The Effects of Tachyonic and Phantom Fields in the Intermediate and Logamediate Scenarios of the Anisotropic Universe

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In this work, we have analyzed two scenarios namely, “intermediate” and “logamediate” scenarios for closed, open and flat anisotropic universe in presence of phantom field, normal tachyonic field and phantom tachyonic field. We have assumed that there is no interaction between the above mentioned dark energy and dark matter. In these two types of the scenarios of the universe, the nature of the scalar fields and corresponding potentials have been investigated. In intermediate scenario, (i) the potential for normal tachyonic field decreases, (ii) the potentials for phantom tachyonic field and phantom field increase with the corresponding fields. Also in logamediate scenario, (i) the potential for normal tachyonic field increases, (ii) the potentials for phantom tachyonic field and phantom field decrease with the corresponding fields.

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I. INTRODUCTION

In recent observations it is strongly believed that the Universe is experiencing an accelerated expansion. The observation from type Ia supernovae [1] in associated with Large scale Structure [2] and Cosmic Microwave Background anisotropies [3] have shown the evidences to support cosmic acceleration. The main theory responsible for this scenario is the theory of dark energy. This mysterious dark energy with negative pressure leads to this cosmic acceleration. Also the observations indicate that the dominating component of the present Universe is dark energy. Dark energy occupies about 73% of the energy of our Universe, while dark matter about 23% and the usual baryonic matter 4%. There are different candidates obey the property of dark energy to violate the strong energy condition $\rho + 3p > 0$ given by – quintessence [4], K-essence [5], Tachyon [6], Phantom [7], ghost condensate [8,9] and quintom [10], interacting dark energy models [11], brane world models [12] and Chaplygin gas models [13]. In [14] Chang etal studied the Phantom field $\phi$ with the potential $V(\phi) = V_0 \exp(-\lambda \phi^2)$ and the dark matter in the spatially flat FRW model with attractor solutions depending on $\lambda$. In [15] Shang-Gang Shi et al discussed the cosmological evaluation of a dark energy model with two scalar fields - Tachyon and the other Phantom Tachyon where the equation of state $w$ changes from $w > -1$ to $w < -1$ during the evaluation of the Universe which is a quintom like behavior. In [16] Benaoum has studied the behaviour of modified Chaplygin gas and effect on the accelerating Universe in FRW model. In [17] Sami has discussed cosmological prospect of rolling Tachyon with exponential potential. In [18] Debnath has shown that the emergent scenario is possible for the closed Universe if the Universe contains the normal Tachyon field and for the Phantom field (or Tachyonic field) the emergent scenario is possible for flat, open and closed Universe. The holographic description of Tachyon dark energy in FRW model has been studied by Setare [19].

Motivated from the consistency of observational measurement of CMB about the spectral index and ratio of tensor to scalar perturbations, we have considered two pre-assigned form of scale factors (backward approach) as: (i) “intermediate scenario” and (ii) “logamediate scenario” [16, 17] to study of the expanding anisotropic Universe in presence of tachyon field and phantom scalar field. This approach is new as we have studied the expansion of the universe in anisotropic model, where we consider the two scale factors independently follow the said scenarios. In the first case the scale factors evolve separately as $a(t) = \exp(A^1)$ and $b(t) = \exp(B^1)$. So the expansion of the Universe is slower than standard de Sitter inflation (arises when $f_1 = f_2 = 1$) but faster than power law inflation with power greater than 1. The Harrison - Zeldovich spectrum of fluctuation arises when $f_1 = f_2 = 1$ and $f_1 = f_2 = 2/3$. In the second case we analyze the inflation with scale factors separately of the form $a(t) = \exp(A(\ln t)^{\lambda_1})$ and $b(t) = \exp(B(\ln t)^{\lambda_2})$. When $\lambda_1 = \lambda_2 = 1$ this model reduces to power law inflation.

Motivated from the consistency of observational measurement of CMB about the spectral index and ratio of tensor to scalar perturbations, we have considered two pre-assigned form of scale factors (backward approach) as: (i) “intermediate scenario” and (ii) “logamediate scenario” [16, 17] to study of the expanding anisotropic Universe in presence of tachyon field and phantom scalar field. This approach is new as we have studied the expansion of the universe in anisotropic model, where we consider the two scale factors independently follow the said scenarios. In the first case the scale factors evolve separately as $a(t) = \exp(A^1)$ and $b(t) = \exp(B^1)$. So the expansion of the Universe is slower than standard de Sitter inflation (arises when $f_1 = f_2 = 1$) but faster than power law inflation with power greater than 1. The Harrison - Zeldovich spectrum of fluctuation arises when $f_1 = f_2 = 1$ and $f_1 = f_2 = 2/3$. In the second case we analyze the inflation with scale factors separately of the form $a(t) = \exp(A(\ln t)^{\lambda_1})$ and $b(t) = \exp(B(\ln t)^{\lambda_2})$. When $\lambda_1 = \lambda_2 = 1$ this model reduces to power law inflation. The logamediate inflationary form is motivated by considering a class of possible cosmological so-
olutions with indefinite expansion which result from imposing weak general conditions on the cosmological model.

II. BASIC EQUATIONS AND SOLUTIONS

We consider homogeneous and anisotropic space-time model described by the line element

\[ ds^2 = -dt^2 + a^2 dx^2 + b^2 d\Omega_k^2 \] (1)

where \( a \) and \( b \) are scale factors and functions of time \( t \) alone: we note that

\[ d\Omega_k^2 = \begin{cases} dy^2 + dz^2, & \text{when } k = 0 \quad \text{(Bianchi I model)} \\ d\theta^2 + \sin^2 \theta d\phi^2, & \text{when } k = +1 \quad \text{(Kantowski-Sachs model)} \\ d\theta^2 + \sinh^2 \theta d\phi^2, & \text{when } k = -1 \quad \text{(Bianchi III model)} \end{cases} \]

Here \( k \) is the curvature index of the corresponding 2-space, so that the above three types are described by Thorne [22] as flat, closed and open respectively.

Now we consider the Hubble parameter \( H \) and the deceleration parameter \( q \) in terms of scale factor as

\[ H = \frac{1}{3} \left( \frac{\dot{a}}{a} + 2 \frac{\dot{b}}{b} \right) \quad \text{and} \quad q = -1 - \frac{\dot{H}}{H^2} \] (2)

We consider that the Universe contains normal matter and Phantom field (or Tachyonic field). The Einstein field equations for the space time given by the equation (1) are

\[ \frac{\ddot{a}}{a} + 2 \frac{\ddot{b}}{b} = -\frac{1}{2}(\rho_\phi + \rho_m + 3p_\phi + 3p_m) \] (3)

and

\[ \frac{j^2}{b^2} + 2 \frac{\dot{a} \ddot{b}}{ab} + \frac{k^2}{b^2} = (\rho_\phi + \rho_m) \] (4)

where \( \rho_m \) and \( p_m \) are the energy density and pressure of the normal matter with the equation of state given by \( p_m = w\rho_m, -1 \leq w \leq 1 \) and \( \rho_\phi \) and \( p_\phi \) are the energy density and pressure due to the Phantom field (or Tachyonic field).

Now considering that there do not exist any interaction between normal matter and the Phantom field (or Tachyonic field), that is they are separately conserved, the energy conservation equation for normal matter and the Phantom field (or Tachyonic field) are

\[ \dot{\rho}_m + 3H(p_m + \rho_m) = 0 \] (5)

and

\[ \dot{\rho}_\phi + 3H(p_\phi + \rho_\phi) = 0 \] (6)

From equation (5) we have the expression for energy density of matter as

\[ \rho_m = \rho_0 \left(ab^2\right)^{-(w+1)} \] (7)

where \( \rho_0 \) is the integration constant.
• **Tachyonic field:** The energy density $\rho_\phi$ and pressure $p_\phi$ due to the Tachyonic field $\phi$ is given by

$$\rho_\phi = \frac{V(\phi)}{\sqrt{1 - \epsilon \dot{\phi}^2}} \quad (8)$$

$$p_\phi = -V(\phi)\sqrt{1 - \epsilon \dot{\phi}^2} \quad (9)$$

where $V(\phi)$ is the relevant potential for the Tachyonic field $\phi$. It can be seen that $\frac{p_\phi}{\rho_\phi} = -1 + \epsilon \dot{\phi}^2 > -1$ or $< -1$ according to normal Tachyon ($\epsilon = +1$) or Phantom Tachyon ($\epsilon = -1$).

From the field equations (3), (4), (8) and (9) the expression for $\dot{\phi}^2$ and $V(\phi)$ are given by

$$\dot{\phi}^2 = \frac{-\frac{2}{3}(\frac{\ddot{a}}{a} + \frac{\ddot{b}}{b} - \frac{\dot{a}^2}{a^2} - 2\frac{\dot{a} \dot{b}}{ab}) + (w + 1)\rho_m + \frac{2k}{3b^2}}{\epsilon \rho_\phi} \quad (10)$$

and

$$(V(\phi))^2 = -\rho_\phi p_\phi \quad (11)$$

• **Phantom field:** The energy density and pressure of the Phantom field $\phi$ are respectively given by

$$\rho_\phi = -\frac{1}{2} \dot{\phi}^2 + V(\phi) \quad (12)$$

and

$$p_\phi = -\frac{1}{2} \dot{\phi}^2 - V(\phi) \quad (13)$$

where $V(\phi)$ is the Phantom field potential. From the equations (3), (4), (12) and (13) we have

$$\dot{\phi}^2 = \frac{2}{3} \left( \frac{\ddot{a}}{a} + \frac{\ddot{b}}{b} - \frac{\dot{a}^2}{a^2} - 2\frac{\dot{a} \dot{b}}{ab} \right) + (w + 1)\rho_m - \frac{2k}{3b^2} \quad (14)$$

and

$$V(\phi) = \dot{H} + 3H^2 + \frac{1}{2}(w - 1)\rho_m + \frac{2k}{3b^2} \quad (15)$$

**A. Intermediate Scenario**

Here we consider a particular form of intermediate scenario, where the form of the scale factors $a(t)$ and $b(t)$ are defined as, [23]

$$a(t) = \exp(At^{f_1}) \quad \text{and} \quad b(t) = \exp(Bt^{f_2}) \quad (16)$$

Using these expressions we have the Hubble parameter and its derivatives as,

$$H = \frac{At^{f_1} + 2Bt^{f_2} f_2}{3t}, \quad \dot{H} = \frac{At^{f_1}(-1 + f_1) + 2Bt^{f_2} f_2(-1 + f_2)}{3t^2} \quad (17)$$

and
Figs. 1 - 2 show the variations of $\phi$ and $V$ against $t$ and fig. 3 shows the variations of $V$ against $\phi$, for $A = 1.2, B = 1.1, f_1 = .7, f_2 = .6, k = 1, w = 1/3, \rho_0 = 1$ in presence of normal tachyonic field ($\epsilon = +1$) in intermediate scenario.

\[
\dddot{H} = \frac{A f_1 (2 + (-3 + f_1)f_1) + 2B t^2 f_2 (2 + (-3 + f_2)f_2)}{3t^3} \tag{18}
\]

Hence, in presence of normal tachyonic field and for expanding Universe, $Af_1 > 0$ and $Bf_2 > 0$. Also, from the derivative of Hubble parameter we have $0 < f_1 < 1$ and $0 < f_2 < 1$ and then $A > 0$ and $B > 0$.

And in presence of phantom field and for a expanding Universe $Af_1 > 0$ and $Bf_2 > 0$. Also, from the derivative of Hubble parameter we have $f_1 > 1$ and $f_2 > 1$ and then $A > 0$ and $B > 0$.

Now putting the assumed values of the scale factors in (10) and (11), we have the required expressions for tachyonic field $\phi$ and its potential $V$ as

\[
\phi = \int \left[ \frac{2k e^{-2B t^2 / 2}}{e^{2B t^2 / 2}k + 2ABt^{-2} + f_1 f_2 f_1 + f_2 + B^2 t^{-2} - 2f_2 f_1 - (e^{At + 2B t^2})^{-1}} \right]^{1/2} dt \tag{19}
\]
Figs. 4 - 5 show the variations of $\phi$ and $V$ against $t$ and fig. 6 shows the variations of $V$ against $\phi$, for $A = 1.2, B = 1.1, f_1 = 1.5, f_2 = 1.7, k = 1, w = 1/3, \rho_0 = 1$ in presence of phantom tachyonic field ($\epsilon = -1$) in intermediate scenario.

and

$$V = \left[ e^{-2Bt^2} k + 2ABt^{-2} f_1 f_2 f_1 f_2 + B^2 t^{-2} f_2^2 - (e^{At^1 + 2Bt^2})^{-1} - \omega \rho_0 \right] \times$$

$$\left[ \frac{k_2 e^{-2Bt^2} - 2(A^{t^1} f_1 (-1 + (1 + At^{t^1}) f_1) + B^3 t^{-2} f_2^2 + 2Bt^2 f_2 (-1 - At^{t^1} f_1 + f_2))}{(e^{-2Bt^2} k + 2ABt^{-2} f_1 f_2 f_1 f_2 + B^2 t^{-2} f_2^2 - (e^{At^1 + 2Bt^2})^{-1} - \omega \rho_0)} \right]^{1/2}$$

Now putting the assumed values of the scale factors in (14) and (15), we have the required expressions for phantom field $\phi$ and its potential $V$ as

$$\phi = \int \left[ \frac{2(A^{t^1} f_1 (-1 + (1 + t^{t^1}) f_1) + B^3 t^{-2} f_2^2 + 2Bt^2 f_2 (-1 - At^{t^1} f_1 + f_2))}{3t^2} \right]^{1/2}$$

$$+ (e^{At^1 + 2Bt^2})^{-1} - \omega \rho_0 \frac{2}{3} e^{-2Bt^2} k \]^{1/2} dt$$

(21)
Figs. 7 - 8 show the variations of $\phi$ and $V$ against $t$ and fig. 9 shows the variations of $V$ against $\phi$, for $A = 2, B = 3, f_1 = 1.5, f_2 = 1.7, k = 1, w = 1/3, \rho_0 = 1$ in presence of phantom field in intermediate scenario.

and

$$V = \frac{(At^{f_1} f_1 + 2Bt^{f_2} f_2)^2 + At^{f_1} (-1 + f_1) f_1 + 2Bt^{f_2} (-1 + f_2) f_2}{3t^2}$$

$$+ \frac{1}{2}(e^{At^{f_1} + 2Bt^{f_2}})^{-1 - w}(-1 + w)\rho_0 + \frac{2}{3}e^{-2Bt^{f_2} k}$$

(22)

And the dark energy density and mass for of the universe or the two cases are given by

$$\rho_\phi = e^{-2Bt^{f_2} k} + 2ABt^{-2 + f_1 + f_2} f_1 f_2 + B^2 t^{-2 + 2f_2} f_2^2 - (e^{At^{f_1} + 2Bt^{f_2}})^{-1 - w} \rho_0$$

(23)

$$Mass = \frac{e^{At^{f_1}} (kt^2 + Bc^{2Bt^{f_2} f_2} f_2 (2At^{f_1} f_1 + Bt^{f_2} f_2))}{t^2}$$

(24)

From above we see that the expressions of tachyonic field and phantom field and their corresponding potentials are very complicated. The normal tachyonic field ($\epsilon = +1$) and corresponding potential against time $t$ have been drawn in figures 1, 2 respectively and the potential against the corresponding field have been drawn in figures 3 in intermediate scenario for $A = 1.2, B = 1.1, f_1 = .7, f_2 = .6, k = 1, w = 1/3, \rho_0 = 1$. Also the phantom tachyon field ($\epsilon = -1$) and phantom field with the corresponding potentials have been drawn in figures 4, 5, 7 and 8 respectively and the fields potentials against the corresponding fields have been drawn in figures
Figs. 10 - 11 show the variations of $\phi$ and $V$ against $t$ and fig. 11 shows the variations of $V$ against $\phi$, for $A = 1.1, B = 1.2, \lambda_1 = 2, \lambda_2 = 3, k = 1, w = 1/3, \rho_0 = 1$ in presence of normal tachyonic field ($\epsilon = +1$) in logamediate scenario.

6 and 9 respectively in intermediate scenario for $A = 1.2, B = 1.1, f_1 = 1.5, f_2 = 1.7, k = 1, w = 1/3, \rho_0 = 1$.

From figures 1-3, we see that the normal tachyonic field always increases with time, potential decreases against time and normal tachyonic field. From figures 4-6, we see that the phantom tachyonic field and potential always increase with time and potential increases with phantom tachyonic field. Also, from figures 7-9, we see that the phantom field and potential always increase with time and potential increases with phantom field.

**B. Logamediate Scenario**

Consider a particular form of logamediate scenario, where the form of the scale factors $a(t)$ and $b(t)$ are defined as [23]

$$a(t) = \exp(A(\ln t)^{\lambda_1}) \quad \text{and} \quad b(t) = \exp(B(\ln t)^{\lambda_2})$$

(25)
Using these expressions we have the Hubble parameter and its derivatives as,

$$H = \frac{A \ln t^{\lambda_1} \lambda_1 + 2B \ln t^{\lambda_2} \lambda_2}{3t \ln t}, \quad \dot{H} = \frac{A \ln t^{\lambda_1} (1 - \ln t + \lambda_1) + 2B \ln t^{\lambda_2} (1 - \ln t + \lambda_2)}{3(t \ln t)^2}$$

and

$$\ddot{H} = \frac{A \ln t^{\lambda_1} (2 + \ln t(3 + 2 \ln t) - 3(1 + \ln t) \lambda_1 + \lambda_1^2) + 2B \ln t^{\lambda_2} (2 + \ln t(3 + 2 \ln t) - 3(1 + \ln t) \lambda_2 + \lambda_2^2)}{3(t \ln t)^3}$$

Hence, for an expanding Universe $A \lambda_1 > 0$ and $B \lambda_2 > 0$. Also, from the derivative of Hubble parameter we have $\lambda_1 > 1$ and $\lambda_2 > 1$ or if $\lambda_1 = \lambda_1 = 1$, then $A > 1$ and $B > 1$.

Now putting the assumed values of the scale factors in (10) and (11), we have the required expressions for tachyonic field $\phi$ and its potential $V$ as

$$\phi = \int \left[ \frac{2ke^{-2B(\ln t)^{\lambda_2}} + \frac{2}{3e^{2B(\ln t)^{\lambda_2}}}(-A(\ln t)^{\lambda_1})(1 + A(\ln t)^{\lambda_1})(\lambda_1)^2 + A(\ln t)^{\lambda_1} \lambda_1(1 + \ln t + 2B(\ln t)^{\lambda_2}) \lambda_2}{\epsilon(e^{-2B(\ln t)^{\lambda_2} k} + \frac{2AB(\ln t)^{-2+\lambda_1+\lambda_2} \lambda_1 \lambda_2}{t^2} + \frac{B^2(\ln t)^{-2+2\lambda_2} \lambda_2^2}{t^2} - (e^{A(\ln t)^{\lambda_1} + 2B(\ln t)^{\lambda_2})(-1-w) \rho_0)} \right]^{1/2} \, dt$$

Figs. 13 - 14 show the variations of $\phi$ and $V$ against $t$ and fig. 15 shows the variations of $V$ against $\phi$, for $A = 1.1, B = 1.2, \lambda_1 = 2, \lambda_2 = 3, k = 1, w = 1/3, \rho_0 = 1$ in presence of phantom tachyonic field ($\epsilon = -1$) in logamediate scenario.
and

\[ V(\phi) = e^{-2B(\ln t)\lambda_2} k + \frac{2AB(\ln t)^{-2+\lambda_1+\lambda_2}\lambda_1\lambda_2 + B^2(\ln t)^{-2+2\lambda_2} \lambda_2^2}{t^2} - \left( e^{A(\ln t)\lambda_1+2B(\ln t)\lambda_2} \right)^{-1-\omega} \rho_0 \]

\[
\left[ 1 - \frac{2k e^{-2B(\ln t)\lambda_2} + \frac{2A(\ln t)^{-2+\lambda_1+\lambda_2}\lambda_1\lambda_2 + B^2(\ln t)^{-2+2\lambda_2} \lambda_2^2}{t^2} - \left( e^{A(\ln t)\lambda_1+2B(\ln t)\lambda_2} \right)^{-1-\omega} \rho_0}{e^{-2B(\ln t)\lambda_2} k + \frac{2A(\ln t)^{-2+\lambda_1+\lambda_2}\lambda_1\lambda_2 + B^2(\ln t)^{-2+2\lambda_2} \lambda_2^2}{t^2} - \left( e^{A(\ln t)\lambda_1+2B(\ln t)\lambda_2} \right)^{-1-\omega} \rho_0} \right]^{1/2}
\]

(29)

Now putting the assumed values of the scale factors in (14) and (15), we have the required expressions for phantom field \( \phi \) and its potential \( V \) as

\[ \phi = \int \left[ -\frac{2k e^{-2B(\ln t)\lambda_2}}{3} + \frac{2}{3} \frac{(-A(\ln t)\lambda_1)(1 + A(\ln t)\lambda_1)(\lambda_1^2 + A(\ln t)\lambda_1(1 + \ln t + 2B(\ln t)\lambda_2)\lambda_2 + \frac{B(\ln t)\lambda_2(2(1 + \ln t)(2 + B(\ln t)\lambda_2))}{3t^2(\ln t)^2} + e^{A(\ln t)\lambda_1+2B(\ln t)\lambda_2} \left( 1 - \omega \right) \rho_0}{\left( e^{-2B(\ln t)\lambda_2} k + \frac{2A(\ln t)^{-2+\lambda_1+\lambda_2}\lambda_1\lambda_2 + B^2(\ln t)^{-2+2\lambda_2} \lambda_2^2}{t^2} - \left( e^{A(\ln t)\lambda_1+2B(\ln t)\lambda_2} \right)^{-1-\omega} \rho_0} \right]^{1/2} \]

(30)
Fig. 19 and Fig. 20 show the variations of $\rho_\phi$ (dark energy density) against $t$ for Intermediate scenario and Logamediate scenario.

and

$$V = \frac{(A(lnt)^{\lambda_1} + 2B(lnt)^{\lambda_2})(-1 + \lambda_1)\lambda_1 + 2B(lnt)^{\lambda_2}(-1 + \lambda_2)\lambda_2}{3t^2(lnt)^2}$$

$$+ \frac{1}{2}(e^{A(lnt)^{\lambda_1} + 2B(lnt)^{\lambda_2}})^{-1 - w}(-1 + w)\rho_0 + \frac{2}{3}e^{-2B(lnt)^{\lambda_2}}k$$

And the dark energy density and mass of the universe for the two cases are given by

$$\rho_\phi = e^{-2B(lnt)^{\lambda_2}} k + \frac{2AB(lnt)^{-2 + \lambda_1 + \lambda_2} \lambda_1 \lambda_2 + B^2(lnt)^{-2 + 2\lambda_2} \lambda_2^2}{t^2} - (e^{A(lnt)^{\lambda_1} + 2B(lnt)^{\lambda_2}})^{-1 - w} \rho_0$$

$$\text{Mass} = \frac{e^{A(lnt)^{\lambda_1}}(kt^2(lnt)^2 + Be^{2B(lnt)^{\lambda_2}}(lnt)^{\lambda_2} \lambda_2(2A(lnt)^{\lambda_1} \lambda_1 + B(lnt)^{\lambda_2} \lambda_2))}{t^2(lnt)^2}$$

From above we see that the expressions of tachyonic field and phantom field and their corresponding potentials are very complicated. The normal tachyonic field ($\epsilon = +1$) and corresponding potential against time $t$ have been drawn in figures 10, 11 respectively and the potential against the corresponding field have been drawn in figures 12. Also the phantom tachyon field ($\epsilon = -1$) and corresponding field potentials have been drawn in figures 13, 14, 16 and 17 respectively and the fields potentials against the corresponding fields have been drawn in figures 15 and 18 respectively in logamediate scenario for $A = 1.1, B = 1.2, \lambda_1 = 2, \lambda_2 = 3, k = 1, w = 1/3, \rho_0 = 1$. From figures 10-12, we see that the normal tachyonic field and potential always increase with time and potential increases against normal tachyonic field. From figures 13-15, we see that the phantom tachyonic field and potential always decrease with time and potential decreases with phantom tachyonic field. Also, from figures 16-18, we see that the phantom field always increases with time and potential always decreases with time and phantom field.

Now, we have graphically analyze the dark energy density for phantom and tachyon scalar field in intermediate and logamediate scenarios.

III. DISCUSSIONS

In this work, we have analyzed two scenarios namely, “intermediate” and “logamadiate” scenarios for closed, open and flat anisotropic universe in presence of phantom field, normal tachyonic field and phantom tachyonic field. We have assumed that there is no interaction between the above mentioned dark energy and dark matter. In these two types of the scenarios of the universe, the nature of the scalar fields and corresponding potentials have been investigated. In case of intermediate scenario we see from figures 1 and 2 that the normal tachyonic field $\phi$ increases and the potential $V(\phi)$ decreases with time but remain positive. From the figure 3 it is clear
that the potential also decreases with the increase of the field. Where as for phantom tachyon we see from the figures 4 and 5 that the field and the potential both are increasing with time. Also from the figure 6 we came to know that potential also increases with the increase of the field. Also for phantom field we see from the figures 7 and 8 that the field and the potential both are increasing with time and from the figure 9 we came to know that potential also increases with the increase of the field. For intermediate scenario we express the dark energy density and mass of the universe in term of cosmic time $t$ and from fig 19 we came to know that the density is decreasing by the evolution of the universe.

In case of logamediate scenario we see from figures 10 and 11 that the normal tachyonic field $\phi$ increases and the potential $V(\phi)$ increases with time but remain positive. From the figure 12 it is clear that the potential also increases with the increase of the field. Where as for phantom tachyon we see from the figures 13 and 14 that the field and the potential both are decreasing with time. Also from the figure 15 we came to know that potential also decreases with the increase of the field. Also for phantom field we see from the figures 16 and 17 that the field increases and the potential decreases with time and from the figure 18 we came to know that potential also decreases with the increase of the field. For logamediate scenario we express the dark energy density and mass of the universe in term of cosmic time $t$ and from fig 20 we came to know that the density is gradually decreasing by the evolution of the universe.

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