Preface

The present investigations have been carried out towards the fulfillment of the requirements for the award of a Ph.D. degree in Mathematics of V.B.S. Purvanchal University, Jaunpur (U.P.), India, under the supervision of Dr. R.C. Upadhyay, Reader, Department of Mathematics, R.S.K.D. P.G. College, Jaunpur (U.P.), India.

The thesis deals with the Studies in present expansion of the Universe. It has been divided into four chapters. The first chapter is introductory. So, we have formulated and discussed some of the techniques and results which are relevant for our subsequent investigations. Hence, we have presented The kinematical Λ models, Dark Energy Universe,, Scalar-field Model.

In chapter II, by including irreversible creation mechanism in BD theory, we can obtain a variety of inflationary models without any fine tuning or artificial assumptions, corresponding to various values of $\propto$ within the range prescribed by (2.25).

The particular choice of $\propto$ in (2.29) leads to the steady state inflationary model dealt with in section 4.

It is evident from (2.31), (2.35), and (2.36) that the rate of creation of particles in this inflationary model just compensates for the dilution of density due to expansion. As such the three physical parameters energy density, pressure and particle number density remain constant throughout. However, this technique can be used to discuss evolutionary models with inflation also. It is worth pointing out that Mathiazhagan and Johri (1984), Steinhardt and La (1989) have obtained the same expressions for the scale factor R(t) and the scalar field $\emptyset(t)$ in the inflationary scenarios discussed by them in the context of the evolutionary models.

In chapter III, we have obtained exact solutions of the field equations of Nordtvedt's theory for constant deceleration parameter and $k = 0$. We have considered only singular solutions with (i) power-law, (ii) exponential expansion and have examined the particular class of models in which the BD parameter w might increase with time. It is found that there exists a variety of models in which w might increase initially and decrease subsequently and vice versa.

In the last chapter, this analysis assumes that the asymptotic "velocity" of the scalar field is given by $\emptyset(\infty)=(2/3n)^{1/2}$ if the expansion of the universe at late times is given by $a(t) = t^n$. This in turn, requires the tachyonic potential $V(\varnothing)$ to have the asymptotic form $A/\varnothing^2$ without any restriction on A. To have accelerated expansion, we must have reasonably large n requiring $\varnothing(\infty)$ to be sufficiently less than unity- which is possible if A is non zero and arbitrary.

The situation is different if there are string theoretic reasons to expect $\varnothing(\infty) = 1$ asymptotically. Since equation (4.16) can be equivalently written as

$$H^{-1}(t) = 3/2 \int \dot{\varnothing}^2 \, dt \quad ,$$

$\varphi(\infty) = 1$ asymptotically will imply $a(t) \propto t^{2/3}$. Then we must have $n = (2/3)$ which is just a dust dominated, zero pressure, expansion law. The cosmological implications are very different depending on whether string theory requires the condition $\varphi(\infty) = 1$ asymptotically or not. Let me discuss the different possibilities briefly.

If it is possible to have $\varnothing(\infty) \neq 1$ asymptotically, then an attractive scenario emerges in which the tachyonic condensate could be driving the acceleration of the universe and mimicking the cosmological constant. In this case, one is interpreting the asymptotic evolution to be applicable during the current phase of the universe, in the range of redshifts, say, $0 < n < 3$. In a realistic model, one may need to worry about the timescales in string theory (presumably $\approx t_{Planck}$) vis-a-vis the cosmological timescale. But this issue will arise in any attempt to use the tachyonic condensate in the late phases in the evolution of the universe, like-for example- as some kind of dark matter.

An easy way out is to use the solutions in the early universe. The solutions I have obtained, of course, could also be used to provide a power law inflation in the very early universe if $t \rightarrow 0\ \infty$ is interpreted merely as $t > t_{Planck}$. It may be easier to have non vanishing pressure for the tachyonic condensate for $t > t_{Planck}$ than during the current epochs of the universe. (I think it would be nicer if string theory could provide an effective cosmological constant at the current epoch- which has some observational support- rather than merely provide yet another inflation field. But the procedure outlined here can be used to construct a wide class of inflationary solutions as will.)

If, on the other hand, string theory demands $\varphi(\infty) = 1$ asymptotically, then $V \rightarrow 0$ asymptotically in such a manner as to give finite ρ and zero pressure. The tachyonic condensate can then contribute, say, $\Omega = 4.7$ in the universe and- together with clustered normal matter contributing $\Omega = 0.3$ - can lead to a $\Omega = 1$ universe. Such a model is an extreme form of mixed dark matter model with a very smoothly distributed component at large scales. It is possible that the model is consistent with CMBR and galaxy clustering data but will contradict the supernova data if it is interpreted as indicating $a > 0$ in the recent past. (Because $a < 0$ when $n > 1$, this model will not be accelerating.) Given the observational uncertainties, it may still be worth studying the consequences of such a model.

Even in this case [with $\varnothing(\infty) = 1$ asymptotically}, it may be possible to provide an accelerated expansion for the universe in the recent past if one considers more complicated potentials. For example, one can arrange matters such that $n >> 1$ in the redshift range of $3 > z > 0$, say, with the asymptotic regime of $n = (2/3)$ coming into effect on in the future. The procedure developed in this chapter can be used to obtain suitable $V(\varnothing)$ which will ensure such a scenario.

Every chapter has been divided into sections following decimal system : e.g. section (1.5) means fifth of chapter first. On the same line, the equations in different chapters are also numbered i.e. eq. (4.5) means fifth equation of chapter four. However references are quoted whenever necessary by writing authors name followed by year in round bracket. At last references are given.