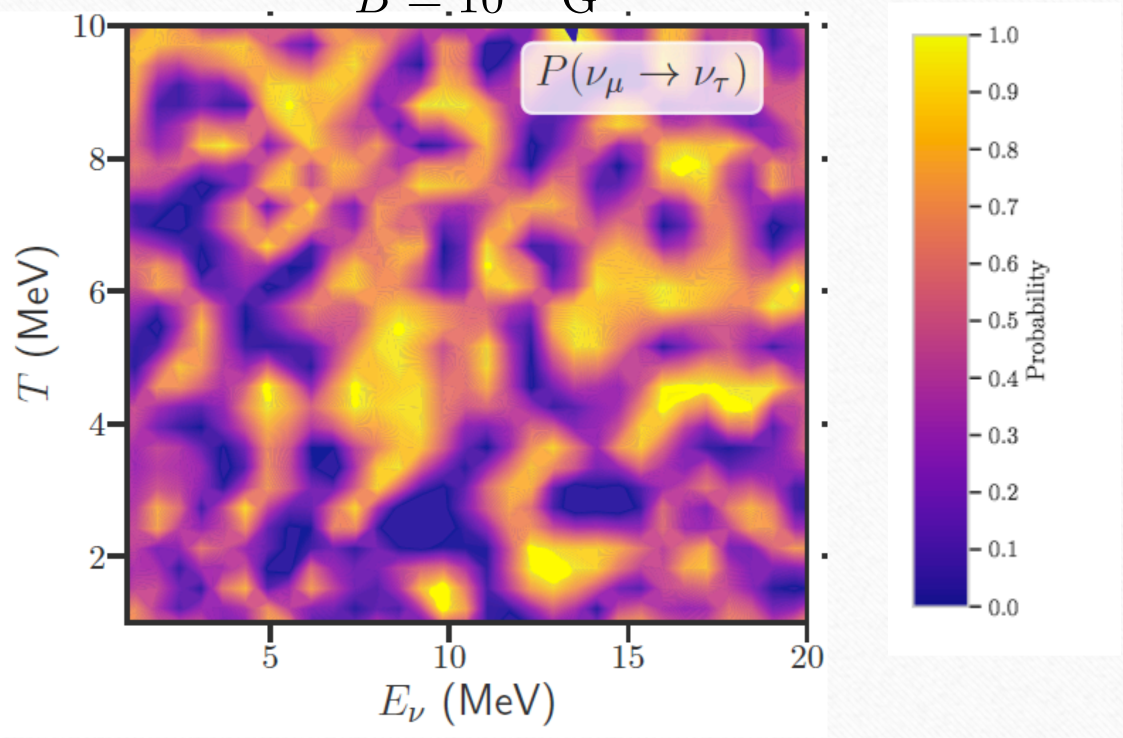


(Morales, G. and Fraija, N., 2021, in prep.)

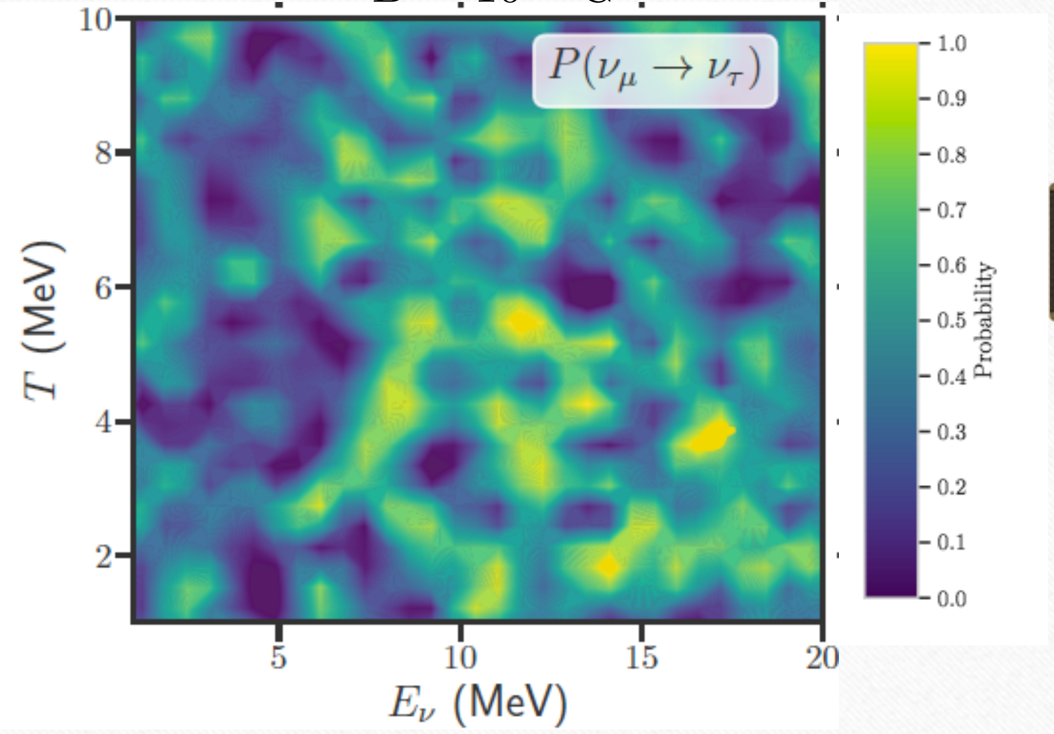
CASE 1 : Magnetar scenario **CASE 2: Neutron star scenario**

- Here we show only the probability $P_{\nu_\mu \to \nu_\tau}$ within a fireball as a function of temperature and neutino energy.

$B = 10^{15}$ G



$B = 10^{12}$ G



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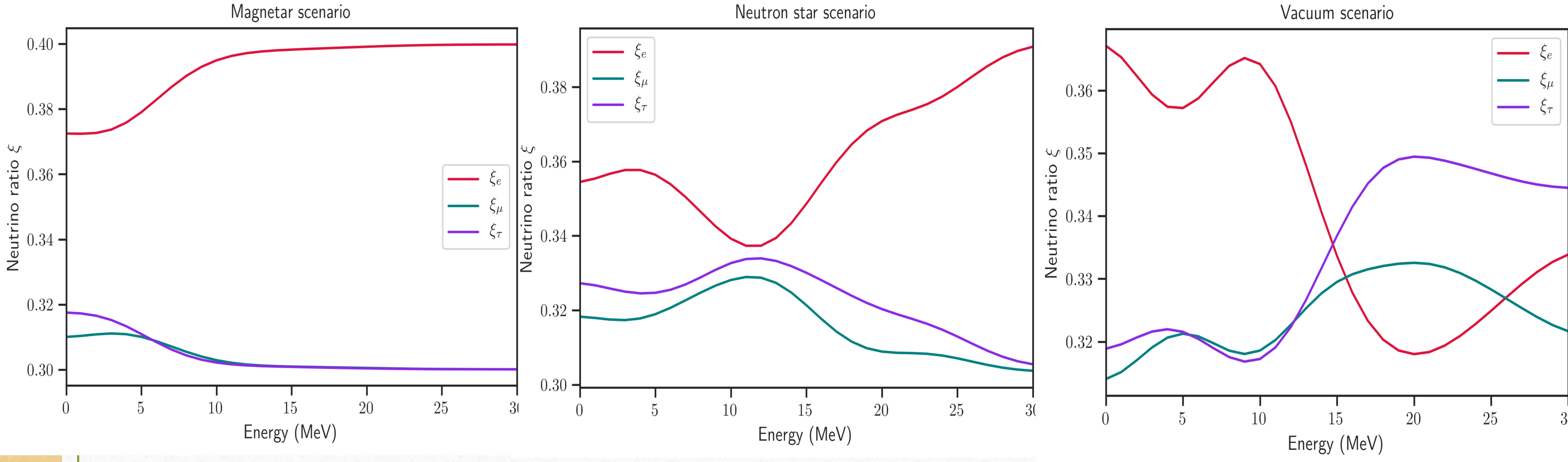
Neutrino ratios as a function of energy

$$\xi_n = \frac{F_n}{\sum_n F_n} \quad \text{with } \mathrm{F_n} = (\nu_\mathrm{e}, \nu_\mu, \nu_\tau)^\mathrm{T}$$

- Are dependent on the chosen initial creation rate
- We have chosen a initial ratio of $(4\ \nu_e, 3\ \nu_\mu, 3\ \nu_\tau)^T$



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Conclusions

- The effect of B is a major contributor to the variation of the oscillation probabilities.
- By studying neutrino rates in terrestrial detectors, we could characterize the type of progenitor that produced them and that corresponds to the remaining surviving compact object left behind.
- Neutrinos could act as an additional detection channel.

¡THANK YOU!