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DARK ENERGY COSMOLOGY WITH TACHYON FIELD IN TELEPARALLEL GRAVITY

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We construct a tachyon teleparallel dark energy model for a homogeneous and isotropic flat universe in which a tachyon as a non-canonical scalar field is non-minimally coupled to gravity in the framework of teleparallel gravity. The explicit form of potential and coupling functions are obtained under the assumption that the Lagrangian admits the Noether symmetry approach. The dynamical behavior of the basic cosmological observables is compared to recent observational data, which implies that the tachyon field may serve as a candidate for dark energy.

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1. INTRODUCTION

Recent observations provide main evidence that the universe is undergoing an accelerating expansion at late times [1]. The source of this acceleration was commonly dubbed as "dark energy" whose origin as a mysterious cosmic fluid has not yet been identified, although several candidates have been proposed in the literature [2–5]. There are two main approaches to explain such a behavior, apart from the simplest candidate of a cosmological constant, which fits the observations well, but is plagued with some severe theoretical difficulties, such as the so-called fine-tuning and cosmic coincidence problems [6].

In the first approach, cosmic acceleration of the universe does not arise from dark energy as a substance, rather it originates from the dynamics of modified gravity which is imposed on the geometric part of the Einstein–Hilbert action of general relativity. The well-known modified gravitational theories, such as teleparallel [7–10], Gauss–Bonnet [11], Horava–Lifshitz [12] and Brans–Dicke [13] belong to this scenario. Among these theories, teleparallel gravity was originally propounded by Einstein with the aim of unifying the gravity and electromagnetism [14]. This theory is characterized by using the Weitzenbock connection, and its Lagrangian density is described by a torsion scalar T instead of the scalar curvature R in general relativity which is formulated using the Levi-Civita connection. In this theory, the dynamical variables are represented by the four linearly independent vierbein (or tetrad) fields which play a role similar to the metric tensor in general relativity. The field equations of teleparallel gravity are obtained by taking variation of the action with respect to the vierbein fields [14]. Recently, an interesting modified gravity by extending the teleparallel theory, so-called $f(T)$ gravity, is proposed to explain the current accelerating expansion of the universe without introducing the matter component [15–25].

The second approach to explore the physical mechanism leading to the acceleration of the universe includes a variety of scalar fields as a matter content of the universe. An example of scalar field dark energy is the so-called quintessence [26], a scalar field slowly evolving down its potential. Provided that the evolution of this field is slow enough, the kinetic energy density becomes less than the potential energy density, giving rise to the negative pressure responsible for the cosmic acceleration. A non-minimal coupling between quintessence and gravity has been proposed by Geng et al. in the framework of teleparallel gravity, so-called, "teleparallel dark energy" [27]. The authors indicated that the resulting model has a richer structure, exhibiting quintessence-like or phantom-like behavior, or experiencing the phantom-divide crossing during cosmological evolution. In a similar work, Geng et al. have used observational data with the quartic, the exponen-

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tial and the inverse hyperbolic cosine form potentials and demonstrated that the scenario of the teleparallel dark energy is compatible with observations [28]. It has also been shown that the resulting model can realize both the quintessence and phantom regimes [28]. In this regard, the dynamics of teleparallel dark energy and its connection with Elko spinor dark energy have been studied by Wei, using the power-law potential [29]. The resulting model indicated that there exist only some dark-energy-dominated de Sitter attractors. Gu et al. have suggested the simplest model of teleparallel dark energy, with purely a non-minimal coupling to gravity and self-potential free [30]. In this work, various features of model have been studied by considering the analytical solutions and the dark energy equation of state, in the radiation, matter, and dark energy dominated eras. It has also been found a crossing of the phantom divide at late times and experiencing a singularity with an expansion rate going to infinity within a finite time. In the phase space, a non-minimal coupling to teleparallel gravity has been performed by Xu et al., indicating that the resulting model has a late time attractor, in which dark energy behaves like a cosmological constant [31]. In this paper, the authors provided a natural way for stabilization of the dark energy equation of state parameter to the cosmological constant value, with no need for parameter tuning.

A generalization of teleparallel dark energy is obtained by inserting a non-canonical scalar field instead of quintessence in the related action, so-called "tachyonic teleparallel dark energy" [32–34]. The dynamics of tachyon teleparallel dark energy have been considered in phase space by focusing on critical point and line structures as well as stabilities of solutions, using the quadratic non-minimal coupling function with the exponential [33] and inverse square [34] potentials. In these interesting investigations, the potential and coupling functions inserted in the theory in an *ad hoc* manner. Furthermore, their corresponding dynamical equations are non-linear and do not have general analytical solutions. On the other hand, since the concept of symmetry plays an essential role throughout the theoretical physics, we are motivated to follow the approach of the Noether symmetry to seek cosmological solutions of the dynamical equations and select models at a fundamental level. This symmetry has been widely used in cosmology in order to simplify a given system of differential equations as well as to find out exact solutions [35–39]. In principle, as a physical criterion, the existence of the Noether symmetry can provide a conserved quantity with a physical interpretation.

This paper is organized as follows. In Sec. 2, we first briefly review teleparallel gravity and then introduce our model in which a tachyon field non-minimally coupled to the teleparallel gravity in Friedmann–Robertson–Walker (FRW) flat space-time. In Sec. 3, the Noether symmetry approach is described and the existence of this symmetry allows to specify the explicit form of potential and coupling functions in the Lagrangian. We find cosmological solutions of the dynamical equations of motion and present their physical interpretations in Sec. 4. Finally, Sec. 5 is devoted to the conclusions.

2. THE GENERALIZED TELEPARALLEL GRAVITY

Here, we briefly review the key ingredients of teleparallel gravity. The orthonormal tetrad components e^i_μ are related to the metric tensor through

$$g_{\mu\nu} = \eta_{ij} e^i_\mu e^j_\nu, \tag{1}$$

where μ and ν are coordinate indices on the manifold running over $0, 1, 2, 3$. Furthermore, e^μ_i form the tangent vectors on the tangent space over which the Minkowski metric η_{ij} is used. In teleparallel gravity, the curvatureless Weitzenbock's connection is defined by

$$\Gamma^\alpha_{\mu\nu} = e_i{}^\alpha \partial_\nu e^i{}_\mu = -e^i{}_\mu \partial_\nu e_i{}^\alpha . \tag{2}$$

The components of the tensor torsion, the contorsion tensor and the scalar torsion are respectively described as

$$\begin{aligned} T^\alpha{}_{\mu\nu} &= \Gamma^\alpha_{\nu\mu} - \Gamma^\alpha_{\mu\nu} = e_i{}^\alpha \left(\partial_\mu e^i{}_\nu - \partial_\nu e^i{}_\mu\right), \\ K^{\mu\nu}{}_\alpha &= -\frac{1}{2}\left(T^{\mu\nu}{}_\alpha - T^{\nu\mu}{}_\alpha - T_\alpha{}^{\mu\nu}\right), \\ T &= T^\alpha{}_{\mu\nu} S_\alpha{}^{\mu\nu}. \end{aligned} \tag{3}$$

Here, the new tensor $S_\alpha{}^{\mu\nu}$ is constructed from the components of the torsion and contorsion tensors as

$$S_\alpha{}^{\mu\nu} = \frac{1}{2}\left(K^{\mu\nu}{}_\alpha + \delta^\mu_\alpha T^{\beta\nu}{}_\beta - \delta^\nu_\alpha T^{\beta\mu}{}_\beta\right).$$

Now, in the framework of teleparallel gravity, let us consider dark energy model of tachyon as a non-canonical scalar field. Specifically, this field comes from the D-brane action (Dirac–Born–Infeld type Lagrangian) in string theory and it represents the lowest energy density [40–42]. The tachyon field associated with unstable D-branes might be responsible for dark energy [43–47]. The action for a tachyon field nonminimally coupled to the teleparallel gravity may be written as [33, 34]

$$S = \int d^4x\, e \left[f(\phi)T - V(\phi)\sqrt{1-\partial_\mu\phi\,\partial^\mu\phi} - \mathcal{L}_m \right], \quad (4)$$

where $e = \det(e^i_\mu) = \sqrt{-g}$, $f(\phi)$ is a generic function that describes the coupling, $V(\phi)$ denotes the tachyon potential and $\mathcal{L}_m$ represents the matter field's Lagrangian density. For the homogeneous and isotropic FRW flat space-time metric,

$$ds^2 = dt^2 - a^2(t)(dx^2 + dy^2 + dz^2), \quad (5)$$

in which $a(t)$ is the scale factor. The torsion scalar can be expressed as $T = -6\dot{a}^2/a^2$ [10]. The corresponding point-like Lagrangian which follows from the action (4) is given by

$$\mathcal{L} = -6f(\phi)a\dot{a}^2 - a^3V(\phi)\sqrt{1-\dot{\phi}^2} - \rho_m^0, \quad (6)$$

where ρ_m^0 is a constant value of the present energy density of the matter field; and a dot indicates differentiation with respect to the cosmic time t. The Hamiltonian associated with the Lagrangian (6) is as follows

$$\mathcal{H} = \dot{a}\frac{\partial\mathcal{L}}{\partial\dot{a}} + \dot{\phi}\frac{\partial\mathcal{L}}{\partial\dot{\phi}} - \mathcal{L} = -6f(\phi)a\dot{a}^2 + \frac{a^3V(\phi)}{\sqrt{1-\dot{\phi}^2}} + \rho_m^0.$$

By imposing the Hamiltonian constraint $\mathcal{H}=0$, one obtains Friedmann equation

$$H^2 = \frac{\rho_\phi + \rho_m}{6f(\phi)}, \quad (7)$$

where $H = \dot{a}(t)/a(t)$ is the Hubble parameter, and ρ_ϕ, ρ_m denote the energy density of tachyon and matter fields respectively as

$$\rho_\phi = \frac{V(\phi)}{\sqrt{1-\dot{\phi}^2}}, \quad \rho_m = a^{-3}\rho_m^0. \quad (8)$$

Furthermore, from the Euler–Lagrange equation for the scale factor, one obtains the acceleration equation, namely

$$\frac{\ddot{a}}{a} = -\frac{\rho_\phi + 3p_\phi}{12f(\phi)}, \quad (9)$$

where

$$p_\phi = 4\dot{\phi}Hf'(\phi) + 2H^2f(\phi) - \frac{V(\phi)\dot{\phi}^2}{\sqrt{1-\dot{\phi}^2}} \quad (10)$$

is the pressure of tachyon field. Likewise, the Euler–Lagrange equation for the scalar field is given by

$$\ddot{\phi} + (1-\dot{\phi}^2)\left[3H\dot{\phi} + \frac{V'(\phi)}{V(\phi)} + \frac{6f'(\phi)H^2}{V(\phi)}\sqrt{1-\dot{\phi}^2}\right] = 0, \quad (11)$$

which is the Klein–Gordon equation for the coupled tachyon field. Obviously, in order to solve the above field equations, one has to specify the coupling function $f(\phi)$ and the potential density $V(\phi)$. In principle, for setting these functions, assumptions cannot be arbitrary and must be permitted by physical criteria. For this purpose, we use the Noether symmetry approach in the following section.

3. NOETHER SYMMETRY APPROACH

As is well known, the so-called Noether symmetry approach plays an essential role throughout the theoretical physics and specially in cosmology to simplify a given system of differential equations as well as finding the exact solutions [35–39]. In principle, the existence of a Noether symmetry can be related to a conserved quantity with physical interpretation.

In this section, the mentioned symmetry allows us to specify the explicit form of potential and coupling functions in the Lagrangian (6) naturally, without any *ad hoc* manner. The configuration space of point-like canonical Lagrangian $\mathcal{L}$ is $\mathcal{Q} = \{a, \phi\}$ and its tangent space is given by $\mathcal{TQ} = \{a, \phi, \dot{a}, \dot{\phi}\}$. Accordingly, the existence of the Noether symmetry implies the presence of an infinitesimal generator X such that

$$\mathbf{X} = \alpha\frac{\partial}{\partial a} + \beta\frac{\partial}{\partial\phi} + \dot{\alpha}\frac{\partial}{\partial\dot{a}} + \dot{\beta}\frac{\partial}{\partial\dot{\phi}}, \quad (12)$$

where α and β depend on a and ϕ. This approach requires that the Lie derivative of the Lagrangian with respect to the vector field vanishes, i. e.

$$\pounds_{\mathbf{X}}\mathcal{L} = 0. \quad (13)$$

This condition gives rise to the following set of coupled differential equations

$$\begin{aligned} &\alpha + \frac{1}{3}\frac{V'(\phi)}{V(\phi)}a\beta = 0, \\ &\alpha + \frac{f'(\phi)}{f(\phi)}a\beta + 2a\frac{\partial\alpha}{\partial a} = 0, \\ &\frac{\partial\alpha}{\partial\phi} - \frac{a^2V(\phi)}{12f(\phi)\sqrt{1-\dot{\phi}^2}}\frac{\partial\beta}{\partial a} = 0, \quad \frac{\partial\beta}{\partial\phi} = 0, \end{aligned} \quad (14)$$

which are obtained by imposing the fact that the coefficients of $\dot{a}^2$, $\dot{\phi}^2$, $\dot{a}\dot{\phi}$, and $\sqrt{1-\dot{\phi}^2}$ should vanish. Using the separation of variables one can find the solutions of the above set of differential equations (14) for α, β, coupling function $f(\phi)$ and the potential density $V(\phi)$ as

$$\alpha = \alpha_0 a, \quad \beta = \beta_0, \quad f(\phi) = f_0 e^{-\phi/\phi_0}, \quad V(\phi) = V_0 e^{-\phi/\phi_0}, \tag{15}$$

where α_0, β_0, f_0 and $V_0 > 0$ are constants and $\beta_0/3\alpha_0 = \phi_0$. Therefore, the vector field X exists, and the existence of the Noether symmetry means that there must exist a conserved charge or constant of motion. To obtain this conserved charge, we rewrite the Noether condition (13) as

$$L_X \mathcal{L} = \left(\alpha \frac{\partial \mathcal{L}}{\partial a} + \frac{d\alpha}{dt}\frac{\partial \mathcal{L}}{\partial \dot{a}}\right) + \left(\beta \frac{\partial \mathcal{L}}{\partial \phi} + \frac{d\beta}{dt}\frac{\partial \mathcal{L}}{\partial \dot{\phi}}\right) = 0. \tag{16}$$

Using the Euler–Lagrange equation $\partial\mathcal{L}/\partial q = dP_q/dt$, we rewrite it as

$$\left(\alpha \frac{dP_a}{dt} + \frac{d\alpha}{dt} P_a\right) + \left(\beta \frac{dP_\phi}{dt} + \frac{d\beta}{dt} P_\phi\right) = 0,$$

or equivalently

$$\frac{d}{dt}\left(\alpha P_a + \beta P_\phi\right) = 0.$$

Thus, the conserved charge is found as

$$Q = \alpha P_a + \beta P_\phi. \tag{17}$$

To obtain this conserved charge explicitly, we first write the momenta conjugate to the dynamical variables using the definition $P_q = \partial\mathcal{L}/\partial\dot{q}$ as

$$P_a = -a\dot{a}\phi^2, \quad P_\phi = a^3\dot{\phi}. \tag{18}$$

By substituting these into (17) and using (14), we have

$$Q = \beta_0 a^3 V(\phi) \frac{\dot{\phi}}{\sqrt{1-\dot{\phi}^2}} - 12\alpha_0 a^2 \dot{a} f(\phi). \tag{19}$$

The constant Q, for simplicity and without loss of generality, can be chosen as zero so that we have

$$\frac{\dot{a}}{a} = \frac{V_0\phi_0}{4f_0}\frac{\dot{\phi}}{\sqrt{1-\dot{\phi}^2}}. \tag{20}$$

Now, we calculate exact solutions of the dynamical variables and discuss on the cosmological behavior of FRW universe through the graphical analysis of these variables. In this regard, we first substitute relation (20) into Eq. (11) which leads to the following ordinary differential equation

$$\ddot{\phi} + \frac{3V_0\phi_0}{4f_0}\left(1 - \frac{V_0}{2\lambda}\right)\dot{\phi}^2(1-\dot{\phi}^2) - {\phi_0}^{-1}(1-\dot{\phi}^2) = 0. \tag{21}$$

The corresponding solution is a linear function as

$$\phi(t) = At + B, \tag{22}$$

where A and B both are constant and the former satisfies the equation

$$A^4 + b^2A^2 - b^2 = 0$$

with

$$b^{-1} = \frac{3V_0\phi_0^2}{4f_0}\left(1 - \frac{V_0}{2\lambda}\right).$$

Substituting this function into Eq. (20) provides an exponential solution for the scale factor as

$$a(t) = a_0 e^{\gamma t}, \tag{23}$$

where

$$\gamma = \frac{V_0\phi_0}{4f_0}\frac{A}{\sqrt{1-A^2}}.$$

Similarly, from (15) we obtain coupling function and potential as

$$f(\phi) = f_0 e^{-kt}, \quad V(\phi) = V_0 e^{-kt}, \tag{24}$$

where $A/\phi_0 = k$. Likewise, the dark energy density (8) and pressure (10) take respectively the forms

$$\rho_\phi = \frac{2\gamma f_0}{A\phi_0}(2 - 3A\gamma\phi_0)e^{-kt} \tag{25}$$

and

$$p_\phi = -\rho_\phi \times \frac{{V_0}^2{\phi_0}^2A^2\gamma^{-2} + 32A{V_0}^{-1}{\phi_0}^{-1}{f_0}^3\gamma + 8{f_0}^2A^2 - 24{f_0}^2\phi_0A\gamma}{8{f_0}^2(2-3A\gamma)}.$$

4. SOLUTIONS

For consideration of the differential equations (9) and (11), as well as analysis of their solutions more physically, it is convenient to switch from time to red-shift parameter. In doing so, let us find the Hubble parameter as a function of the red-shift by introducing the relation $z+1=1/a(t)$, and using

$$\frac{d}{dt}=-H(z+1)\frac{d}{dz}.$$

By rewriting the Klein–Gordon and acceleration equations (9) and (11) in terms of the red-shift parameter, we find

$$\phi''+[H^{-1}H'+(z+1)^{-1}]\phi'+[\phi'^2-(z+1)^{-2}H^{-2}]\times \times\left[3(z+1)H^2\phi'+\frac{6f_0}{V_0\phi_0}H^2\sqrt{1-(z+1)^2H^2\phi'^2}+\frac{1}{\phi_0}\right]=0 \tag{26}$$

and

$$4f_0e^{-\phi/\phi_0}HH'(z+1)=\rho_\phi(z)+\rho_m(z)+p_\phi(z). \tag{27}$$

Here, the energy densities of the tachyon and matter fields and the pressure of the tachyon field are respectively as follows

$$\begin{gathered}\rho_\phi(z)=\frac{V_0e^{-\phi/\phi_0}}{\sqrt{1-[H(z+1)\phi']^2}},\\ \rho_m(z)=\rho_m^0(z+1)^3,\\ p_\phi(z)=-f_0e^{-\phi/\phi_0}(z+1)\times\\ \times H^2\left[\frac{V_0(z+1)\phi'^2}{f_0\sqrt{1-[H(z+1)\phi']^2}}+\frac{4\phi'}{\phi_0}-2(z+1)^{-1}\right],\end{gathered} \tag{28}$$

where the primes represent differentiation with respect to the red-shift z. Equations (26) and (27) are two coupled non-linear system of differential equations and to obtain their numerical solutions, we first introduce

$$\Omega_\phi(z)=\frac{\rho_\phi(z)}{\rho(z)},\quad \Omega_m(z)=\frac{\rho_m(z)}{\rho(z)},$$

in which $\rho(z)=\rho_\phi(z)+\rho_m(z)$ is the total energy density. Then, for simplicity, we also rescale the quantities to become dimensionless as follows

$$\begin{gathered}H\to\frac{H}{\sqrt{\rho(0)}}=\mathcal{H},\quad \phi\to\frac{\phi}{\sqrt{\rho(0)}}=\Phi,\\ V_0\to\frac{V_0}{\rho(0)}=\lambda,\quad \phi_0\to\frac{\phi_0}{\sqrt{\rho(0)}}=\eta^{-1},\end{gathered} \tag{29}$$

where $z=0$ indicates the present time. Now, as initial conditions we assume $\Omega_\phi(0)=0.72$ and $\Omega_m(0)=0.28$ for the tachyon and matter fields at the present time, respectively [48]. Furthermore, since the negative pressure of the tachyon field measures acceleration of the universe, it is required that the scalar field ϕ is varying very slowly in the late time, namely $\dot\phi(0)\ll 1$. Consequently, from relation (8) we have $\rho_\phi(0)\approx V(0)$ which is equivalent with $\Phi(0)=\ln(0.72)^{1/\eta}$, where we have used (15) and $\lambda=1$ for simplicity. On the other hand, the value of gravitational coupling constant is usually taken as $f(\phi)=1/2$ at the present time. Accordingly, from relation (15) we obtain $\Phi(0)=(\ln 2f_0)^{1/\eta}$, which by combining with its previous expression gives $f_0=0.36$. Meanwhile, from the Friedmann equation (7) we obtain $\mathcal{H}(0)=1/\sqrt{3}$. Finally, for numerical solutions of Eqs. (26) and (27), we have appropriately chosen the coupling parameter as $\eta=0.05$, 0.06, and 0.07 and $\Phi'(0)=0.01$.

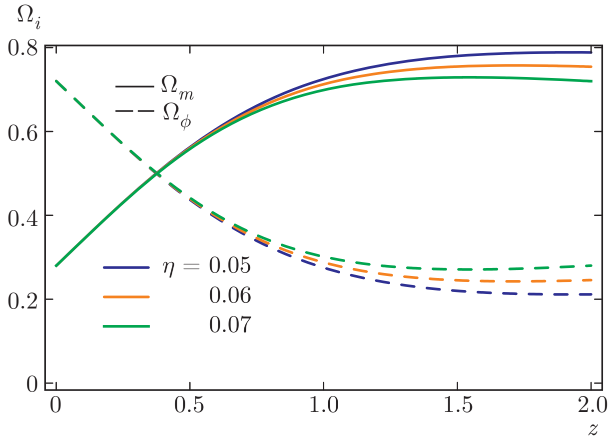

Fig. 1. (Color online) Evolution of the density parameter of the tachyon and matter fields for low red-shift values

In summary, we obtain the variation of density parameters of tachyon and matter fields in terms of red-shift z. Evolution of the density parameters is illustrated in Fig. 1 for low red-shift values. Tachyon density is falling more slowly, as matter density begins to dominate, however, it cannot be ignored in the matter dominated era. Equality in densities happens at $z_{eq}\approx 0.4$. From this figure, it is clear that the coupling parameter plays an effective role in the energy exchange of dark energy and gravitational matter. Moreover, as expected, when η vanishes, this model tends to ΛCDM scenario.

It is worth to mention here that, cosmological models containing tachyon and non-relativistic matter fields have behaviors significantly different from those of quintessence or the cosmological constant models. The most important difference here is that the energy density of the universe beyond $z\geq 1$ in the latter models has an insignificant contribution, whereas in most tachyon models the scalar density is not ignorable in comparison to the matter density.

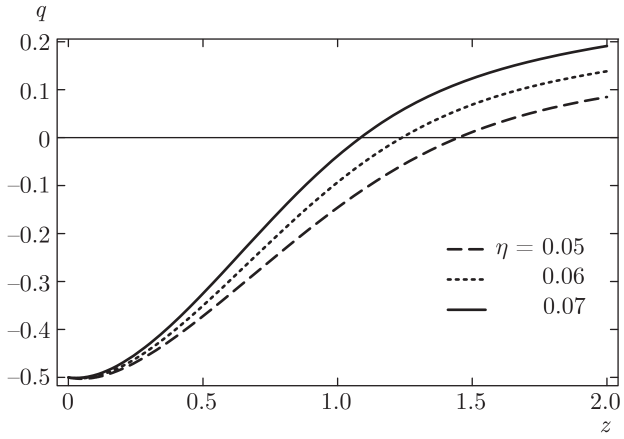

Fig. 2. Variation of the deceleration parameter q in terms of red-shift z for the three different values of the coupling parameter

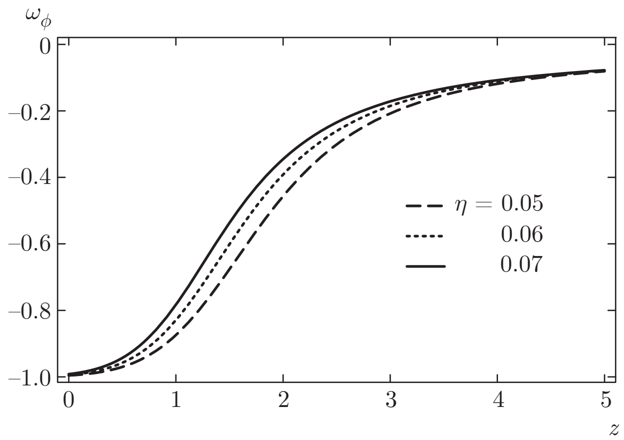

Fig. 3. The ratio of the pressure and energy density of the scalar field $\omega = p/\rho$ as a function of red-shift

Another quantity with considerable physical significance, namely the deceleration parameter, is defined by $q = 1/2 + 3p/2\rho$, which measures the cosmic acceleration of the universe expansion. We have plotted the behavior of this parameter in terms of red-shift in Fig. 2. Obviously, the transition point from deceleration phase to the acceleration one depends on the coupling strength, and occurs around $1 \leq z \leq 1.5$, compatible with the recent observations with the best fit estimate of about $z_t \approx 1.35$ [49]. By increasing the coupling value the transition point z_t moves to lower red-shifts and correspondingly deceleration parameter for the present time $q(0)$ increases. It should be mentioned here that, the deceleration parameter approaches to a common value for high red-shifts, regardless of coupling strength values.

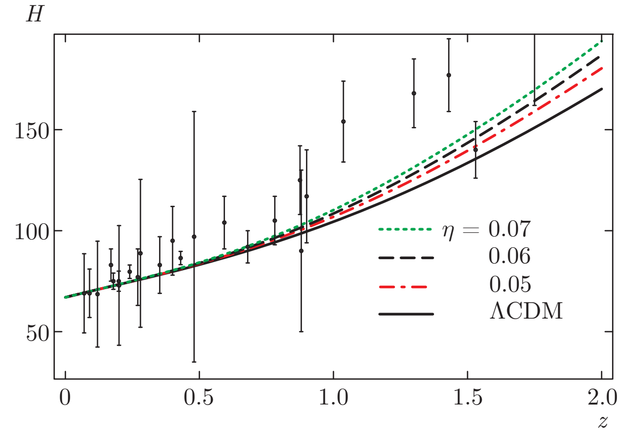

Fig. 4. The behavior of the Hubble parameter in terms of red-shift for four values of the coupling parameter [46]

The ratio of the pressure and energy density of the scalar field $\omega = p/\rho$ is plotted in Fig. 3. Obviously, at lower red-shifts the ratio tends to -1 asymptotically, which is corresponding to ΛCDM model. While, as the red-shift increases, the ratio grows considerably, and at higher values of z it approaches to zero asymptotically, and dark energy eventually becomes a pressureless matter field. This behavior was expected because according to Fig. 1, as the red-shift increases the amount of energy transmission from the gravitational field to dark energy grows considerably for a long time, especially for weaker coupling parameters. Furthermore, this figure indicates that as the coupling parameter decreases, the ratio ω drops to small values. This behavior is confirmed by Fig. 2 in the sense that, by decreasing η the transition point z_t moves to higher red-shifts and correspondingly deceleration parameter in the present time $q(0)$ decreases.

The Hubble parameter H as a function of red-shift is illustrated in Fig. 4 for specified values of the coupling parameter η. According to this figure, the present model fits well with the available observational data from supernovas [46, 50].

5. CONCLUSIONS

In this work, we have proposed a cosmological model with tachyon as a non-canonical scalar field contributing significantly to represent the nature of dark energy. We allowed it to be non-minimally coupled to the scalar torsion in the framework of teleparallel gravity. In this model, by applying the Noether symmetry approach, an exponential form function was obtained for both tachyon potential and coupling function, with linear dependence. Also the dynamical behavior of the basic cosmological observables, namely, the density parameters of the tachyon field $\Omega_\phi(z)$, matter field $\Omega_m(z)$, the deceleration parameter $q(z)$, and the ratio of the pressure and energy density of the tachyon field $\omega(z)$ have been considered for the different values of the coupling parameter. It was observed that the density parameter for tachyons drops to small values as matter begins to dominate, but it does not become negligible at high red-shifts. Furthermore, as the coupling strength increases, the amount of dark energy, unlike the matter field, significantly increases throughout the universe for a long time, and *vice versa*. It is also seen that, with suitable choice of the parameters, our scenario exhibits a transition from deceleration to the acceleration around $z_t = 1.35$, in agreement with recent observational data. Finally, we found that the ratio of the pressure and energy density of the tachyon increases from negative value to zero asymptotically, $-1 \le \omega \le 0$, but contrary to the phantom field, cannot cross -1.

It seems still necessary to explore further dark energy cosmology for the tachyon field in the framework of teleparallel gravity, especially in anisotropic and inhomogeneous metric models, due to the fact that the universe is not rigorously isotropic and homogeneous. It is out of the scope of the present work and is left for future investigations.

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