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From Quarks to Cosmos

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Model dependence of the magnetic field effects on compact stars

Compact stars possess the highest observed surface magnetic fields, and they are supposed to reach even bigger values at their centres. The magnetic field influences the mass, stability, size, and shape (magnetized stars are spheroidal) of compact objects. In the latest years, several theoretical models have been developed to analyse their role in the physics of these objects, sometimes leading to contradictory or opposite results. Here, we aim to establish to what extent the macroscopic features of magnetized stars will depend on the models used to compute them. To do so, we compute the observables of uniformly magnetized white dwarfs, strange stars, and Bose-Einstein condensate stars using two sets of structure equations. The equations of state of the stars that we considered take into account the anisotropy in the energy-momentum tensor caused by the magnetization, and the pressure and energy density of the magnetic field. To properly deal with the energy-momentum anisotropy, the space-times selected to construct the two sets of structure equations are axisymmetric, but besides that, the requirements and approximations of each macroscopic model are rather different. Both models are relatively simple since to construct them it is considered that the quantities inside the star depend only on one of the coordinates, giving, as a result, a set of ordinary differential equations. This has the advantage of a low computational cost and allows us to keep track of the approximations providing a better understanding of the physical origins of the characteristics of the stars. We found that, in general, the effects of the magnetic field predicted by each set of structure equations are consistent, and for the stable stars depend mostly on the equation of state.

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