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From Flat to Curved: Probing Interacting Dark Energy in Light of Observations

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The standard model of cosmology, ΛCDM, has been a fundamental framework for understanding the universe from a theoretical perspective and for explaining a wide range of astrophysical and cosmological observations. Nonetheless, the increasing amount of observational data have given rise to the era of precision cosmology, revealing discrepancies in parameter values across different observables and experiments, challenging the ΛCDM's capacity to comprehensively elucidate the universe's structure and evolution. To address these pressing gaps, I will focus on my studies on the observational signatures of various dark energy frameworks, with a primary emphasis on investigating interacting dark sector models and exploring alternatives to the standard cosmological model. I will talk about their capabilities in an attempt - to tackle significant issues such as the Hubble constant (H_0) tension and the S_8 parameter tension related to matter structure growth, combining theoretical and observational approaches.

In this talk, in particular, I will discuss about the observational data analysis of an interaction model of dark matter and quintessence dark energy. I evaluated this model using cosmological observations from
various sources like the latest observational data like CMB from Planck2018, BAO from several galaxy surveys, SN-Ia, Masers galaxy samples, cosmic chronometers (CC), growth rate ($f\sigma_8$) data, and H_0 measurements from SH0ES study and strong lensing time delay (SLTD). Due to the uncertainty involved in the dark energy physics and in the observational measurements, we found that the data constrains H_0 towards Planck CMB+ΛCDM results when SH0ES H_0 is excluded and it shifts the H_0 towards Riess et al. results with <1σ consistency when H_0 from SH0ES is included. Additionally, by freely evolving the interaction parameter, we found that while the interaction remains small, it is not disfavoured by the data at late times. These results found to be more robust in tightening constraints on H_0, S_8, and dark matter density parameter (Ω_{DM}) together at 68% confidence, and justify the reduced uncertainty and hence the parameter space. Next, I will discuss the coupled quintessence model within the framework of curved spatial geometry (Coupled+Ω_K model) and examine the
inconsistencies in spatial curvature and their implications for the H_0 and S_8 tensions. The obtained results provide evidence for an open universe in the Coupled+Ω_K model. Moreover, the results also
indicate a lower value of dark energy equation of state (ω_{de}) parameter compared to the flat interacting scenario, attributable to the curvature effect. I will delve deeper into how these findings
within the Coupled+Ω_K picture suggest that relaxing the flatness assumption in coupled dark sector models leads to more precise constraints on H_0 and S_8, as well as significantly better agreement
between theory and observations. In the end, I will shed light on the ongoing research with DESI data, focusing on interacting dark energy models of the quintessence and phantom types.

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