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ORIGINAL ARTICLE

Variety of well behaved exact solutions of Einstein–Maxwell field equations: an application to Strange Quark stars, Neutron stars and Pulsars

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Abstract We present a variety of well behaved classes of Charge Analogues of Tolman's iv (1939). These solutions describe charged fluid balls with positively finite central pressure, positively finite central density; their ratio is less than one and causality condition is obeyed at the centre. The outmarch of pressure, density, pressure-density ratio and the adiabatic speed of sound is monotonically decreasing, however, the electric intensity is monotonically increasing in nature. These solutions give us wide range of parameter for every positive value of n for which the solution is well behaved hence, suitable for modeling of super dense stars. keeping in view of well behaved nature of these solutions, one new class of solutions is being studied extensively. Moreover, this class of solutions gives us wide range of constant K ($0.3 \le K \le 0.91$) for which the solution is well behaved hence, suitable for modeling of super dense stars like Strange Quark stars, Neutron stars and Pulsars. For this class of solutions the mass of a star is maximized with all degree of suitability, compatible with Quark stars, Neutron stars and Pulsars. By assuming the surface density $\rho_b = 2 \times 10^{14}$ g/cm^3 (like, Brecher and Caporaso in Nature 259:377, 1976), corresponding to $K = 0.30$ with $X = 0.39$, the resulting well behaved model has the mass $M = 2.12 M_\Theta$, radius $r_b \approx 15.27$ km and moment of inertia $I = 4.482 \times 10^{45}$ g cm^2; for $K = 0.4$ with $X = 0.31$, the resulting well behaved model has the mass $M = 1.80 M_\Theta$, radius $r_b \approx 14.65$ km and moment of inertia $I = 3.454 \times 10^{45}$ g cm^2; and corresponding to $K = 0.91$ with $X = 0.135$, the resulting well behaved model has the mass $M = 0.83 M_\Theta$, radius $r_b \approx 11.84$ km and moment of inertia $I = 0.991 \times 10^{45}$ g cm^2. For $n = 0$ we rediscovered Pant et al. (in Astrophys. Space Sci. 333:161, 2011b) well behaved solution. These values of masses and moment of inertia are found to be consistent with other models of Neutron stars and Pulsars available in the literature and are applicable for the Crab and the Vela Pulsars.

Keywords Charge fluid · Reissner–Nordstrom · Einstein–Maxwell · Exact solution

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1 Introduction

The charged fluid distributions with Einstein–Maxwell field equations, have always been interesting and realistic by virtue of the following reasons:

(i) the presence of some charge in a spherical material distribution provides an additional resistance against the gravitational contraction by mean of electric repulsion and hence, the catastrophic collapse of the entire mass to a point singularity can be avoided.
(ii) A solution which is not well behaved in neutral arena can be made well behaved with suitable choice of electrical intensity.
(iii) Einstein–Maxwell solutions are more general in nature due to presence of charge parameter K. Further, for $K = 0$, we are left with neutral solutions.

Due to vitality of above reasons, the modeling through Einstein–Maxwell field equations, more effectively explain the immense gravity astrophysical objects. Such models successfully explain the characteristics of massive objects like