Dirac stars in the presence of Maxwell and Proca fields

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Abstract

The configurations consisting of a gravitating nonlinear spinor field ψ, with a nonlinearity of the type $\lambda\left(\bar{\psi}\psi\right)^2$, minimally coupled to Maxwell and Proca fields through the coupling constants Q_M (U(1) electric charge) and Q_P, respectively are considered. In order to ensure spherical symmetry of the configurations, we use two spin-1/2 fields having opposite spins. By means of numerical computations, we find families of equilibrium configurations with a positive ADM mass described by asymptotically flat solutions for static Maxwell and Proca fields and for stationary spinor fields. For the case of the Maxwell field, it is shown that, with increasing the charge Q_M, the masses of the objects increase and diverge as the charge tends to a critical value. For negative values of the coupling constant λ, it is demonstrated that, by choosing physically reasonable values of this constant, it is possible to obtain configurations with masses comparable to the Chandrasekhar mass and with effective radii of the order of kilometers. It enables us to speak of an astrophysical interpretation of such systems, regarding them as charged Dirac stars. In turn, for the system with the Proca field, it is shown that the mass of the configurations also grows with increasing both of $|\lambda|$ and of the coupling constant Q_P. Although in this case the numerical calculations do not allow us to make a definite conclusion about the possibility of obtaining masses comparable to the Chandrasekhar mass for physically reasonable values of λ, one may expect that such masses can be obtained for certain values of free parameters of the system under consideration.

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