Astrophys Space Sci (2012) 337:147–150
DOI 10.1007/s10509-011-0809-4

ORIGINAL ARTICLE

New class of well behaved exact Solutions for static charged Neutron-star with *perfect fluid*

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Received: 27 June 2011 / Accepted: 20 July 2011 / Published online: 1 September 2011

Abstract The paper presents a class of interior solutions of Einstein–Maxwell field equations in general relativity for a static spherically symmetric distribution of a charged fluid. This class of solutions describes well behaved charged fluid balls. This solution gives us wide range of parameter K $(0.53 \leq K \leq 0.95)$, for which the solution is well behaved hence, suitable for modeling of super dense star. For this solution the mass of a star is maximized with all degree of suitability and by assuming the surface density $\rho_b = 2 \times 10^{14}$ g/cm^3. Corresponding to $K = 0.95$ with $X = -0.15$, the maximum mass of the star comes out to be $M = 1.56\ M_\Theta$ with radius $r_b \approx 9.22$ km and the surface red shift $Z_b \approx 0.124207$. It has been observed that under well behaved conditions this class of solutions gives us the mass of super dense object within the range of neutron star. However, its neutral counter part is not well behaved.

Keywords Charge fluid · Reissener–Nordstrom · General relativity · Exact solution

1 Introduction

Ever since the formulation of Einstein's field equations, the relativists have been proposing different models of immense gravity astrophysical objects by considering the distinct nature of matter or radiation(energy-momentum tensor) present in them. Such models successfully explain the characteristics of massive objects like quasar, neutron star, pulsar, quark star, black-hole or other super-dense object. These stars are specified in terms of their masses as white dwarfs (Mass <1.44 solar mass), Quark star (2 solar mass–3 solar mass) and Neutron star (1.35 solar mass–2.1 solar mass).

Exact solutions with well behaved nature of Einstein–Maxwell field equations are of vital importance in relativistic astrophysics. Such solutions may be used to make a suitable model of super dense object with charge matter. Eventually, these exact solutions of the Einstein-Maxwell field equations joining smoothly to the Nordstrom solution at the pressure free interface. It is interesting to observe that, in the presence of charge, the gravitational collapse of a spherical symmetric distribution of the matter to a point singularity may be avoided. In this scenario gravitational attraction is counter balanced by the Colombian repulsive force together with the pressure gradient. On account of the nonlinearity of Einstein–Maxwell field equations, not many realistic well behaved, analytic solutions are known for the description of relativistic charge fluid spheres. For well behaved model of relativistic star with charged and perfect fluid matter, following conditions should be satisfied (Pant et al. 2011a):

(i) The solution should be free from physical and geometrical singularities i.e. finite and positive values of central pressure, central density and non zero positive values of e^{λ} and e^{υ}.
(ii) The solution should have positive and monotonically decreasing expressions for pressure and density (p and ρ) with the increase of r. The solution should have positive value of ratio of pressure-density and less than 1 (weak energy condition) and less than $1/3$ (strong energy condition) throughout within the star.
(iii) The solution should have positive and monotonically decreasing expression for fluid parameter $\frac{p}{\rho c^2}$ with the increase of r.
(iv) The solution should have positive and monotonically decreasing expression for velocity of sound $(\frac{dp}{d\rho})$ with

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