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Does General Relativity hold in galactic scales? A test at a z ˜0.3 elliptical lens galaxy

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General Relativity (GR) has been successfully tested mainly at Solar system scales; however, in the last few decades, galaxy-scale tests have become popular. In particular, some recent works dedicate close attention to the $\eta_{\rm PPN}$ parameter, which is commonly associated with the spatial curvature generated per unit mass. Under the assumption of GR, and a vanish anisotropic stress tensor, $\eta_{\rm PPN} = 1$. In this work, using ALMA, HST, and VLT/MUSE data, we combine mass measurements, using gravitational lensing and galactic dynamics, for the SDP.81 elliptical lens galaxy ($z = 0.299$) to constrain the slip parameter. We assume a self-consistent mass profile, parameterised by a sum of elliptical Gaussians, which is flexible enough to allow us to decompose the mass profile into two components: (i) a stellar-mass component, obtained by deprojecting the observed lens surface brightness profile; (ii) a dark matter halo, described by a Navarro-Frank-White profile. We model the gravitational lensing effect by solving the lens equation and reconstructing the source object, whereas the kinematical data were modelled by solving the Jeans equations. We infer, for our fiducial model, $\eta_{\rm PPN} = 1.42 \pm 0.27$, which is in tension with GR within 1σ. For this result, we take into account possible systematic uncertainties, for instance, the mass profile adopted, the uncertainty in the Hubble constant, and the impact of the stellar templates used to fit the kinematic data. However, this result should be faced with care. Although we carry out a thorough analysis, it is necessary to highlight that our kinematic data have poor quality and can bias the results. Nonetheless, we notice that if we choose a narrow Gaussian prior that privileges GR, i.e. centred at GR predictions, we found $\eta_{\rm PPN} = 1.13 \pm 0.27$, which recovers their predictions. Although, we believe that such a prior should not be used, as it assumes that GR could be valid from the beginning. Some recent works using a sample of strong gravitational lenses and their velocity dispersions have found higher values for $\eta_{\rm PPN}$ as well, typically in statistical accordance with our fiducial model result. A common feature between those results and ours is the inclusion of galaxies at intermediate redshift, which may be bringing $\eta_{\rm PPN}$ to higher values. To clarify this issue, better kinematic data are needed. In that regard, the newer state-of-art NIRSpec instrument, onboard JWST, will play an essential role, possibly providing data with a higher signal-to-noise ratio and more spatial resolution, allowing strong constraints in the dynamic mass of galaxies at intermediate redshift.

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