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The variation of the fine-structure constant from disformal couplings

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We study a theory in which the electromagnetic field is disformally coupled to a scalar field, in addition to a usual non–minimal electromagnetic coupling. We show that disformal couplings modify the expression for the fine–structure constant, α. As a result, the theory we consider can explain the non–zero reported variation in the evolution of α by purely considering disformal couplings. We also find that if matter and photons are coupled in the same way to the scalar field, disformal couplings itself do not lead to a variation of the fine–structure constant. A number of scenarios are discussed consistent with astrophysical, geochemical, laboratory and the cosmic microwave background radiation constraints on the cosmic evolution of α. We also use cosmological data, including type Ia supernova data for which we present an effective dark energy equation of state. We find that the Oklo bound in particular will put strong constraints on the model parameters. From our numerical results, we find that the introduction of a non–minimal electromagnetic coupling enhances the cosmological variation in α. Better constrained data is expected to be reported by ALMA and with the forthcoming generation of high–resolution ultra–stable spectrographs such as PEPSI, ESPRESSO, and ELT–HIRES. Furthermore, an expected increase in the sensitivity of molecular and nuclear clocks will put a more stringent constraint on the theory.

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