Chapter-2

Literature Review

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2.1 Introduction

Literature review is a critical outline of already published research article associated with a topic under consideration for the research. The survey of the previous related works is totally necessary for any research in any field as it provides the researchers several ideas, theories and methods for conducting the research smoothly. It helps the researchers in selecting the proper and standard research problems. It also prevents the repetition of the matching or similar works already done. In this chapter, we have reviewed various topics related to already done research works of several authors.

2.2 Accelerated expansion of the Universe

The Accelerated expansion of the Universe was proved by two well known projects namely "The Supernova Cosmology Project" headed by S. Perlmutter (Perlmutter, S. et al., 1998 & 1999) and "The High red-shift Supernova Search Team" headed by A.G. Riess and B. P. Schmidth (Riess, A.G. et al., 1998 & 2004) measuring the distances of remote supernovae (exploding stars) of Type Ia (SNe Ia) and using their red-shift. Some astrophysical and cosmological observation's data that supported it are, The Wilkinson Microwave Anisotropy Probe (WMAP), which is a spacecraft operated by NASA between 2001 and 2010, mapped the sky and measured the differences in temperature in the microwave background (CMB) radiation across the sky, Sloan Digital Sky Survey (SDSS), using a 2.5 meter wide-angle optical telescope at Apache Point Observatory, New Mexico maps the sky to examine the history and large scale structures of the Universe, Chandra X-Ray Observatory, which is a flagship class telescope launched on July 23, 1999 and one of the NASA's Great observatories through which the scientists are able to understand the structure and evolution of the Universe by collecting, observing and analyzing X-ray radiation. The Baryon Acoustic Oscillations (BAO) is considered as 'standard ruler' for the length scale measurement in cosmology and its measurements help the cosmologists to know more about the nature of dark energy that indicates the accelerated expansion of the Universe by constraining cosmological parameters. A good numbers of research papers have been published based on these data. Spergel et al., (2003, 2007), Bennett et al., (2003a, 2003b, 2011, 2013), Tegmark et al., (2004), Hinshaw et al., (2007, 2009, 2013) analyzed data from WMAP. York et al., (2000), Gunn et al., (2006), Eisenstein et al., (2011), Blanton et al., (2017), analyzed data from SDSS. Beutler et al., (2011) for 6dF Galaxy Survey; Blake et al., (2011) for Wiggle Z; Anderson et al., (2012) for BOSS analyzed data from BAO. Allen (1998); Allen et al., (2001, 2007); Weisskopf, M.C. (2005, 2010) analyzed data from Chandra X-Ray Observatory.

All these analyses satisfy the discovery of the two Supernova teams.

2.3 Holographic dark energy models

Holographic dark energy model is based on Holographic Principle (HP). Consistent with this principle, the entropy of a physical system scales with its bounding area and not with its volume. In the sense of black hole physics, G't Hooft (1993) and Susskind (1995) first proposed this principle and first extended it to cosmological settings by W. Fischler and L. Susskind (Fischler & Susskind, 1998). Subsequently, various modifications of this version of the Holographic Principle were proposed (Bousso, 1999 & 2002; Kaloper & Linde, 1999; Li, 2004; Hsu, 2004). According to Cohen et al., (1999), the Holographic DE is given by

$$\rho_\Lambda = 3n^2 M_P^2 L^{-2} \tag{2.1}$$

Here n^2 is a constant and M_P is the reduced Planck mass given by $M_P^{-2} = 8\pi G$, G being the gravitational constant and $L$is the size of the Universe at time t.Various Holographic dark energy models are found in the literature.

Huang and Li (2004) studied the Holographic dark energy in non-flat Universe.

Myung (2005) established that in a weakly gravitating system, the Holographic dark energy bound come from the Bekenstein Hawking bound.

Gong and Zhang (2005) used the Holographic principle to discuss the Holographic dark energy model and found that the Bekenstein–Hawking entropy bound is far from saturation under certain conditions. They also derived some constraints on the parameter of the Holographic dark energy model.

Setare (2006) investigated the interacting Holographic dark energy models and found the equation of state of the Holographic energy density for the closed non-flat Universe.

Zhao (2007) discussed the evolution of Holographic hessence model.

Myung (2007) examined the difference between the Holographic dark energy, Chaplygin gas, and Tachyon model within the context of constant potential.

Zhang et al. (2007) established a connection between the Tachyon scalar-field and the Holographic dark energy.

Myung and Seo (2009) studied about the origin of Holographic dark energy models. Also confirmed that the Agegraphic and Holographic dark energy model with different IR length scales are same

Bisabr (2009) studied Holographic dark energy models in scalar tensor theory.

Paul (2010) studied Holographic dark energy models with Chaplygin gas.

Wu et al. (2010) studied Holographic dark energy models with modified Chaplygin gas.

Sheykhi (2011) investigated scalar field models of Holographic dark energy.

Sheykhi et al. (2012) studied Holographic dark energy models in Brans-Dicke theory.

Chattopadhyay and Pasqua (2013) discussed Holographic dark energy models in different contexts.

Wang, S. et al. (2017) described the properties of the Holographic dark energy model by choosing the future event horizon as the characteristic length scale.

2.4 New Agegraphic dark energy models

To avoid the drawback of the Holographic dark energy models, R. G. Cai (Cai, 2007) has planned a new dark energy model, known as Original Agegraphic dark energy (OADE), wherever the time scale is chosen to be the age of the Universe. There are some difficulties within the Agegraphic dark energy model as a result of it cannot justify the matter dominated era. Consequently, H. Wei and R.G. Cai (Wei & Cai,

2008) introduced the New Agegraphic dark energy (NADE) model wherever the time scale is preferred for the conformal time.

Various Original and New Agegraphic dark energy models are found within the literature.

Kim et al. (2008) studied the New Agegraphic dark energy models for the generalized uncertainty principle.

Karami and Abdolmaleki (2010b) researched the New Agegraphic dark energy model using the principle of Brans–Dicke.

Sheykhi and Setare (2010) considered the New Agegraphic model of dark energy with a variable gravitational constant G in an exceedingly non-flat Universe and obtained the equation of state and therefore the deceleration parameters for each interacting and non-interacting New Agegraphic dark energy. They additionally found the equation of motion for deciding the evolution behavior of the dark energy density with a time variable gravitational constant G.

Karami et al. (2012) studied the New Agegraphic dark energy (NADE) model through the power-law corrected entropy and Hořava–Lifshitz cosmology.

Zhang, J.-F. (2014) planned a new version of the interacting model of New Agegraphic dark energy (INADE) analyzed thoroughly. They showed that the INADE model is best than the NADE model.

2.5 Scalar field dark energy models

Scalar field could be a function that provides us one value of some variable for each purpose in space. It's wide utilized in cosmology throughout the last 3 decades. There are several scalar fields like Quintessence, Phantom, K-essence, Tachyon, Dilaton, etc. are thought of as a candidate for the dark energy to clarify the accelerated growth of the Universe.

Quintessence scalar field models of dark energy are presented by Zlatev et al., (1999), Brax and Martin (1999),Steinhardt et al., (1999), Barreiro et al., (2000), Chiba, T. et al., (2000), Sahni and Wang (2000), Doran and Wetterich (2003), Capozziello

(2002), Wetterich (2002), Granda (2009), Avelino et al., (2011), Tsujikawa (2013), Khurshudyan et al., (2014), Chaubey and Shukla (2015), Yang et al., (2019).

K-essence models by Armendariz-Picon et al., (1999, 2001), Chiba (2002), Malquarti et al., (2003), Sen (2006), De Putter and Linder (2007), Bose and Majumdar (2009), Yang and Gao (2009), Karami et al., (2010), Rozas-Fernandez (2012), Yang et al., (2015), Cordero et al., (2017).

Phantom models by Caldwell et al., (2002, 2003), Carroll et al., (2003), Dabrowski (2007), Jhingam et al., (2008), Baushev (2010), Karami et al., (2009), Ludwick (2017), Albarram et al., (2017), Roy and Bhadra (2018).

Tachyon models by Sen (1998, 2002), Padmanabhan (2002), Bagla et al. ,(2003), Jassal (2004), Chattopadhyay and Debnath (2009), Karami et al., (2010), Avelino et al., (2011), Noorbakhsh and Ghominejad (2013), Martins and Moucherrek (2016).

Dilaton models by Amendola et al., (2003), Lu et al., (2004), Piazza and Tsujikawa (2004), Huang et al., (2006, 2008), Rozas-Fernandez (2011), Karami et al., (2010), Hossienkhani et al., (2018).

2.6 Polytropic Gas dark energy models

In this thesis, our works concerned to the Polytropic gas. So, we have highlighted the works done by numerous authors concerning this field.

Mukhopadhyay et al. (2008) thought-about Polytropic gas equation of state for a few of the kinematical models and discovered that for the dust-filled Universe, there's no distinction between Barotropic and Polytropic equations of state and non-dust cases admitted the presence of either Quintessence or vacuum fluid or Phantom energy after inflation.

Karami et al. (2009) introduced a Polytropic gas as an alternate dark energy model in FRW Universe and showed that the Universe dominated by Phantom dark energy.

Karami and Abdolmaleki (2010a) developed various f (T)-gravity models of dark energy for the Polytropic gas and Chaplygin gas.

Malekjani et al. (2011) thought-about a non-flat FRW Universe dominated by interacting Polytropic gas dark energy and CDM and studied the cosmic behavior of the Polytropic gas model.

Adhab (2011) studied the compact Kaluza-Klein cosmology, during which the Polytropic gas interacts with the dark matter.

Taji and Malekjani (2013) investigated the relation among the Holographic and Polytropic gas models in FRW Universe and found that the Polytropic gas behaves as a Phantom dark energy.

Setare and Darabi (2013) studied chaotic inflation within the context of a modified gravity model impressed by the Polytropic gas equation of state. They found that chaotic inflation is possible within the context of a modified gravity model impressed by the Polytropic gas equation of state.

Khurshudyan (2015) analyzed numerous cosmological scenarios wherever nonlinear interacting Polytropic gas models are concerned and dark matter is taken to be a pressure less fluid.

Sarkar (2015) recognized a relation with the Holographic DE and the Polytropic gas DE model and obtained the dynamics and potential for the scalar field that indicates the Polytropic cosmology.

Chattopadhyay et al. (2015) studied on the cosmological effects raised in reconstructing f (T) gravity through New Holographic Polytropic dark energy model and assumed two approaches, namely, a Hubble parameter H and a solution for f (T). They additionally studied the state finder parameters under each approach that end in the very fact that state finder trajectories are found to attain to realize. Additional they mentioned about the stability of the reconstructed models with the square speed of sound and concluded that this model is stable in the late times.

Wang et al. (2016) studied the evolution of the viscous Polytropic gas dark energy model interacting with the dark matter for the Einstein cosmology and investigated the dynamic evolution of the interacting viscous Polytropic gas dark energy along with the dark matter by the phase space analysis technique and its critical stability. They found that the viscosity property of the dark energy creates a benefit for the stable critical dynamic evolution of the interaction model between dark matter and dark energy within the flat Friedmann–Robertson–Walker Universe and therefore the viscosity of dark energy can soften the coincidence drawback similar to the interacting dark energy model.

Moradpour et al. (2016) studied Polytropic gas's thermo-dynamic activity as a dark energy candidate. They found that there is a thermodynamically stable Polytropic gas.

2.7 Friedmann –Robertson–Walker Metric

In this section, we have discussed a few relevant works done by different authors connected to the Robertson-Walker Metric.

Lemaître (1931) has independently derived similar results as Friedmann.

Robertson (1935) and Walker (1937) independently have shown the non-static cosmological metric known as the Robertson-Walker metric.

Bondi and Gold (1948) studied the steady state model of the Universe. They have shown that the separation of the matter increases exponentially and the continuous matter creation is necessary to clarify the density of matter.

Buchdahl (1972) considered the time-like geodesies of the Robertson-Walker spaces from the Lagrangian point of view. He obtained the characteristic function V of an arbitrary Robertson-Walker space from the Hamiltonian point of view by integrating the differential equations that govern V.

Heller and Suszycki (1974) have studied dust model of FRW Universe with bulk viscosity and shown that initial singularity may be avoided for suitable conditions.

Barrow and Matzner (1977) have studied the homogeneity and isotropy of the Universe and found that the chaotic cosmology is essentially ruled out.

Starobinsky (1980) recognized a new kind of isotropic cosmological models with no singularity.

Beesham (1986) have considered a FRW Universe with a time-varying gravitational constant G as variable and has shown that there is no creation even though the rest mass of matter particles is constant in a Universe with variable G andΛ.

Johri and Sudharsan (1988) investigated the effects of the bulk viscosity on the evolution of the Friedmann models and observed that the presence of a little time independent bulk viscosity will play a crucial role in driving the present day Universe into a steady state Universe.

Tarachand and Ibotombi (1989) carried out a study of imperfect fluid interacting with the gravitational field for spherically symmetric Robertson-Walker metric and found that the Big Bang does not take place when the viscous fluid interact with the gravitational field at the early stages.

Abdel-Rahman (1990) considered a cosmological model wherein the Universe has its critical density and the gravitational (G) and cosmological constant (Λ) are time-dependent. The horizon and monopole problems may be solved by this model. Moreover, it predicted an expanding Universe wherein G increases and Λ decreases with time in a way dependable with the conservation of the energy-momentum tensor.

Sistero (1991) studied about the cosmology with the gravitational and Gravitational constants generalized as coupling scalars in Einstein's theory. He found exact solutions for zero pressure models satisfying certain condition.

Beesham (1991) confirmed that the scale covariant theory of gravity admits the possibility of a time varying gravitational constant with a gauge function wherein there is no independent equation. He also investigated the situation of obtaining the explicit forms of the gauge function in the Friedmann-Robertson-Walker cosmological models.

Ibotombi and Biren (1992) found an exact solution of the Einstein's field equations for a conformally invariant scalar field with the trace free energy-momentum tensor for the Robertson-Walker models with $K = +1, -1$ and discussed the physical properties of the solution.

Beesham (1993) considered non flat variable-Lambda cosmological models with bulk viscosity. He obtained its solutions and elucidated their relationship with bulk viscosity solutions. He also derived exponentially expanding solutions and discussed the stability of the models.

Johri and Desikan (1994) investigated cosmological models by considering the constant deceleration parameter in Brans-Dicke theory and studied each singular and non-singular models of the Universe. They explained that the growth of singular models supported big-bang impulse and also the growth of non-singular models because of creation of matter particles.

Abdussattar and Vishwakarma (1997) studied some Robertson-Walker models considering a contracted Ricci collineation with the fluid flow vector and having time-varying G and Λ. They obtained the character of the growth of the models within the cases k = ±1 and located to be interchanged from the corresponding standard FRW models.

Ibotombi and Gokulchandra (1998) established the relativistic cosmological field equations and its solutions for a Robertson-Walker house time interacting with viscous fluid and large scalar field. They additionally studied the character of the scalar field and the viscous fluid and located that the solutions obtained are realistic just for a closed Universe.

Banerjee and Sen (1998) investigated the character of the potential function V (φ) relevant to power law inflation in an exceedingly minimally coupled scalar field cosmology together with a perfect or causal viscous fluid and discovered that if the coefficient of viscosity is proportional to the square root of the density of the fluid, the desired potential is an exponential function of the scalar fieldφ.

Friedmann (1999) has deduced some necessary results of the Friedmann– Lemaitre–Robertson–Walker (FLRW) model.

Vishwakarma (2001) considered four variable Λ-models to investigate the magnitude-redshift relation and angular size-redshift relation for the type Ia supernovae and updated compact radio sources data respectively.

Kremer and Devecchi (2003) shown that a present acceleration with a past deceleration may be a possible solution to the Friedmann equation by considering the Universe as a combination of a scalar with a matter field and by together with a non equilibrium pressure term within the energy-momentum tensor. They additionally concluded that the dark energy density decays a lot of slowly with reference to the time than the matter energy density does.

Debnath and Paul (2006) thought-about the evolution of a flat Friedmann-Roberstson-Walker Universe in higher derivative theories, together with αR^2 terms to the Einstein-Hilbert action within the presence of variable gravitational and cosmological constants. They additionally studied the evolution of the gravitational and cosmological constants within the presence of radiation and matter domination era of the Universe.

Dutta Choudhury and Sil (2006) have investigated evolution of a homogenous, isotropic Universe with flat geometry stuffed with a viscous fluid in presence of a variable cosmological Λ and obtained a non-singular solution of a variable deceleration parameter that reduces to the solution of Murphy in 'no Λ limit' and to the solution of Vishwakarma in 'no viscosity limit'. .

Arbab (2008) studied a cosmological model of Phantom energy using a variable cosmological constant (Λ) that depend on the energy density (ρ). He thought-about the cosmological constant in such the way that it varies reciprocally proportional the energy density of the Universe.

Copeland et al. (2009) investigated the dynamics of a particular scalar field within the Friedmann-Robertson-Walker Universes through the spatial curvature and obtained the fixed point solutions that are indicated to be late time attractors. They additionally determined the corresponding scalar field potentials that correspond to those stable solutions.

Ibotombi et al. (2009) investigated FRW models of universe in presence of viscous fluid within the cosmological theory supported Lyra's Manifold. They obtained exacts solutions by considering the deceleration parameter to be a variable and the viscosity coefficient of bulk viscous fluid to be a constant and investigated the physical properties of the models.

Leon and Saridakis (2010) studied various varying-mass models of dark matter particle within the framework of phantom cosmology and investigated whether or not there exist late-time cosmological solutions, equivalent to an accelerating Universe and having the dark energy and dark matter densities of a similar order. They ended that the coincidence problem cannot be solved or may be relieved.

El-Nabulsi (2010a) studied a new cosmological model of the Universe supported a spatially flat FRW metric. He created a new kind of extended modified gravity theory to explain a dark energy dominated accelerating Universe employing a Gauss–Bonnet invariant term and a new Einstein–Hilbert term.

El-Nabulsi (2010b) presented a four-dimensional Dilaton-Brans-Dicke cosmological situation related to the multiverse occupied by dark energy or Phantom energy with a positive cosmological constant containing countless without end Big Rip singularities.

Jamil and Debnath (2011) thought-about a cosmological model of variable G and Λ for the FRW Universe and obtained the solutions in the form of cosmological constant for the flat model. They additionally found the cosmological parameters for dust, radiation and stiff matter.

Mostafapoor and Gron (2011) studied the flat Λ cold dark matter models through the bulk viscosity and investigated the role of the bulk viscosity in case of evolution of the Universe. They obtained the dynamical equations for these models and resolved for a few cases of bulk viscosity. They additionally obtained the differential equations for the Hubble parameter and also the energy density of dark matter.

Tiwari (2011) studied the Einstein's field equations for the gravitational and cosmological constants in presence of perfect fluid in a Robertson-Walker Universe by considering the cosmological term to be reciprocally proportional to the scale factor of the Universe. He additionally presented varied solutions of the field equation and discussed the physical significance of the cosmological models.

Singh, C.P. (2012) studied the dynamical consequence of the bulk viscosity and particle creation for the early evolution of the Friedmann -Robertson -Walker model in case open thermo dynamical systems and thought of bulk viscosity and Particle creation as separate irreversible processes.

Mohajan (2013) established Friedmann, Robertson-Walker (FRW) models on the premise of the idea that the Universe is homogeneous and isotropic altogether epochs to explain the FRW models with easier mathematical calculations, physical interpretations and diagrams wherever necessary.

Singh and Bishi (2015) studied the FRW metric for the universal gravitational constant G and cosmological constant Λ within the $f(R,T)$ gravity using the modified Chaplygin gas equation of state. They obtained the solution of the field equations by using the hybrid exponential law (HEL) for the scale factor and discussed some physical behavior of the model.

Chand, A. et al. (2016) found the exact solution for the modified Einstein's field equations in case of spatially homogeneous and isotropic Fraidmann-Robertson-Walker (FRW) space-time that filled by the perfect fluid within the Brans-Dicke scalar-tensor theory of gravity. They also investigated the flat, open and closed FRW models and the consequence of the cosmological term on the evolution of the Universe.

Tiwari, R.K. et al. (2017) investigated the equation of state parameter of dark energy for the spatially homogeneous and isotropic Friedmann-Robertson-Walker (FRW) model with Barotropic fluid.

Zhang and Kuang (2018) studied the quantum effect of the modified Friedmann equation within the Friedmann-Robertson-Walker Universe. They also investigated the bounce cosmological solution for the spatially flat geometry in the modified Friedmann equation.