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Anisotropic Charged Solutions for Quark Stars with Linear Equation of State

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Abstract

We present two new classes of solutions for the Einstein-Maxwell system of field equations in a spherically symmetric spacetime considering the MIT bag model equation of state and a particular form of one of the metric potentials. The obtained solutions can be written in terms of elementary functions, namely polynomials and algebraic functions. The first class has a singularity at the centre. For the second class a physical analysis indicates that is regular and well behaved in the stellar interior.

Keywords: MIT bag model; Einstein-Maxwell system; Metric potential; Singularity

Introduction

The search of exact solutions for the Einstein-Maxwell system of field equations is an interesting area of research because it allows describe compact objects with strong gravitational fields as neutron stars [1,2]. It is for this reason that many researches have used a great variety of techniques to try in order to obtain solutions of the Einstein-Maxwell field as has been demonstrated by Komathiraj and Maharaj [3], Thirukkanesh and Maharaj [4], Maharaj, et al. [5], Thirukkanesh and Ragel [6,7], Feroze and Siddiqui [8,9], Sunzu, et al. [10], Pant, et al. [11] and Malaver [12-15].

Stellar models consisting of spherically symmetric distribution of matter with presence of anisotropy in the pressure have been widely considered in the frame of general relativity [16-24]. The existence of anisotropy within a star can be explained by the presence of a solid core, phase transitions, a type III super fluid [25], a pion condensation or another physical phenomenon by the presence of an electrical field [26].

In order to analytically integrate field equations the choice of the appropriate equation of state allows obtain models of compact stars physically acceptable [27]. Komathiraj and Maharaj [3], Malaver [28], Thirukkanesh and Maharaj [29] and Dey, et al. [30] assume linear equation of state for quark stars. Feroze and Siddiqui [8] consider a quadratic equation of state for the matter distribution and specify particular forms for the gravitational potential and electric field intensity. Mafa Takisa and Maharaj [31] obtained new exact solutions to the Einstein-Maxwell system of equations with a polytropic equation of state.

In this paper we generated new classes of exact solutions for anisotropic charged distribution with a linear equation of state consistent with quark matter. New models have been obtained by specifying a particular form for one of the metric potentials and for the measure of anisotropy. The paper has been organized as follows: In section 2, we present the Einstein-Maxwell field equations. In section 3, we have chosen a particular form of one of the gravitational potentials and the measure of anisotropy. In section 4, we conclude.

Field Equations

We consider a spherically symmetric, static and homogeneous spacetime. In Schwarzschild coordinates the metric is given by:

$$ds^2=-e^{2\nu(r)}dt^2+e^{2\lambda(r)}dr^2+r^2(d\theta^2+\sin^2\theta d\phi^2) \quad (1)$$

where $\nu(r)$ and a $\lambda(r)$ are two arbitrary functions.

Using the transformations, $x=cr^2$, $Z(x)=e^{-2\lambda(r)}$ and $A^2y^2(x)=e^{2\nu(r)}$ with arbitrary constants A and c>0, suggested by Durgapal and Bannerji [32], the Einstein-Maxwell field equations shown in [29] can be written as:

$$\frac{1-Z}{x}-2\dot{Z}=\frac{\rho}{C}+\frac{E^2}{2C} \quad (2)$$

$$4Z\frac{\dot{y}}{y}-\frac{1-Z}{x}=\frac{p_r}{C}-\frac{E^2}{2C} \quad (3)$$

$$p_t=p_r+\Delta \quad (4)$$

$$\frac{\Delta}{C}=4xZ\frac{\ddot{y}}{y}+\dot{Z}\left(1+2x\frac{\dot{y}}{y}\right)+\frac{1-Z}{x}-\frac{E^2}{C} \quad (5)$$

$$\sigma^2=\frac{4CZ}{x}\left(x\dot{E}+E\right)^2 \quad (6)$$

ρ is the energy density, p_r is the radial pressure, E is electric field intensity, p_t is the tangential pressure, σ is the charge density, $\Delta=p_t-p_r$ is the measure of anisotropy and dots denote differentiations with respect to x.

In this paper, we assume the following linear equation of state in the bag model

$$p_r=\frac{1}{3}\left(\rho-4B\right) \quad (7)$$

where B is the bag constant. We can write the Einstein-Maxwell field equations with the equation (7) in the following form

$$\rho=3p_r+4B \quad (8)$$

$$\frac{p_r}{C}=Z\frac{\dot{y}}{y}-\frac{1}{2}\dot{Z}-\frac{B}{C} \quad (9)$$

$$p_t=p_r+\Delta \quad (10)$$

$$\frac{E^2}{2C}=\frac{1-Z}{x}-3Z\frac{\dot{y}}{y}-\frac{1}{2}\dot{Z}-\frac{B}{C} \quad (11)$$

$$\sigma=2\sqrt{\frac{CZ}{x}}\left(x\dot{E}+E\right) \quad (12)$$

The Equations (8),(9), (10), (11), (12) governs the gravitational behavior of a anisotropic charged quark star.

New Classes of Solutions

Using the method suggested by Komathiraj and Maharaj [3], it is possible to obtain a exact solution of the Einstein-Maxwell system. According to Malaver [23], Komathiraj [33] and Komathiraj and Sharma [34], we take the particular form of the metric potential.

$$y(x)=\left(a+\alpha x^m\right)^n \quad (13)$$

where *a*, *m* and *n* are constants and α is an adjustable parameter. This potential is regular at the origin and well behaved in the interior of the sphere. We specify the measure of anisotropy of the following form:

$$\Delta=Cx\left(\alpha+x\right)^n \quad (14)$$

In this paper we have considered the particular cases:

Case I: With α=2/3, *n*=1 and *m*=1/2, the substitution of (13) and (14) in (5) allows to obtain the equation of the first order

$$\dot{Z}+\frac{\left[\frac{4x}{3\sqrt{x}}+a+\frac{2\sqrt{x}}{3}\right]}{2x\left[\frac{x}{3\sqrt{x}}+a+\frac{2\sqrt{x}}{3}\right]}Z=\frac{\left(\frac{x\Delta}{C}+1-\frac{2xB}{C}\right)\left(a+\frac{2\sqrt{x}}{3}\right)}{2x\left[\frac{x}{3\sqrt{x}}+a+\frac{2\sqrt{x}}{3}\right]} \quad (15)$$

Integrating (15), we obtain

$$Z(x)=\frac{6\sqrt{x}+\frac{4}{3}x^{5/2}+\frac{3}{2}x^{7/2}+\frac{18}{7}ax^{3}+\frac{12ax^{2}}{5}+18a-\frac{Bx\left(6\sqrt{x}+12a\right)}{C}}{18\left(\sqrt{x}+a\right)} \quad (16)$$

Z(x) allows generate the following analytical model:

$$e^{2\nu}=A^{2}\left(a+\frac{2}{3}x^{1/2}\right)^{2} \quad (17)$$

$$e^{2\lambda}=\frac{18\left(\sqrt{x}+a\right)}{6\sqrt{x}+\frac{4}{3}x^{5/2}+\frac{3}{2}x^{7/2}+\frac{18}{7}ax^{3}+\frac{12a}{5}x^{2}+18a-\frac{Bx}{C}\left(6\sqrt{x}+12a\right)} \quad (18)$$

$$p_r=\frac{6C\left(\sqrt{x}+3a\right)-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^{2}\left(\frac{2}{5}+\frac{3}{7}x\right)}{54\sqrt{x}\left(\sqrt{x}+a\right)\left(a+\frac{2}{3}\sqrt{x}\right)}$$
$$-\frac{\frac{3C}{\sqrt{x}}+3B\left(9\sqrt{x}+8a\right)+\frac{5}{2}Cx^{3/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+\frac{3}{2}Cx^{5/2}+12aCx\left(\frac{2}{5}+\frac{3}{7}x\right)+\frac{18}{7}aCx^{2}}{36\left(\sqrt{x}+a\right)} \quad (19)$$
$$+\frac{9\left(6C\sqrt{x}+18aC-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^{2}\left(\frac{2}{5}+\frac{3}{7}x\right)\right)}{2\left(18\left(\sqrt{x}+a\right)\right)^{2}\sqrt{x}}$$

$$\rho=\frac{6C\left(\sqrt{x}+3a\right)-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^{2}\left(\frac{2}{5}+\frac{3}{7}x\right)}{18\sqrt{x}\left(\sqrt{x}+a\right)\left(a+\frac{2}{3}\sqrt{x}\right)}$$
$$-\frac{\frac{3C}{\sqrt{x}}-3B\left(7\sqrt{x}+8a\right)+\frac{5}{2}Cx^{3/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+\frac{3}{2}Cx^{5/2}+12aCx\left(\frac{2}{5}+\frac{3}{7}x\right)+\frac{18}{7}aCx^{2}}{12\left(\sqrt{x}+a\right)} \quad (20)$$
$$+\frac{27\left(6C\sqrt{x}+18aC-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^{2}\left(\frac{2}{5}+\frac{3}{7}x\right)\right)}{2\left(18\left(\sqrt{x}+a\right)\right)^{2}\sqrt{x}}$$

$$p_t = \frac{6C\left(\sqrt{x}+3a\right)-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^2\left(\frac{2}{5}+\frac{3}{7}x\right)}{54\sqrt{x}\left(\sqrt{x}+a\right)\left(a+\frac{2}{3}\sqrt{x}\right)}$$

$$-\frac{\frac{3C}{\sqrt{x}}+3B\left(9\sqrt{x}+8a\right)+\frac{5}{2}Cx^{3/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+\frac{75}{2}Cx^{5/2}+12aCx\left(\frac{2}{5}+\frac{3}{7}x\right)+\frac{270}{7}aCx^2+24aCx+24Cx^{3/2}}{36\left(\sqrt{x}+a\right)} \quad (21)$$

$$+\frac{9\left(6C\sqrt{x}+18aC-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^2\left(\frac{2}{5}+\frac{3}{7}x\right)\right)}{2\left(18\left(\sqrt{x}+a\right)\right)^2\sqrt{x}}$$

$$E^2 = \frac{12C\sqrt{x}-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aC\left(\frac{2}{5}+\frac{3}{7}x\right)}{9x\left(\sqrt{x}+a\right)}$$

$$-\frac{\frac{3C}{\sqrt{x}}+6B\left(3\sqrt{x}+2a\right)+\frac{5}{2}Cx^{3/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+\frac{3}{2}Cx^{5/2}+12aCx\left(\frac{2}{5}+\frac{3}{7}x\right)+\frac{18}{7}aCx^2}{18\left(\sqrt{x}+a\right)}$$

$$+\frac{9\left(6C\sqrt{x}+18aC-6Bx\left(\sqrt{x}+2a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^2\left(\frac{2}{5}+\frac{3}{7}x\right)\right)}{2\left(18\left(\sqrt{x}+a\right)\right)^2\sqrt{x}} \quad (22)$$

$$-\frac{6C\left(\sqrt{x}+3a\right)-6Bx\left(\sqrt{x}+3a\right)+Cx^{5/2}\left(\frac{4}{3}+\frac{3}{2}x\right)+6aCx^2\left(\frac{2}{5}+\frac{3}{7}x\right)}{9\sqrt{x}\left(\sqrt{x}+a\right)\left(a+\frac{2}{3}\sqrt{x}\right)}$$

We have obtained a new exact solution to the Einstein-Maxwell system of equations with the MIT bag model equation of state. This new solution can be expressed in terms of elementary functions and has a simple form. The obtained model is singular in the charge density and energy density at the origin r=0, feature that is shared with the Mak and Harko [35] model but the metric potentials functions $e^{2\nu}$ and $e^{2\lambda}$ remain finite at the centre in contrast with the singularities that shown in the gravitational potentials of Mak and Harko when x=0.

Case II: With α=3, *n*=2 and *m*=1 we obtain for the metric function (13)

$$y(x) = \left(a+3x\right)^2 \quad (23)$$

and the equation of first order can be written as

$$\dot{Z} + \frac{\left[72x^2+36x(a+3x)+(a+3x)^2\right]}{2x\left[6x(a+3x)+(a+3x)^2\right]}Z = \frac{\left(x^2(3+x)^2+1-\frac{2xB}{C}\right)\left(a+3x\right)^2}{2x\left[6x\left(a+3x\right)+(a+3x)^2\right]} \quad (24)$$

Integrating (24), the gravitational potential *Z(x)* is given by

$$Z(x)=\frac{\begin{array}{l}81081x^{7}+(93555a+561330)x^{6}+(36855a^{2}+663390a+995085)x^{5}\\+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+\left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\\\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}-\frac{2Bx}{C}\left(135135x^{3}+173695ax^{2}+81081a^{2}x+15015a^{3}\right)\end{array}}{45045\left(a+3x\right)^{2}\left(9x+a\right)} \quad (25)$$

With equation (23) and equation (25) we can find the following analytical model

$$e^{2\nu}=A^{2}\left(a+3x\right)^{4} \quad (26)$$

$$e^{2\lambda}=\frac{45045\left(a+3x\right)^{2}\left(9x+a\right)}{\begin{array}{l}81081x^{7}+(93555a+561330)x^{6}+(36855a^{2}+663390a+995085)x^{5}\\+(5005a^{3}+270270a^{2}+1216215a)x^{4}+(38610a^{3}+521235a^{2}+173745)x^{3}+\\(81081a^{3}+243243a)x^{2}+135135a^{2}x+45045a^{3}-\frac{2Bx}{C}(135135x^{3}+173695ax^{2}+81081a^{2}x+15015a^{3})\end{array}} \quad (27)$$

$$\begin{array}{l}p_{r}=\dfrac{6C\left[\begin{array}{l}81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}\\+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+\left(38610a^{3}+521235a^{2}+173745\right)x^{3}\\+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}-\frac{2Bx}{C}\left(135135x^{3}+173695ax^{2}+81081a^{2}x+15015a^{3}\right)\end{array}\right]-45045B\left(a+3x\right)^{3}\left(9x+a\right)}{45045\left(a+3x\right)^{3}\left(9x+a\right)}\\
-C\dfrac{\left[\begin{array}{l}567567x^{6}+6\left(93555a+561330\right)x^{5}+5\left(36855a^{2}+663390a+995085\right)x^{4}+4\left(5005a^{3}+270270a^{2}+1216215a\right)x^{3}\\+3\left(38610a^{3}+521235a^{2}+173745\right)x^{2}+2\left(81081a^{3}+243243a\right)x+135135a^{2}-\frac{2B}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right)\\-\frac{2Bx}{C}\left(81081a^{2}+347390ax+405405x^{2}\right)\end{array}\right]}{90090\left(a+3x\right)^{2}\left(9x+a\right)}\\
+C\dfrac{\left[\begin{array}{l}81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+\\\left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}\\-\frac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right)\end{array}\right]}{15015\left(a+3x\right)^{3}\left(9x+a\right)}\\
+C\dfrac{\left[\begin{array}{l}81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}\\+\left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}\\-\frac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right)\end{array}\right]}{10010\left(a+3x\right)^{2}\left(9x+a\right)^{2}}\end{array} \quad (28)$$

$$
\begin{aligned}
\rho = {} & \frac{6C\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5} \\ +\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+\left(38610a^{3}+521235a^{2}+173745\right)x^{3} \\ +\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}-\dfrac{2Bx}{C}\left(135135x^{3}+173695ax^{2}+81081a^{2}x+15015a^{3}\right) \end{array}\right] +15015B\left(a+3x\right)^{3}\left(9x+a\right)}{15015\left(a+3x\right)^{3}\left(9x+a\right)} \\
& -C\frac{\left[\begin{array}{l} 567567x^{6}+6\left(93555a+561330\right)x^{5}+5\left(36855a^{2}+663390a+995085\right)x^{4}+4\left(5005a^{3}+270270a^{2}+1216215a\right)x^{3} \\ +3\left(38610a^{3}+521235a^{2}+173745\right)x^{2}+2\left(81081a^{3}+243243a\right)x+135135a^{2}-\dfrac{2B}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \\ -\dfrac{2Bx}{C}\left(81081a^{2}+347390ax+405405x^{2}\right) \end{array}\right]}{30030\left(a+3x\right)^{2}\left(9x+a\right)} \\
& +C\frac{\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+ \\ \left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3} \\ -\dfrac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \end{array}\right]}{5005\left(a+3x\right)^{3}\left(9x+a\right)} \\
& +3C\frac{\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4} \\ +\left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3} \\ -\dfrac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \end{array}\right]}{10010\left(a+3x\right)^{2}\left(9x+a\right)^{2}}
\end{aligned} \tag{29}
$$

$$
\begin{aligned}
p_{t} = {} & \frac{6C\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5} \\ +\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+\left(38610a^{3}+521235a^{2}+173745\right)x^{3} \\ +\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3}-\dfrac{2Bx}{C}\left(135135x^{3}+173695ax^{2}+81081a^{2}x+15015a^{3}\right) \end{array}\right] -45045B\left(a+3x\right)^{3}\left(9x+a\right)+45045Cx(3+x)^{2}\left(a+3x\right)^{3}\left(9x+a\right)}{45045\left(a+3x\right)^{3}\left(9x+a\right)} \\
& -C\frac{\left[\begin{array}{l} 567567x^{6}+6\left(93555a+561330\right)x^{5}+5\left(36855a^{2}+663390a+995085\right)x^{4}+4\left(5005a^{3}+270270a^{2}+1216215a\right)x^{3} \\ +3\left(38610a^{3}+521235a^{2}+173745\right)x^{2}+2\left(81081a^{3}+243243a\right)x+135135a^{2}-\dfrac{2B}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \\ -\dfrac{2Bx}{C}\left(81081a^{2}+347390ax+405405x^{2}\right) \end{array}\right]}{90090\left(a+3x\right)^{2}\left(9x+a\right)} \\
& +C\frac{\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4}+ \\ \left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3} \\ -\dfrac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \end{array}\right]}{15015\left(a+3x\right)^{3}\left(9x+a\right)} \\
& +C\frac{\left[\begin{array}{l} 81081x^{7}+\left(93555a+561330\right)x^{6}+\left(36855a^{2}+663390a+995085\right)x^{5}+\left(5005a^{3}+270270a^{2}+1216215a\right)x^{4} \\ +\left(38610a^{3}+521235a^{2}+173745\right)x^{3}+\left(81081a^{3}+243243a\right)x^{2}+135135a^{2}x+45045a^{3} \\ -\dfrac{2Bx}{C}\left(15015a^{3}+81081a^{2}x+173695ax^{2}+135135x^{3}\right) \end{array}\right]}{10010\left(a+3x\right)^{2}\left(9x+a\right)^{2}}
\end{aligned} \tag{30}
$$

$$E^2 = 2C\frac{\left[\begin{array}{l}675675Ca^2+2837835Cax+3648645Cx^2-81081Cx^6-\left(93555a+561330\right)Cx^5-\left(36855a^2+663390a+995085\right)Cx^4\\ -\left(5005a^3+270270a^2+1216215a\right)Cx^3-\left(38610a^3+521235a^2+173745\right)Cx^2-\left(81081a^3+243243a\right)Cx\\ -2B\left(135135x^3+173695ax^2+81081a^2x+15015a^3\right)-45045\left(a+3x\right)^2\left(9x+a\right)\end{array}\right]}{45045\left(a+3x\right)^2\left(9x+a\right)}$$
$$-2C\frac{\left[\begin{array}{l}81081x^7+\left(93555a+561330\right)x^6+\left(36855a^2+663390a+995085\right)x^5+\left(5005a^3+270270a^2+1216215a\right)x^4\\ +\left(38610a^3+521235a^2+173745\right)x^3+\left(81081a^3+243243a\right)x^2+135135a^2x+45045a^3-\frac{2Bx}{C}\left(15015a^3+81081a^2x+173695ax^2+135135x^3\right)\end{array}\right]}{5005\left(a+3x\right)^3\left(9x+a\right)}$$
$$-C\frac{\left[\begin{array}{l}567567x^6+6\left(93555a+561330\right)x^5+5\left(36855a^2+663390a+995085\right)x^4+4\left(5005a^3+270270a^2+1216215a\right)x^3+\\ 3\left(38610a^3+521235a^2+173745\right)x^2+2\left(81081a^3+243243a\right)x+135135a^2-\frac{2B}{C}\left(15015a^3+81081a^2x+173695ax^2+135135x^3\right)\\ -\frac{2Bx}{C}\left(81081a^2+347490ax+405405x^2\right)\end{array}\right]}{45045\left(a+3x\right)^2\left(9x+a\right)}$$
$$+2C\frac{\left[\begin{array}{l}81081x^7+\left(93555a+561330\right)x^6+\left(36855a^2+663390a+995085\right)x^5+\left(5005a^3+270270a^2+1216215a\right)x^4\\ +\left(38610a^3+521235a^2+173745\right)x^3+\left(81081a^3+243243a\right)x^2+135135a^2x+45045a^3\\ -\frac{2Bx}{C}\left(15015a^3+81081a^2x+173695ax^2+135135x^3\right)\end{array}\right]}{15015\left(a+3x\right)^3\left(9x+a\right)}$$
$$+\frac{C}{5005\left(a+3x\right)^2\left(9x+a\right)^2}\left[\begin{array}{l}81081x^7+\left(93555a+561330\right)x^6+\left(36855a^2+663390a+995085\right)x^5+\left(5005a^3+270270a^2+1216215a\right)x^4\\ +\left(38610a^3+521235a^2+173745\right)x^3+\left(81081a^3+243243a\right)x^2+135135a^2x+45045a^3\\ -\frac{2Bx}{C}\left(15015a^3+81081a^2x+173695ax^2+135135x^3\right)\end{array}\right] \quad (32)$$

This new exact model satisfies the Einstein-Maxwell field equations and constitutes a new family of analytical solutions for a charged strange quark star. The metric potentials $e^{2\nu}$ and $e^{2\lambda}$ can be written in terms of polynomials and elementary functions, are continuous, well behaved in the interior of the sphere and take finite values at the centre. The energy density ρ is positive throughout the interior of the star, regular at the centre and has the value $\rho_0 = 2\left(\frac{18C}{a}+B\right)$. The radial pressure is regular at the centre and reaches the value $p_0 = 2\left(\frac{6C}{a}-\frac{B}{3}\right)$. The electric field intensity is continuous inside the star and vanishes at the origin, $E^2 = 0$ en $x = 0$. Therefore the exact models can describe charged strange stars with physically acceptable interior distributions. The Figures 1-4 shows the dependence of e^{ν}, e^{λ}, ρ and p_r with the radial coordinate for a=0.4, B=0.05 and A=C=1. We considered the interval $0 \le r \le 1$.

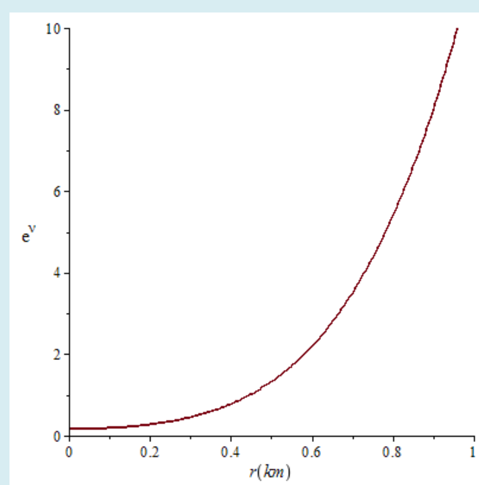

Figure 1: Metric potential e^{ν} with radial coordinate.

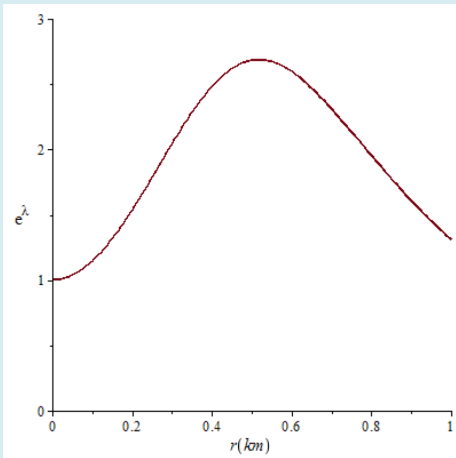

Figure 2: Metric function e^{λ} with radial coordinate.

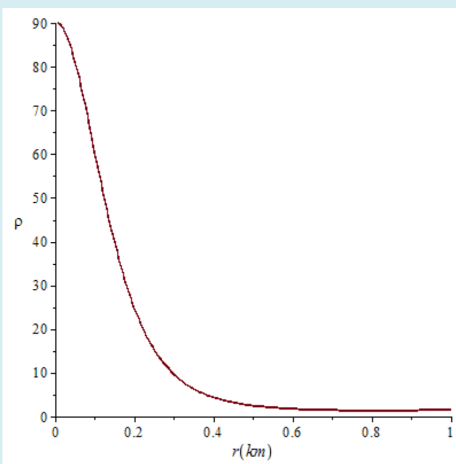

Figure 3: Energy density with radial coordinate.

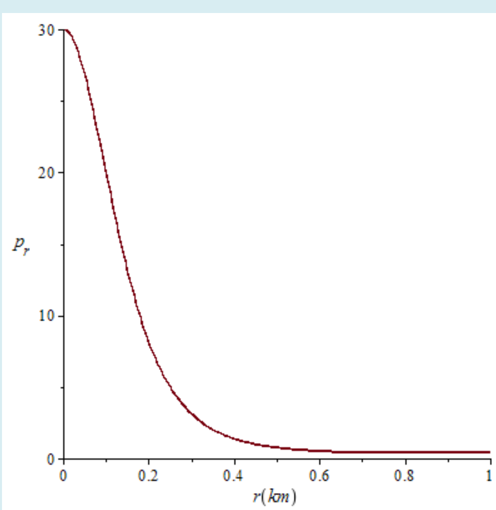

Figure 4: Radial pressure with radial coordinate.

Conclusion

We found a new class of exact solutions for the Einstein-Maxwell field equations for an anisotropic charged stellar configuration choosing a particular form the measure of anisotropy and one of the metric potentials. The MIT bag model equation of state was incorporated in the new obtained models for strange quark stars. We have analyzed two cases: The first is a model that admits a singularity in the electric field, radial pressure and energy density at the centre of the stellar object. The second is regular is regular throughout the stellar interior, has finite values for the gravitational potentials and not include singularities at the origin *r=0*. We hope that the new obtained models may contribute to studies of anisotropic quark stars with an electromagnetic field distribution and provide useful information in the description of compact strange candidates considering different equations of state.

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