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ORIGINAL ARTICLE

Wormholes supported by two non-interacting fluids

Farook Rahaman · Saibal Ray · Safiqul Islam

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Abstract We provide a new matter source that supplies fuel to construct wormhole spacetime. The exact wormhole solutions are found in the model having, besides real matter, an anisotropic dark energy. We have shown that the exotic matters that are the necessary ingredients for wormhole physics violate null and weak energy conditions but obey strong energy condition marginally. Though the wormhole comprises of exotic matters yet the effective mass remains positive. We have calculated the effective mass of the wormhole up to 8 km from the throat (assuming throat radius as 4 km) as $1.3559 M_{\odot}$. Some physical features are briefly discussed.

Keywords General relativity · Dark energy · Wormholes

1 Introduction

It was revealed by the observations on supernova due to the High-z Supernova Search Team (HZT) and the Supernova Cosmology Project (SCP) (Riess et al. 1998; Perlmutter et al. 1998) that the present expanding Universe is getting gradual acceleration. As a cause of this acceleration it is argued that a kind of exotic matter having repulsive force is responsible for speeding up the Universe some 7 billion years ago. To understand the nature of this hypothetical energy that tends to increase the rate of expansion of the Universe several models have been proposed by the scientists so far (Overduin and Cooperstock 1998; Sahni and Starobinsky 2000).

As far as matter content of the Universe is concerned, it is convincingly inferred from distant supernovae, large scale structure and CMB, that 96 % of matter is hidden mass constituted by 23 % dark matter and 73 % unknown exotic entity known as dark energy whereas only 4 % mass in the form of ordinary mass which is visible contrary to the non-luminous dark matter (Pretzl 2004; Freeman and McNamara 2006; Wheeler 2007; Gribbin 2007).

On the other hand, theoretically a *wormhole*, which is similar to a tunnel with two ends each in separate points in spacetime or two connecting black holes, was conjectured first by Weyl (Coleman and Korte 1985) and later on by Wheeler (1957). This is essentially some kind of hypothetical topological feature of spacetime which may acts as *shortcut* through spacetime. In principle this means that a wormhole would allow travel in time as well as in space and can be shown explicitly how to convert a wormhole traversing space into one traversing time (Morris et al. 1988). The possibility of traversable wormholes in general relativity was demonstrated by Morris and Thorne (1988) which held open by a spherical shell of exotic matter whereas quite a number of wormhole solutions were obtained much earlier with different physical motivation by other scientists (Ellis 1973; Bronnikov 1973; Clement 1984).

However, other types of wormholes where the traversing path does not pass through a region of exotic matter were also available in the literature (Visser 1989, 1996).

In this connection we are interested to mention that in some of our previous works we dealt with a new type of thin-shell wormhole constructed by applying the cut-and-

F. Rahaman · S. Islam
Department of Mathematics, Jadavpur University, Kolkata 700 032, West Bengal, India

F. Rahaman
e-mail: rahaman@iucaa.ernet.in

S. Islam
e-mail: sofiqul001@yahoo.co.in

S. Ray (✉)
Department of Physics, Government College of Engineering & Ceramic Technology, Kolkata 700 010, West Bengal, India
e-mail: saibal@iucaa.ernet.in