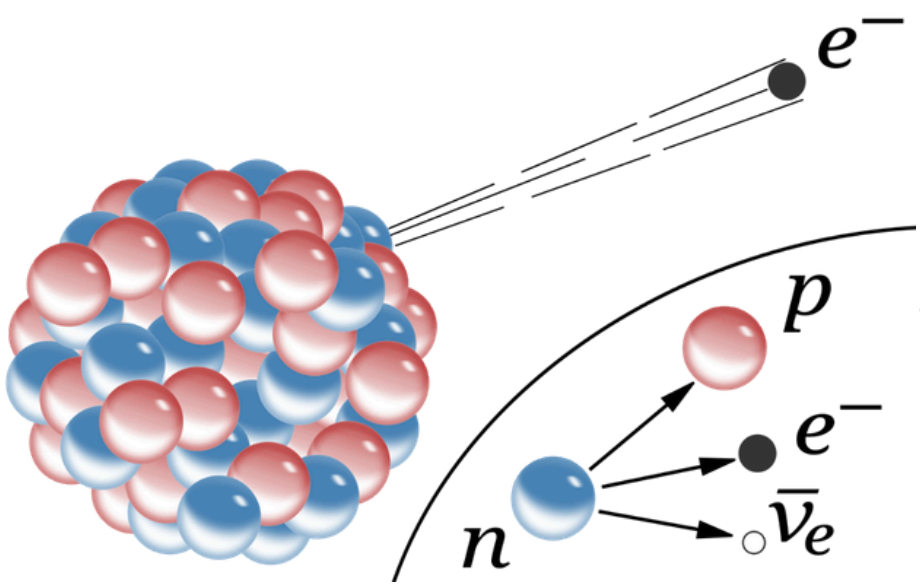
Dark Neutron Decay in Neutron Stars

M. Vikiaris [1] , Ch. Moustakidis [1] , V. Petousis [2] , M. Veselský [2]

[1] Department of Theoretical Physics, Aristotle University of Thessaloniki, 54124 Thessaloniki, Greece
[2] Institute of Experimental and Applied Physics, Czech Technical University



Theory:

The dominant neutron decay channel is the classical β-decay where:

$$n \longrightarrow p + e^- + \bar{\nu}_e$$

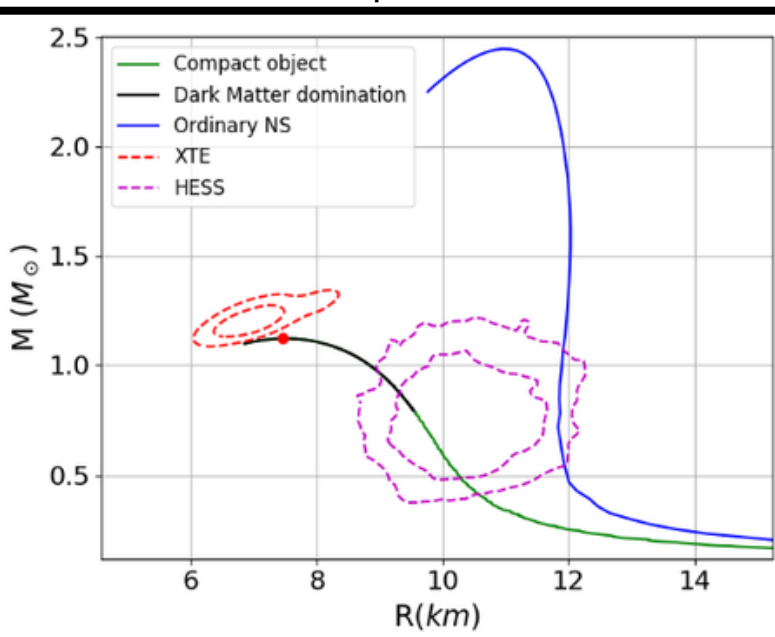
To explain the different life times for the neutron given by two different experiments (beam and bottle) we suppose that there is a chance for a dark channel to exist:

$$n \longrightarrow \chi + \phi$$

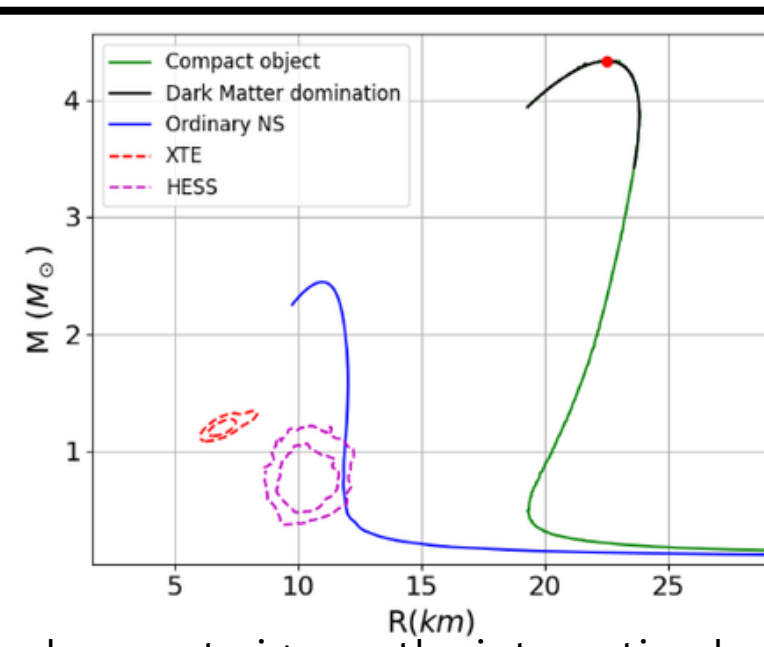
- Create the resulting EoS from the dark decay (equating chemical potentials of baryonic and dm)
- Solve the TOV equations for the model

$$\frac{\partial \mathcal{E}_{\rm nucl}(n_n)}{\partial n_n} - \frac{\partial \mathcal{E}_\chi(n_\chi)}{\partial n_\chi} + \frac{(\hbar c)^3}{2z_{\chi n}^2}(n_\chi - n_n) = 0$$

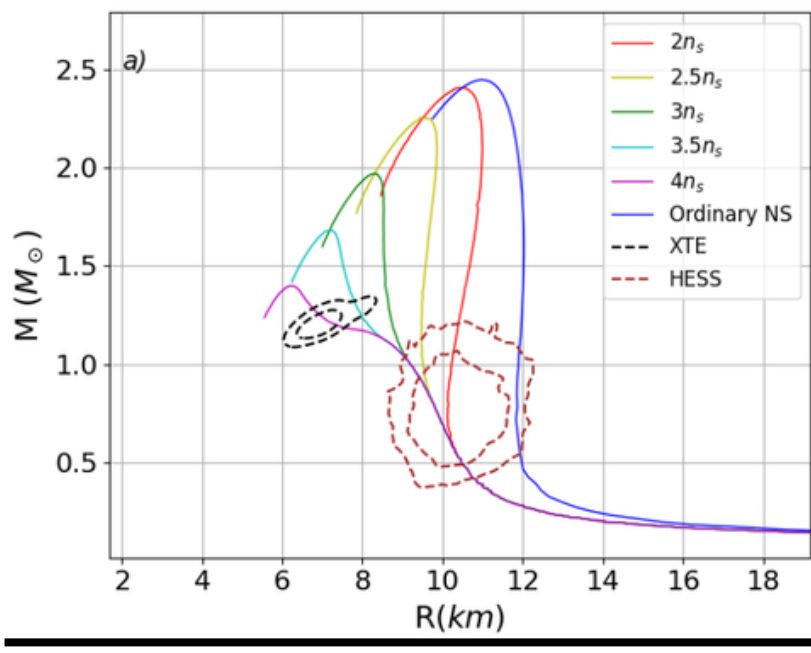
Results:



By choosing specific types of interaction we can explain “unexpected” observational data such ass HESS and XTE, populate the lower left side of the MR diagram (multiple branches theory)



If one chooses to ignore the interaction between dm particles and chooses baryonic-dm interaction the resulting strucutres are populating the mass gap, providing another explanation to the mystery of the mass gap



Choosing to stop the dm production mechanism we can achieve both a soft at start and a stiff at the end EoS to explain everything. The reason could be:

- **Additional degree of freedom**: The emergence of additional subatomic degrees of freedom, such as kaons, hyperons, or even quarks, may drastically limit, or even completely suppress, the appearance of dark particles at supranuclear densities.
- **Strong repulsive interaction**: A possible strong density dependence of the repulsive interaction among dark particles may also play a role.

Find more on our publication:

Neutron Dark Decay and Exotic Compact Objects
M Vikiaris, V Petousis, M Veselsky, CC Moustakidis
arXiv preprint arXiv:2602.04477