Neutron to DM decay in Neutron Stars

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- Measurements in which the neutrons are trapped and simply counted show a lifetime 8 seconds shorter than measurements of neutrons in a beam where the protons from the beta decay are measured directly at the end.
- This discrepancy amounts to approximately 3.6σ.

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- They propose a new decay channel, either $n \to \chi_{\mathsf{DM}} + \lambda_{\mathsf{SM}}$ or $n \to \chi_{\mathsf{DM}} + \phi_{\mathsf{DM}}$
- And as long as the mass constraints are met

$$\begin{aligned} 937.900\mathrm{MeV} < M_\chi < 938.543\mathrm{MeV} \\ 937.900\mathrm{MeV} < M_\chi + m_\phi < 939.565\mathrm{MeV}. \end{aligned} \tag{1}$$

it can account for the discrepancy

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- Considering that big Fermi seas generate a lot of degeneracy pressure and that neutron-neutron repulsion also contributes to the pressure...
- It's bound to soften the EOS

Neutron Stars

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- All that conserving baryon number densty, charge neutrality, etc, plus the equilibrium condition $\mu_N = \mu_\chi$, we can write $\epsilon(n)$

Neutron Stars

- In fact we do observe a large population of dark matter particles

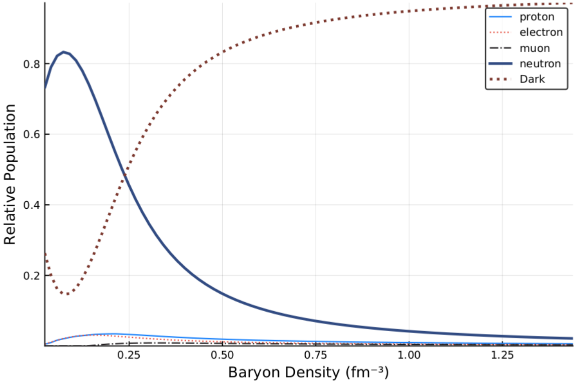

Figure: Relative population of each particle species per baryon density

Neutron Stars

- And it softens the equation of state quite severely

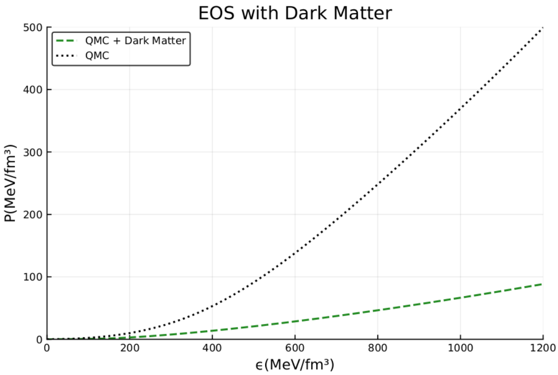

Figure: EoS including dark matter

Neutron Stars

- What does that do to the structure of neutron stars?

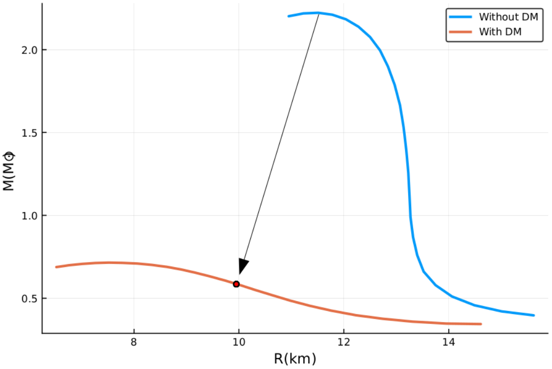

Figure: Mass-radius relationship for stars obeying the equation of state with and without DM

Self Repulsion?

- What if the dark matter is self repellent? We tested a simple massive vector boson repulsion.

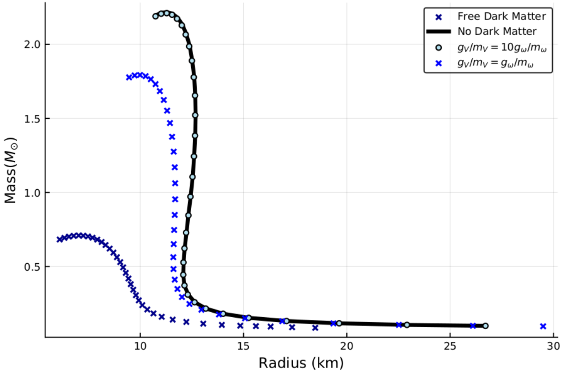

Figure: Self repulsive dark matter effects

Conclusions

- The proposal by Fornal et al. is definitely in tension with NS physics unless this DM particle is very self repulsive
- The self repulsion strength has to be higher than that of the residual strong force (for a massive vector boson), which is way too high

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References

TFM, P.A.M. Guichon, A.W. Thomas *J.Phys.G 45 (2018) 5, 05LT01*

B. Fornal, B. Grinstein *Phys.Rev.Lett. 120 (2018) 19, 191801, Phys.Rev.Lett. 124 (2020) 21, 219901*