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RESEARCH ARTICLE

ANISOTROPIC FLUID SPHERE IN GENERAL RELATIVITY

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ABSTRACT

Einstein's field equations for static field sphere with anisotropic pressure can be fixed exact. The solution is free from singularity and density of the fluid sphere drops continuously from its maximum value at the centre to the value which is positive at the boundary. The solution may be used in describing ultra compact objects also. If we choose the equation of state $P_r = P_l$, then in this case we obtain the well known Schwarzschild interior solution.

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INTRODUCTION

Analytical solutions of Einstein's field equation are of much value in General theory of relativity. Einstein's field equations solutions are obtained by using different conditions & assumptions. One of the assumption made for obtaining the solution is space –time be conform ally flat. Schwarzschild considered perfect fluid spheres with homogeneous density and Isotropic pressure in general relativity & obtained the solutions of relativistic field equations. Tolman developed a mathematical method for solving Einstein's field equations applied to static fluid sphere in such a manner as to provide explicit solutions in terms of known analytic functions. A numbers of new solutions were thus obtained and the properties of three of them were examined in details. Durgopal & Gehlot have obtained exact internal solution for dense massive stars in which the central pressure & density are infinitely large. Durgopal & Gehlot have further obtained exact solutions for a massive sphere with two different density distributions. The density being minimum at the surface varies inversely proportional to the square of the distance from the centre. The distribution has a core of constant density and Static & non – static solutions of Einstein's field equations have also been extremely discussed by Leibovitz for the spherical distributions. In investigation concerning massive object in general relativity the matter distribution is usually assumed to be locally isotropic. However, in the last few years theoretical studies on relativistic stellar models indicate that some massive object may be locally anisotropic. There are numbers of interesting solutions that have provided insight into the effects of anisotropy on star parameters. However many of these solutions have a limited applicability to astrophysical solutions since they do not satisfy certain physical restrictions usually imposed upon density and pressure viz. that the pressure should not exceed the energy density [dominant energy conditions] and that the [adiabatic] derivatives of the pressure with respect to the density should be less than or equal to unity [macro causality condition]. We have obtained an exact analytical solution of Einstein's field equations for static anisotropic fluid sphere by assuming that space-time is conform ally flat and by taking a judicious choice of energy density 'ρ'. The model is physically reasonable and free from singularity, energy density 'ρ' radial and tangentially pressure have been calculated for the model.

It is seen that densities for these motels drop continuously from their maximum values at the centre to the values, which are positive at the boundary.

Solution of the field equations

We have actually three equation in four unknown ρ, ρ_r, $P_\perp$ and H(r) and hence the system is indeterminate. For determinacy of the system we chose energy density 'ρ' as

$$16\pi\rho/3 = \mu [(3 + \mu r^2)] / (1 + \mu r^2)^2 \quad (1)$$

Where 'μ' is a constant to be a fixed up by boundary conditions.

$$e^{\lambda} = 2h / (3 - h) \quad (2)$$

$$h = (1 + LZ) \quad (3)$$

$$Z = r^2 / r_0^{\ 2} \quad (4)$$

$$L = 4\varepsilon / (3 - 4\varepsilon) \quad (5)$$

Where 'm' & 'r_0' are the mass and radius of the sphere. Also the function H(r) is given by

$$e^{-H} r_0^2 = \exp [\sqrt{2} \mathrm{Sin}^{-1} (3 - 2h)/3] X [3 + h + 2 \sqrt{2}(1+h - L^2Z^2) / Z] \quad (6)$$

Putting these values in equation (6), we can find the value of e^{γ}

$$e^{-\gamma} = r^2 [\alpha e^{H(r)} + \beta e^{-H(r)}] \quad (7)$$

Where μ,α and β are constants of integration.

The density, radial pressure and tangential pressure are obtained as

$$8\pi\rho\, r_0^{\ 2} = L / h[(2+ h)/2h] \quad (8)$$

$$8\pi P_r r_0^2 = B_z/\alpha\, e^{-H} r_0^2 [4 + 4z (9\text{-}5h + 2\sqrt{2t} - 5LZ - \sqrt{2t})] / 2zh[LZ + B_z /\alpha\, e^{-H} r_0^2] \quad (9)$$

$$8\pi P_\perp r_0^2 = 3L^2z/ h^2 + B_z/\alpha\, e^{-H} r_0^2 [9 + 5h - 2\sqrt{2t} + LZ (9\text{-}5h+2\sqrt{2t})] / 2zh[LZ + B_z /\alpha\, e^{-H} r_0^2] \text{ --} \quad (10)$$

$$\text{Where } t = (1 + h - L^2 Z^2]^{1/2} \quad (11)$$

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