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ORIGINAL ARTICLE

Electromagnetic field and dynamics of tilted Lemaitre-Tolman-Bondi spacetimes

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Abstract In this paper, we investigate the dynamics of Lemaitre-Tolman-Bondi spacetimes with imperfect fluid in the presence of electromagnetic field. We study the effects of charge with respect to an observer moving radially relative to the fluid, that is, a tilted observer. The relationship between various quantities in the tilted and non-tilted congruences is developed using the Einstein-Maxwell field equations. We explore various factors affecting the inhomogeneities in the energy density of the fluid and also discuss the stability of the non-tilted congruence.

Keywords Tilted observers · Electromagnetic field · Energy density inhomogeneity

1 Introduction

It is a well-known fact that a number of spacetimes with different energy-momentum tensors satisfy the Einstein field equations. This is due to the fact that the description of the energy-momentum tensor depends upon the arbitrary choice of the four-velocity of the observer. The four-velocity plays a key role in deciding the values of many basic quantities (such as acceleration, entropy, shear tensor, expansion scalar etc.) in different physical processes. Thus the significance of the observer cannot be denied in any physical phenomenon. It would, therefore, be interesting to explore properties of a spacetime with respect to two observers with different velocities such that one observer congruence corresponds to a boost of the other. In reality, the physical scenario of relative velocity (tilting) can be observed in the motion of our galaxy relative to the microwave background radiation.

Coley and Tupper (1983) studied the flat FRW model with perfect fluid and found that for the observers at rest relative to the timelike congruence, i.e., standard observers, this behaves as a perfect fluid model. However, for the observers in motion relative to the congruence, i.e., tilted observers, this model corresponds to the exact solution for a viscous dissipative fluid. They concluded that the tilted observer detects inhomogeneities in the energy density of an imperfect fluid along with the differences in the shear tensor and expansion scalar.

Triginer and Pavon (1995a) proved that an imperfect fluid may admit the reversible processes. They argued that it is necessary to check the compatibility of the imperfect fluid with reversible process which is related to the divergence of four-vector entropy. The non-zero divergence implies dissipation within the fluid. According to Eckart theory (Eckart 1940), the reversible process within the imperfect fluid (i.e., vanishing entropy production) can be developed through a conformal Killing vector $\mathcal{K}^\alpha$, where $\mathcal{K}^\alpha = \frac{V^\alpha}{T}$. Here V^α and T denote the four-velocity and temperature, respectively. However, if a general transport equation within the context of causal Israel-Stewart theory is adopted then due to the conformal Killing vector and the condition of reversibility the heat flux vector vanishes and the system no longer remains dissipative (Herrera et al. 2012). Diffusion and streaming out are the two possible approximations considered in the dissipative process (Sharif and Bashir 2012).

A high measure of dissipation is observed during the process of gravitational collapse of a star. When nuclear fuels of a star burn out, gravity starts taking over which initiates

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