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Signatures of composite dark matter in the cosmic microwave background spectral distortions

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We propose a new method to detect a class of composite dark matter models where the electromagnetic transitions between dark matter states result in spectral distortions in the Cosmic Microwave Background (CMB) spectrum. We show that the spectral distortion signature depends sensitively on the dark matter transition frequency and the strength of couplings of dark matter with the visible sector particles as well as its self-interactions, thus opening a new window to probe the nature of dark matter. The unique shapes of non-thermal distortions make them distinguishable from the standard μ and y-type distortions and potentially detectable in the next-generation experiments such as Primordial Inflation Explorer (PIXIE). We find that the spectral distortion limits from the COsmic Background Explorer/Far-Infrared Absolute Spectrophotometer (COBE/FIRAS) already give a constraint on the electromagnetic coupling of dark matter which is three orders of magnitude stronger compared to the current direct detection limits for ~ MeV mass dark matter with transition energy in ~ 1-10 eV range. Further, the upcoming 21 cm experiments will probe the non-thermal distortion signatures of dark matter in the 50-100 MHz range. We also show that the absorption of CMB photons by dark matter in the 100-200 GHz frequency range can explain the strong absorption feature detected by the Experiment to Detect the Global Epoch of Reionization Signal (EDGES) collaboration.

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