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Towards a new model-independent calibration of Gamma-Ray Bursts

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Low-redshift observations play a crucial role in constraining cosmological parameters but current data on baryon acoustic oscillations and Supernovae of Type Ia (SNIa) cover up to $z \sim 2.5$. Gamma-Ray Bursts (GRBs) stand out as one of the most promising observables as they exhibit characteristics that suggest they are potentially standardizable candles. This allows their use to extend the distance ladder beyond SNIa. However, GRB correlations are still challenging due to the spread in their intrinsic properties. In this work, we propose an innovative and cosmology-independent method of calibration of the three-dimensional Dainotti relation, the fundamental plane relation between the peak prompt luminosity, the rest-frame end time of the plateau phase, and its corresponding luminosity. We employ state-of-the-art data on Cosmic Chronometers (CCH) at $z < 2$ and use the Gaussian Processes reconstruction tool. We select 20 long GRBs in the range $0.553 \leq z \leq 1.96$ from the Platinum sample, which consists of well-defined GRB plateau properties that obey the fundamental plane relation. We verify that the choice of priors on the parameters of the Dainotti relation and the modelling of CCH uncertainties and covariance have negligible impact on our results. Moreover, we consider the case in which the redshift evolution of the physical features of the plane is accounted for. We find that CCH allows us to identify a sub-sample of GRBs that adhere even more closely to the fundamental plane relation, with an intrinsic scatter of $\sigma_{int} = 0.20_{-0.05}^{+0.03}$ obtained when evolutionary effects are considered. In an epoch in which we strive to reduce uncertainties on the GRB correlations variables to tighten constraints on cosmological parameters, we have found a novel model-independent approach to pinpoint a sub-sample that can represent a valuable set of standardizable candles. This allows us to extend the cosmic distance ladder presenting a new catalogue of calibrated luminosity distances up to $z = 5$.

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