Bayesian inference of dark matter admixed neutron stars with multi-messenger data

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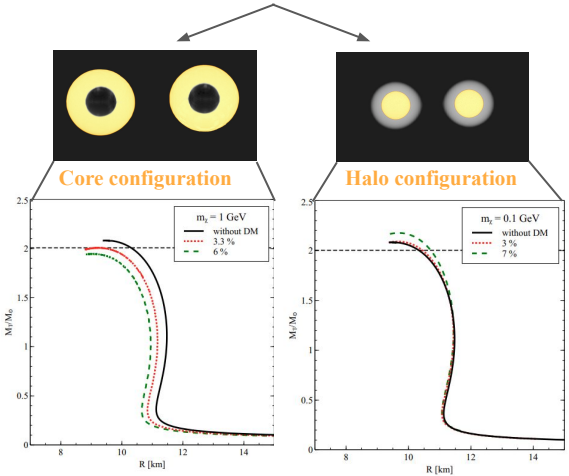
1 Dark matter | Theory

We study the impact of *asymmetric dark matter* (DM) on the properties of neutron stars, whereas DM is considered as fermionic gas. We neglect the interaction of baryonic matter (BM) with DM. Both interact only gravitationally and their energy-moment tensors are conserved separately:

$$\frac{dp_j}{dr} = -\frac{(\epsilon_j + p_j)(M + 4\pi r^3 p)}{r^2(1-2M/r)} \quad ; \quad j = B, \chi \quad ; \quad \chi = \text{DM}, \; B = \text{BM}$$

We consider two **configurations**:



[Ivanytskyi, Sagun, Lopes (2020)]

2 NMMA: Multi-messenger framework

NMMA allows to simultaneously infer properties of compacts object using different messengers such as:

- Gravitational-wave emission,
- Electromagnetic emission
  (Gamma-ray burst, kilonova, supernova),

while including nuclear physics information in the sampling through the equation-of-state (EOS) containing information on the mass, radius, and tidal deformability - EOS (M, R, L).

Paper: Pang et al. (2022), arXiv:2205.08513
Github: github.com/nuclear-multimessenger-astronomy/nmma

3 Implementation of dark matter in NMMA

We aim to implement the sampling on **two additional parameters:**

- DM particle mass m_χ
- DM fraction f_χ

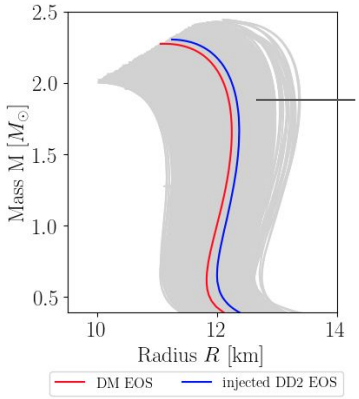
Using the 'DD2' baryonic model of Typel, Wolter (1999), we:

1. compute a DD2 EOS set, and
2. model the DM contribution following Ivanytskyi et al. (2020), to
3. obtain a DM EOS set.

The DM EOS set will be used in the sampling process to obtain properties about DM admixed neutron stars.

4 Plan of investigations

1) We inject one DM EOS with a core configuration and recover the injection with our baryonic DD2 EOS set.



2) With the new code implementation in NMMA, we aim to study GW observations, i.e., for observed data such as GW170817 and for synthetic data.

3) In addition, we plan to investigate the effect of DM admixed neutron stars in the multi-messenger context (using: GW170817+GRB170817A+AT2017gfo).

References: Ivanytskyi, O. et al., PRD 102 6, 2020 | Typel & Wolter, Nuclear Physics 656 3, 1999 | Pang et al. (2022), arXiv:2205.08513