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Searching for dilaton fields in the Lyalpha forest

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Dilatons (and moduli) couple to the masses and coupling constants of ordinary matter, and these quantities are fixed by the local value of the dilaton field. If, in addition, the dilaton with mass $m\varphi$ contributes to the cosmic dark matter density, then such quantities oscillate in time at the dilaton Compton frequency. We show how these oscillations lead to broadening and shifting of the Voigt profile of the Lyα forest, in a manner that is correlated with the local dark matter density. We further show how tomographic methods allow the effect to be reconstructed by observing the Lyα forest spectrum of distant quasars. We then simulate a large number of quasar lines of sight using the lognormal density field, and forecast the ability of future astronomical surveys to measure this effect. We find that in the ultra low mass range $10{-}32\ \mathrm{eV} \lesssim m\varphi \lesssim 10{-}28\ \mathrm{eV}$ upcoming observations can improve over existing limits to the dilaton electron mass and fine structure constant couplings set by fifth force searches by up to five orders of magnitude. Our projected limits apply assuming that the ultralight dilaton makes up a few percent of the dark matter density, consistent with upper limits set by the cosmic microwave background anisotropies.

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