The role of dark radiation and dark pressure on compact stellar structures

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The success of general relativity is beyond any doubt, however due to its inconsistency with quantum mechanics, it is not possible to ensure that this theory keeps its original structure at high energies. In the context of theories of gravity beyond Einstein, specifically braneworld theories, the consequences of extra dimensional gravity on compact stellar distributions is discussed through a new solution to Einstein's field equations. In order to generate the braneworld version containing the anisotropic effects necessary for realistic stellar models, the minimal geometric deformation approach is used to break the perfect fluid solution represented by the general relativistic solution. Hence some important features of the extra dimensional consequences on physical variables inside compact distributions is clarified. In order to elucidate the specific role played by the dark radiation $\mathcal{U}^+$ and dark pressure $\mathcal{P}^+$ on compact stellar systems, the braneworld solution generated within the compact distribution is matched with two different exterior solutions, namely, the Dadhich, Maartens, Papadopoulos and Rezania solution (DMPR) and the Casadio, Fabbri and Mazzacurati solution (CFM). Both exterior solutions show different effects on stellar systems. It is shown that the DMPR solution produces an increase in the pressure and that the CFM reduces it. The fact that the CFM solution has no dark radiation, which is the main difference with the DMPR solution, seems to be the most likely cause of the opposite effects of these two exterior solutions on stellar distributions. Hence, it is presented a strong evidence showing that the exterior dark radiation $\mathcal{U}^+$ always increases both the pressure and the compactness of the stellar structures, and that the exterior "dark pressure" $\mathcal{P}^+$ always reduces them. If this is a general feature, it would mean that both exterior Weyl functions $\mathcal{U}^+$ and $\mathcal{P}^+$ have well defined consequences on stellar structures. Therefore an exterior solution with $\mathcal{U}^+ = 0$ and $\mathcal{P}^+ \neq 0$ surrounding a stellar distribution might be seen as an environment whose physical effects on the stellar structure are such that it can be considered as a region with negative effective pressure, hence this effect could be seen as a dark energy at cosmological scales. This is certainly an interesting case which deserves further investigation.

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