INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

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The observations across different scales of the Universe often diverge from the predictions of General Relativity. These discrepancies between theoretical expectations and observational data leave a large room to explore and study alternative gravity models. Therefore, the phenomenological analysis of alternative gravity theories at astrophysical scales also becomes crucial for assessing their consistency. In this thesis, we explore a few alternative gravity models in the galactic scales expanding into two regimes: the ultra-diffuse galaxies (UDGs) and the rotationally supported galaxies. For the former, we study the velocity dispersion data from three UDGs. For the latter, we analyze the galaxy rotation velocities from the Spitzer Photometry and Accurate Rotation Curves (SPARC) database. For UDGs, the alternative gravity model parameters are statistically fitted to the velocity dispersion (VD) observations. Observed UDGs like NGC1052-DF2 and NGC1052-DF4, which exhibit minimal dark matter and align with Newtonian dynamics, are analyzed using a couple of $f(R)$ gravity models and Renormalization Group correction to General Relativity (RGGR). For this, we assume that the motion of galaxies within the cluster follows isotropic motion, i.e., the radial and tangential anisotropy components are equal. The chosen gravity models are consistent with the observational VD of both the UDGs when parameters are constrained locally and globally. The same analysis is extended to the dark matter-dominated UDG, NGC1052-DF44, however here we focus on the radial anisotropy of the VD. In particular, for NGC1052-DF44, we compare three alternative gravity models- Modified Newtonian Dynamics (MOND), $f(R)$ gravity, and RGGR with a dark matter scenario modeled using a Navarro-Frenk-White (NFW) halo and investigate the role of anisotropy in explaining modified kinematics. We find that only two alternative gravity models out of the three considered, viz. MOND and RGGR remain competitive with the NFW DM profile. Additionally, the anisotropic VD scenario with constant anisotropy suggesting a tangential motion is found to be statistically comparable with the conventional isotropic motion. Moving ahead to the second part of the thesis, we use the SPARC data and examine the galactic kinematics under two alternative gravity frameworks: RGGR and a Yukawa Modified Gravity (YMOG). YMOG considers a general Yukawa term added to the Newtonian gravity model. We analyze the consistency of these models and investigate how the free-model parameters correlate with galaxy morphology. Additionally, we assess the goodness of fit using the standard empirical relations such as the Radial Acceleration Relation (RAR) and the Baryonic Tully-Fisher Relation (BTFR). Our analysis shows that both models, that is, RGGR and YMOG, compete well with an alternative NFW DM model.