

# ADVANCES IN CONTEMPORARY PHYSICS

HIGH-ENERGY, COSMOLOGY,  
AND SOFT MATTER



Editor:

Dr. Syed Salman Ahmad Warsi

# **Advances In Contemporary Physics**

**High-Energy, Cosmology, and Soft Matter**

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# DYNAMICAL SYSTEM ANALYSIS IN COSMOLOGY

Muskan Khan and Mohd Shahalam

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In this chapter, we explore the dynamics of the standard cosmological model by framing it as a Newtonian dynamical system. The total energy density  $\rho_{eff}$ , is specified by the expansion factor  $a(t)$ , allowing us to interpret the cosmological constant and curvature terms as specialized types of fluid. Our study extends to the analysis of autonomous dynamical system, focusing on the asymptotic behavior of the models under consideration. We introduced a set of first-order differential equations to describe the evolution of variables  $x(t)$  and  $y(t)$ , identifying critical points and analyzing their stability through eigenvalues. The stability of these points, classified as stable, unstable and saddle points, provides insights into the dynamical behavior of the universe. We delve into scalar field models, specifically quintessence, to understand their role in the accelerated expansion of the universe. The cosmological dynamics of the scalar field, governed by a potential  $V(\phi)$ , are analyzed using dimensionless variables and autonomous system. We choose two models: a single exponential potential and a double exponential potential, examining their fixed point analysis. In case of single exponential potential, the system exhibits a critical point that is stable for certain parameter values, indicating a stable attractor. However, the double exponential potential model demonstrates the capability to achieve both scaling and stable accelerating solutions. Concurrently, that feature is not possible with a single exponential potential. Through phase space analysis, we visualize the trajectories and stability of these models, providing a comprehensive understanding of the cosmological dynamics driven by scalar fields. Our findings contribute to the theoretical framework of cosmology, addressing key questions about the expansion of the universe and the cosmic acceleration.

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## INTRODUCTION:

Astronomy is one of the oldest wisdom which is the study of elysian objects similar as stars, worlds, globes and moons etc. An affiliated subject, cosmology is concerned with the study of the entire Universe. It tries to use the scientific system to understand the origin, elaboration and the fate of Universe. It involves the conformation of propositions or suppositions about the Universe that makes particular prognostications for marvels which can be tested with compliances. Depending on the outgrowth of the cosmological data, the propositions will be demanded to be abandoned, revised or extended to accommodate it. The prevailing proposition about the origin and elaboration of the Universe is known as Big Bang proposition, popularly called the standard model of the Universe. The standard cosmological model is based on the general theory of relativity. Albert Einstein proposed the general theory of relativity in 1915, and