ABSTRACT

According to several cosmological experiments and observations, the present Universe is expanding with acceleration due to the presence of dark energy (DE). There are many DE candidates, so we require further investigate about these candidates to know about the expansion history and behavior of the Universe. Polytropic gas is one of them so here we investigate about the different Polytropic gas DE models in this work. The thesis entitled "POLYTROPIC GAS DARK ENERGY MODELS IN COSMOLOGY" consists of 10 (Ten) chapters and its 7 (Seven) chapters are based on the Polytropic gas DE models of different kinds.

Chapter-1 deals with the Introduction about this research work. In this chapter, we have highlighted the definition and history of the cosmology, some Principles and laws associated to the topic, cosmological models, the fate of the Universe, different cosmological parameters, terms related with basic terminologies, some observational facts for the DE and present accelerated expansion of the Universe, some candidates for DE, some cosmological problems, Einstein's field equation, Friedmann -Robertson-Walker (FRW) metric and Friedmann equations. Further, the objectives of the research work are also presented here.

In **Chapter-2**, we have presented some literature reviews of our topic. Here, we have highlighted the various research works of several authors in the fields of accelerated expansion of the Universe especially Holographic DE models, New Agegraphic DE models, Scalar field DE models, Polytropic Gas DE models and Friedmann –Robertson–Walker models.

In **Chapter-3**, we have studied about a model "Universe dominated by the Polytropic gas as dark energy". In this chapter, we have investigated the dominance of the Polytropic gas as DE in the Universe and deduced that the Universe is dominated by it. Because of the existence of the Polytropic gas in the type $P_\Lambda = K\rho_\Lambda^{1+\frac{1}{n}}$, a Universe may be dominated by Phantom DE or Quintessence DE according to $\omega_\Lambda \left(=\frac{p_\Lambda}{\rho_\Lambda}\right) \lesseqgtr -1$. Also $V(\varphi) > \frac{1}{2}\dot{\varphi}^2$, the Universe may be dominated by Phantom

DE or Quintessence DE according to negative kinetic energy$(-\frac{1}{2}\dot{\varphi}^2)$ or positive kinetic energy$(\frac{1}{2}\dot{\varphi}^2)$.

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In **Chapter-4**, we have studied about the correspondence between the scalar fields and the Polytropic gas DE model**.** Here, we have established a correspondence of the Polytropic gas with the Quintessence, K-essence and Tachyon scalar fields. The Polytropic Quintessence model indicates a potential dominated scalar field Universe in the slow-roll approximation that corresponds to the accelerated expansion of the Universe. The Polytropic K-essence model interprets that the Universe expands with acceleration expansion when $\frac{1}{3} < \chi < \frac{1}{2}$ and may be dominated by Phantom field or Quintessence field according to $K < Ba^{3/n}$ *or* $K > Ba^{3/n}$. The Polytropic Tachyon model represents that the Universe may be dominated by Phantom field or Quintessence field according to $K > Ba^{3/n}$ *or* $K < Ba^{3/n}$. Also from this correspondence, we have reconstructed the dynamics and potential of the Quintessence, K-essence and Tachyon scalar fields in the context of the Polytropic gas DE model.

Some related works of this chapter has been published in

(i) ***"International Journal of Advanced Scientific Research and Management (IJASRM)"***, ISSN 2455-6378*(UGC Approved, Sl. No.-63502),* Volume-4, Issue-1, pp. 169-171, January 2019.

(ii) ***"The International Journal of Current Advanced Research (IJCAR)",*** ISSN 2319-6475 (E) / 2319-6505 (P) *(UGC Approved, Sl. No.-43892)*, Volume-7, Issue-11(C), pp. 16377-16378, November 2018.

(iii) ***"International Journal of Advanced Scientific Research and Management (IJASRM)"***, ISSN 2455-6378*(UGC Approved, Sl. No.-63502),* Volume-3, Issue-12, pp. 154-156, December 2018.

In **Chapter-5**, we have discussed about the reconstruction of the Holographic and New Agegraphic DE Models for the Polytropic Gas. Here, we have mainly studied the Polytropic gas DE model with the Holographic and New Agegraphic DE models within the flat FRW Universe. If $K > Ba^{3/n}$, then a Polytropic gas model of Phantom activities that indicates an accelerated expanding Universe is obtained. For $c = 1$, Holographic DE model functions nearly as a cosmological constant. Also for $a \to \infty$, New Agegraphic DE model roughly acts as a cosmological constant. In addition, we have projected a correspondence for the scalar fields of the Polytropic gas with the Holographic and New Agegraphic DE models. Due to the evolution of the Holographic and New Agegraphic DE, these correspondences describe a Universe of accelerating expansion. The potential and dynamics of the Polytropic gas scalar fields have been reformed.

The work presented in this chapter has been published in ***"International Journal of Advanced Research in Engineering and Technology*** **(*IJARET)"***, UGC care listed (Scopus Indexed, SL. No.-96521100944103). Volume- 11, Issue- 10, pp. 241-246, October 2020.ISSN 0976-6480(P), 0976-6499(E)

Chapter-6 of this thesis consists of Modified Polytropic$f(T)$ gravity model. In this chapter, we have modified $f(T)$ gravity model with the Polytropic gas and its equation of state represent a phantom-like an accelerated Universe.

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In **Chapter-7**, we have investigated about the Bianchi Type-I Polytropic gas DE models in cosmology in presence of Polytropic gas. The model's physical and cosmological parameters suggest that the Universe's spatial volume is zero at $t = 0$ and increases infinitely as $t \to \infty$. At $t = 0$, the pressure, energy density, expansion scalar, the mean Hubble parameter, and shear scalar are infinite and approaches 0 as $t \to \infty$.When $m = 1$, the Universe is isotropic and flat and when $m \neq 1$, it is anisotropic and open. The model is thus anisotropic in the evolution of the Universe, with the exception of $m = 1$.

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In **Chapter-8**, we have studied about the possibility of the Polytropic gas that may avoid Big Rip singularity. In the FRW Universe, we have found that if the DE acts concurrently as a fluid with $P_\Lambda = \omega_\Lambda \rho_\Lambda\,, \omega_\Lambda < -1$ and Polytropic gas with $P_\Lambda = K\rho_\Lambda^{1+\frac{1}{n}}$, then the ultimate explanations are as follows

i) For the positive kinetic energy i.e. $\dot{\varphi}^2 > 0$ we have $\omega_0 > -1$ which represents a Quintessence fluid dominated Universe and for the negative kinetic energy i.e. $\dot{\varphi}^2 < 0$ we have $\omega_0 < -1$ which represents a Phantom fluid dominated Universe. These results match with results obtained by Hoyle-Narlikar in C-field with negative kinetic energy for steady state theory of Universe.

ii) For $t \to \infty$, we have $a(t) \to \infty$ which indicates that the present model is free from finite time future singularity.

iii) For $t \to \infty$ we have $H^{-1} \neq 0$ which indicates that the galaxies will not disappear as $t \to \infty$, avoiding Big Rip singularities. Therefore one can conclude that when cosmic dark energy behaves like a fluid with an equation of state parameter $P_\Lambda = \omega_\Lambda \rho_\Lambda$, $\omega_\Lambda < -1$ as well as Polytropic gas then the Big Rip singularity does not arise and the scale factor is found to be regular for all time.

The content of this chapter has been published in ***"International Journal of Research and Analytical Reviews (IJRAR)"***, ISSN 2348-1269(E)/2349-5138(P) (UGC Approved, Sl. No.-43602), Volume-6, Issue-2, pp. 688-691, June 2019.

The **Chapter-9** discussed on the topic "Polytropic gas has Thermodynamic manners in cosmology"**.** In this chapter, we have studied the thermo dynamical behavior of the Polytropic gas.

(i) In the sense of thermodynamics, the deceleration parameter is studied and our study reveals that the Universe is decelerated and accelerated at the early and late stage of it respectively.

(ii) Both the conditions of the thermodynamic stability of the Polytropic gas are studied and our analysis shows that the Polytropic gas is thermodynamically stable.

The work enclosed in this chapter has been published in ***"Ratio Mathematica"*** (UGC Care listed, SL. No.-352), Volume-39, pp. 261-268, December 2020, ISSN 1592-7415, eISSN 82-8214.

The **Chapter-10** of this thesis consists of the findings and suggestions.