IJASRM

International Journal of Advanced Scientific Research and Management, Volume 3 Issue 12, Dec 2018

www.ijasrm.com

ISSN 2455-6378

Correspondence between the polytropic gas dark energy model and Tachyon scalar field

Prasanta Das[1], Dr.Shibu.Basak[2]

[1]Research Scholar, Department of Mathematical Sciences, Bodoland University, Kokrajhar, BTC, Assam, India.

[2] Associate Prof.and Head of Department of Mathematics, Kokrajhar Govt. College, Kokrajhar, BTC, Assam, India

Abstract: In this work we establish a correspondence between the polytropic gas dark energy model and Tachyon scalar field. Also we find the dynamics and potential of the Tachyon field in the context of polytropic gas dark energy model.

Keywords: *Dark energy, Polytropic gas, Tachyon field.*

1. Introduction

Cosmologist's belief that our universe expands under an accelerated expansion [1]-[7].In standard Friedman Lemaitre Robertson Walker (FLRW) cosmology, a new energy with negative pressure, called dark energy (DE) is responsible for this expansion [8]. The nature of the DE is still unknown and various problems have been proposed by the researchers in this field**.** About 70% of the present energy of the universe is contained in the DE. The cosmological constant with the time independent equation of state is the earliest and simplest candidate for the dark energy. Besides the cosmological constant, there are many dynamical dark energy models with the time dependent equation of state that have been proposed to explain the cosmic acceleration. Polytropic gas is one of the dynamical dark energy models [9]. In this work, we focus on the polytropic gas model as a DE model. The polytropic gas DE model is a phenomenological model of dark energy where the pressure is a function of energy density [10]. The Tachyon scalar field can be considered as a source of dark energy. In this paper we establish a correspondence between the polytropic gas dark energy model and Tachyon scalar field. Also we find the dynamics and potential of the Tachyon field in the context of polytropic gas dark energy model.

2. Polytropic gas Tachyon field model

Equation of state (EOS) of the polytropic gas is given by [11]

$$p_\Lambda = k\rho_\Lambda^{1+\frac{1}{n}} \qquad (1)$$

Where p_Λ , ρ_Λ , k, and n are the pressure, energy density, polytropic constant and polytropic index respectively. The polytroic index is considered to be even.

The conservation equation for the dark energy in the FRW universe is given by

$$\dot{\rho}_\Lambda + 3H(\rho_\Lambda + p_\Lambda) = 0 \qquad (2)$$

Where H is the Hubble parameter and a dot are denotes the differentiation with respect to the cosmological time.

Using the EOS (1) into the conservation equation (2) and integrating we get

$$\rho_\Lambda = \left[Ba^{3/n} - k\right]^{-n} \qquad (3)$$

Where B is a positive integration constant and $a(t)$ is a time scale factor of the universe .

IJASRM

International Journal of Advanced Scientific Research and Management, Volume 3 Issue 12, Dec 2018

www.ijasrm.com

ISSN 2455-6378

When $k > Ba^{3/n}$, we see that $\rho_\Lambda > 0$ for even values of n .Also when $k = Ba^{3/n}$, we see that $\rho_\Lambda \to \infty$ and the polytropic gas has a finite time singularity at $a_s = \left(\frac{k}{B}\right)^{n/3}$.

Using equations (1) & (3), the EOS parameter of the polytropic gas dark energy model is obtained as

$$\omega_\phi = \frac{p_\Lambda}{\rho_\Lambda} = -1 + \frac{Ba^{3/n}}{Ba^{3/n} - k} \quad (4)$$

When $k > Ba^{3/n}$, we see that $\omega_\Lambda < -1$ which corresponds to a universe dominated by phantom field; when $k < Ba^{3/n}$, we see that $\omega_\Lambda > -1$ which corresponds to a quintessence dominated universe; also when $k = Ba^{3/n}$, we see that $\omega_\Lambda \to \infty$ which corresponds to a singularity at $a_s = \left(\frac{k}{B}\right)^{n/3}$

The energy density and pressure of the Tachyon scalar field are

$$\rho_\phi = \frac{V(\phi)}{\sqrt{1-\dot{\phi}^2}} \quad (5)$$

$$p_\phi = -V(\phi)\sqrt{1-\dot{\phi}^2} \quad (6)$$

The EOS parameter of the Tachyon field is given by

$$\omega_\phi = \frac{p_\phi}{\rho_\phi} = \dot{\phi}^2 - 1 \quad (7)$$

When $\dot{\phi}^2 < 0$ then from (7) we see that $\omega_\phi < -1$ which represents a phantom field. The phantom field lead to accelerated expansion of the universe and hence the Tachyon field can interpret the accelerated expansion of the Universe.

Using equation (4) in (15) and (3) in (13) we get

$$\omega_\phi = -1 + \frac{Ba^{3/n}}{Ba^{3/n} - k} = \dot{\phi}^2 - 1 \quad (8)$$

$$\rho_\Lambda = \left[Ba^{3/n} - k\right]^{-n} = \frac{V(\phi)}{\sqrt{1-\dot{\phi}^2}} \quad (9)$$

From the equations (8) and (9) we can find the dynamics and potential of the Tachyon field in the context of polytropic gas dark energy model as follows

$$\dot{\phi}^2 = \frac{Ba^{3/n}}{Ba^{3/n} - k} \quad (10)$$

$$V(\phi) = \left[Ba^{3/n} - k\right]^{-n}\sqrt{1-\dot{\phi}^2} \quad (11)$$

If $k > Ba^{3/n}$, then from the equation (10) we see that $\dot{\phi}^2 < 0$ which represents the phantom behavior of the Tachyon field and from the equation (11) we see that $V(\phi) > 0$

3. Conclusion

The correspondence between the polytropic gas dark energy model and Tachyon scalar field can be established and we see that the Tachyon field behaves as phantom field. Therefore the Tachyon field can interpret the accelerated expansion of the Universe. Also we can find the dynamics and potential of the Tachyon field in the context of polytropic gas dark energy model.

Acknowledgements

We would like to thank Dr.D.K.Mitra (HOD), Department of Mathematical Sciences, Bodoland University, Kokrajhar, BTC, Assam, India and our colleagues for valuable Suggestions.

References

[1] A.G. Riess, et al.: "Type Ia Supernova Discoveries at z > 1 from the Hubble Space Telescope: Evidence for Past Deceleration and Constraints on Dark Energy Evolution", *Astro phys. J.*, vol. 607, pp. 665-687, June 2004

[2] A.G. Riess, et al., "New Hubble space telescope discoveries of type Ia supernovae at z≥ 1: narrowing constraints on the early behavior of dark energy", *Astrophys. J* .vol. 659, pp. 98–121, Apr 2007

[3] R. R. Caldwell and M. Doran, "Cosmic microwave background and supernova constraints on quintessence: concordance regions and target models," *Physical Review D*, vol. 69, no.10, Article ID103517, 2004

[4] T. Koivisto and D. F. Mota, "Dark energy anisotropic stress and large scale structure formation," *Physical Review D*, vol. 73, no. 8, Article ID 083502, 12 pages, 2006. View at

Publisher · View at Google Scholar ·View at MathSciNet

[5] S. F. Daniel, R. R. Caldwell, A. Cooray, and A. Melchiorri, "Large scale structure as a probe of gravitational slip," *Physical Review D*, vol. 77, no. 10, Article ID 103513, 12 pages, 2008. View at Publisher· View at Google Scholar

[6] D. N. Spergel, et al., "First-Year Wilkinson Microwave Anisotropy Probe (WMAP)*Observations: Determination of Cosmological Parameters", *Ap J S*, vol.148, pp.135-159, Sep. 2003.

[7] M.Tegmark, et al,"Cosmological parameters from SDSS and WMAP", *Physical Review D*, vol-69, pp.103501, May 2004

[8] R. Kalita"Dark Energy", *Journal of Modern Physics*, vol-6, pp.1007-1011, June 2015

[9] U. Mukhopadhyay, S. Ray, S.B. Dutta Choudhury, "Dark energy with polytropic equation of state", *Mod.Phys. Lett.A*, vol. 23, pp. 3187-3198, Dec 2008.

[10] M.Malekjani, "Polytropic Gas Scalar Field Models of Dark Energy*", Int J Theor Phys*, vol. 52, pp. 2674-2685, August. 2013.

[11] J. Christensen-Dalsgard, *Lecture Notes on Stellar and Structure and Evolution*, 6th edn, Aarhus University Press, Aarhus, 2004.

[12] M.R.Setare, V.Kamali, "Tachyon–polytropic inflation on the brane" *Cent. Eur. J.Phys*. vol.11, pp.545-552, May 2013

[13] A.Sheykhi, "Interacting agegraphic tachyon model of dark energy" *Physics Letter B*, vol.682, pp.329-333, Jan 2010.