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Research Article

K-ESSENCE POLYTROPIC GAS DARK ENERGY MODEL

Prasanta Das[1] and Shibu Basak[2]

[1]Department of Mathematical Sciences, Bodoland University, Kokrajhar, BTC, Assam, India
[2]Department of Mathematics, Kokrajhar Govt. College, Kokrajhar, BTC, Assam, India

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A B S T R A C T

In this work, we study the correspondence between the K-Essence scalar field and the polytropic gas dark energy model. This correspondence allows for reconstructing the K-Essence scalar field with reference to the polytropic gas dark energy model, which describe accelerated expansion of the universe.

INTRODUCTION

Many Cosmological experiments and observations such as Type 1a Supernovae[1],[2], Cosmic Microwave Background Radiation[3], Large Scale Structure[4],[5], Wilkinson Microwave Anisotropy Probe[6], Sloan Digital Sky Survey[7]etc. indicates that our universe expands under an accelerated expansion. 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]. The polytropic gas DE model is a phenomenological model of dark energy where the pressure is a function of energy density [10]. In this work, we study the correspondence between the K-Essence scalar field and the polytropic gas dark energy model. This correspondence allows to reconstructing the K-Essence scalar field with reference to the polytropic gas dark energy model, which describe accelerated expansion of the universe.

Corresponding author:* **Prasanta Das
Department of Mathematical Sciences, Bodoland University, Kokrajhar, BTC, Assam, India

Reconstruction of K-Essence Polytropic Gas Dark Energy Model

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

$$p_\Lambda = k\rho_\Lambda^{1+\frac{1}{n}} \tag{1}$$

Wherep_Λ,ρ_Λ ,k,and n are the pressure, energy density, polytropic constant and polytropic index respectively.

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

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

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

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

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

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

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

When $k > Ba^{3/n}$, then from (4) we see that $\omega_\Lambda < -1$ which corresponds to a universe dominated by phantom dark energy; when $k < Ba^{3/n}$, then from (4) 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 K-Essence scalar field is given by

$$S = \int d^4x\sqrt{-g}\ p(\phi,\chi) \tag{5}$$

Where the Lagrangian density $p(\phi,\chi)$ correspondence to the pressure density and energy density via the following equations

$$p(\phi,\chi) = f(\phi)(-\chi + \chi^2) \tag{6}$$

$$\rho(\phi,\chi) = f(\phi)(-\chi + 3\chi^2) \tag{7}$$

The EOS parameter of K-Essence is given by

$$\omega_k = \frac{p(\phi,\chi)}{\rho(\phi,\chi)} = \frac{\chi-1}{3\chi-1} \tag{8}$$

When $\frac{1}{3} < \chi < \frac{1}{2}$, then $\omega_k < -1$ which represents phantom energy and hence the K-Essence scalar field can interpret the accelerated expansion.
Using (4) in (8) we get

$$\omega_\phi = -1 + \frac{Ba^{3/n}}{Ba^{3/n} - k} = \frac{\chi-1}{3\chi-1} \tag{9}$$

The parameter χ can be obtained as

$$\chi = \frac{2+\frac{Ba^{3/n}}{k-Ba^{3/n}}}{4+3\frac{Ba^{3/n}}{k-Ba^{3/n}}} \tag{10}$$

Using $2\chi = \dot{\phi}^2$ in (10) we get

$$\dot{\phi}^2 = \frac{4+2\frac{Ba^{3/n}}{k-Ba^{3/n}}}{4+3\frac{Ba^{3/n}}{k-Ba^{3/n}}} \tag{11}$$

When $k > Ba^{3/n}$, then from (11) we see that $\dot{\phi}^2 > 0$, (positive kinetic energy), therefore the scalar field is a quintessence field. When $k < Ba^{3/n}$, then from (11) we see that $\dot{\phi}^2 < 0$(negative kinetic energy), therefore the scalar field is a phantom field. The phantom field lead to super accelerated expansion of the universe.

CONCLUSIONS

Due the presence of polytropic gas in the form $p_\Lambda = k\rho_\Lambda^{1+\frac{1}{n}}$, wherep_Λ,ρ_Λ, k and n are pressure, energy density, polytropic constant and polytropic index , an universe may bedominated by the K-Essence scalar field which can interpret the accelerated expansion when$\frac{1}{3} < \chi < \frac{1}{2}$and may be dominated by phantom field or quintessence field according as $k < Ba^{3/n}$or $k > Ba^{3/n}$.

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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”, *Astrophys. 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,” *PhysicalReview 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”DarkEnergy”, *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 TheorPhys, vol. 52, pp. 2674-2685, August. 2013.
11. J. Christensen-Dalsgard, *Lecture Notes on Stellar and Structure and Evolution*, 6thedn, Aarhus University Press, Aarhus, 2004.
12. M.Malekjani, A.Khodam-Mohammadi, M.Taji, “Cosmological Implications of interacting Polytropic Gas Dark Energy Model in Non-flat Universe”, *Int J TheorPhys*, vol. 50, pp. 3112-3124, Oct. 2011.
13. S.Perlmutter, “Supernovae, Dark Energy and the accelerating Universe”, *Physics Today*, vol 56, pp. 53, April 2003.
14. M.R.Setare, F.Darabi, “Polytropic Inspired Inflation”, *Chinese Journal of Physics*, vol 51, pp. 427-434, June 2013.
15. S.Asadzadeh, Z.Safari, K.Karami, A. Abdolmaleki, ”Cosmological Constraints on Polytropic Gas Model” *Int J Theor Phys*, vol. 53, pp.1248-1262, April. 2015.