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PLANE GRAVITATIONAL WAVES WITH WET DARK ENERGY IN BIMETRIC RELATIVITY

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ABSTRACT

Four dimensional plane gravitational waves Z = z – t is studied with the source of matter dark energy component of the universe i.e. wet dark fluid in the context of Bimetric Theory Of Relativity , and found that the matter does not exist in this theory.

Key Words:*-Plane gravitational waves, wet dark fluid, bimetric relativity.*

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1. INTRODUCTION:

One of the mysteries of cosmology is the nature of the dark energy component of the Universe. There is ,definitely no lack of :cosmological constant , phantom energy , quintessence k- essence etc. To explain the acceleration of the Universe ,modified Friedmann equation such as Cardassion expansion and also what might be derived from brane cosmology have been used. Inthis work ,wet dark fluid (WDF) as a model for dark energy is used in Bimetric Relativity. This model is generalized Chaplygin gas (GCG) where an equation of state is offered with properties relevant for the dark energy problem.

The equation of state for WDF is very simple.

$$p_{WDF} = \gamma (\rho_{WDF} - \rho_*) \quad (1.1)$$

and it is a good approximation for many fluids including water, where the internal attraction of the molecules make negative pressure possibly. The parameters γ and ρ_* are taken to be positive with $0 \le \gamma \le 1$.

In the homogeneous, isotropic FRW model, the wet dark fluid has been used as dark energy and the early stage of expansion of the Universe exhibits substantially non Friedmannian nature. (for detail one may refer [1])

In this paper we have studied Z = z – t type plane gravitational wave with the matter source dark energy component of the universe i.e. wet dark fluid in the context of Bimetric Theory Of Relativity , and found that plane gravitational wave does not accommodate wet dark fluid in this theory .

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2. FIELD EQUATIONS IN BIMETRIC RELATIVITY:

The field equations of bimetric relativity proposed by Rosen [2, 3] are -

$$K_i^j = N_i^j - ½ N g_i^j = - 8\pi k T_i^j \quad (2.1)$$

Where

$$N_i^j = ½ \gamma^{\alpha\beta} [g^{hj} g_{hi} |\alpha]|\beta \quad (2.2)$$

It means

$$N_i^j = ½ \gamma^{\alpha\beta} [g^{hj}{}_{|\beta} g_{hi|\alpha} + g^{hj} g_{hi|\alpha|\beta}] \quad (2.3)$$

$$N = N_\alpha^\alpha \qquad k = \sqrt{(g / \gamma)} \ , \ g = \det.g_{ij} , \gamma = \det. \gamma_{ij} \quad (2.4)$$

And a vertical bar (|)denotes the γ – differentiation with respect to γ_{ij} .

T_i^j is the energy momentum tensor of the source wet dark energy is denoted by

$$T_i^j = (\rho_{wdf} + p_{wdf}) u_i u^j - p_{wdf} \delta_i^j \quad (2.5)$$

where u^i is the flow vector satisfying

$$g_{ij}u^i u^j = 1 \quad (2.6)$$

In a commoving system of coordinates, from equation (2.5) we find that

$$T_4^4 = \rho_{wdf},\ T_1^1 = T_2^2 = T_3^3 = -\,p_{wdf} \qquad (2.7)$$

3. PLANE GRAVITATIONAL WAVE SOLUTIONS WITH WET DARK FLUID:

Let us consider four dimensional $Z = z - t$ plane gravitational wave

$$ds^2 = -\,A dx^2 - B dy^2 - (1-E)\,dz^2 - 2E\,dz\,dt + (1+E)\,dt^2 \qquad (3.1)$$

where $A = A(Z)$, $B = B(Z)$, $E = E(x,y,z,t)$ and $Z = z - t$

and corresponding to equation (3.1) the background metric is

$$d\sigma^2 = -\,(dx^2 + dy^2 + dz^2) + dt^2 \qquad (3.2)$$

since γ_{ij} Lorentze metric (-1,-1,-1,+1), the γ –covariant derivative becomes the ordinary partial derivative.

Using the equations (3.1), (3.2) and (2.3)we have -

$$g_{11|3} = -A', \quad g^{11}{}_{|3} = A^{-2}A', \quad g_{11|3|3} = -A''$$

$$g_{11|4} = A', \quad g^{11}{}_{|4} = -A^{-2}A', \quad g_{11|4|4} = -A''$$

$$g_{22|3} = -B', \quad g^{22}{}_{|3} = B^{-2}B', \quad g_{22|3|3} = -B''$$

$$g_{22|4} = B', \quad g^{22}{}_{|4} = -B^{-2}B', \quad g_{22|4|4} = -B''$$

$$g_{33|1} = E_x, \quad g^{33}{}_{|1} = -E_x, \quad g_{33|1|1} = E_{xx}$$

$$g_{33|2} = E_y, \quad g^{33}{}_{|2} = -E_y, \quad g_{33|2|2} = E_{yy}$$

$$g_{33|3} = E_z, \quad g^{33}{}_{|3} = -E_z, \quad g_{33|3|3} = E_{zz}$$

$$g_{33|4} = E_t, \quad g^{33}{}_{|4} = -E_t, \quad g_{33|4|4} = E_{tt}$$

$$g_{44|1} = E_x, \quad g^{44}{}_{|1} = -E_x, \quad g_{44|1|1} = E_{xx}$$

$$g_{44|2} = E_y, \quad g^{44}{}_{|2} = -E_y, \quad g_{44|2|2} = E_{yy}$$

$$g_{44|3} = E_z, \quad g^{44}{}_{|3} = -E_z, \quad g_{44|3|3} = E_{zz}$$

$$g_{44|4} = E_t, \quad g^{44}{}_{|4} = -E_t, \quad g_{44|4|4} = E_{tt}$$

$$g_{34|1} = -E_x, \quad g^{34}{}_{|1} = -E_x, \quad g_{34|1|1} = -E_{xx}$$

$$g_{34|2} = -E_y, \quad g^{34}{}_{|2} = -E_y, \quad g_{34|2|2} = -E_{yy}$$

$$g_{34|3} = -E_z, \quad g^{34}{}_{|3} = -E_z, \quad g_{34|3|3} = -E_{zz}$$

$$g_{34|4} = -E_t, \quad g^{34}{}_{|4} = -E_t, \quad g_{34|4|4} = -E_{tt}$$

$$g_{43|1} = -E_x, \quad g^{43}{}_{|1} = -E_x, \quad g_{43|1|1} = -E_{xx}$$

$$g_{43|2} = -E_y, \quad g^{43}{}_{|2} = -E_y, \quad g_{43|2|2} = -E_{yy}$$

$$g_{43|3} = -E_z, \quad g^{43}{}_{|3} = -E_z, \quad g_{43|3|3} = -E_{zz}$$

$$g_{43|4} = -E_t, \quad g^{43}{}_{|4} = -E_t, \quad g_{43|4|4} = -E_{tt} \qquad (3.3)$$

where $\partial A / \partial Z = A'$, $\partial^2 A / \partial Z^2 = A''$, $\partial E / \partial x = E_x$, $\partial^2 E / \partial x^2 = E_{xx}$ .etc.

Using the equations (2.1) to (3.3) we have the field equations:

$$K_1^1 = K_2^2 = 0 = 8\pi k p_{wdf} \qquad (3.4)$$

$$K_3^3 = \tfrac{1}{2}\,(E_{xx} + E_{yy} + E_{zz} - E_{tt}) = 8\pi k p_{wdf} \qquad (3.5)$$

$$K_4^4 = \tfrac{1}{2}\,(E_{xx} + E_{yy} + E_{zz} - E_{tt}) = 8\pi k \rho_{wdf} \qquad (3.6)$$

Using the equations (3.4) – (3.6) we get –

$$p = 0 = \rho \qquad (3.7)$$

Thus equation (3.7) shows that , there is no contribution from wet dark fluid to the plane gravitational waves in bimetric theory of relativity.

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