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A dark matter solution to the □0 and □8 tensions, and the integrated Sachs-Wolfe void anomaly

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The significant tensions in constraints on the Hubble constant ($_0$) and clustering amplitude ($_8$) between early- and late-universe observations challenge key assumptions of the LCDM cosmological model. One of these assumptions is the presence of cold dark matter, a yet-to-be-detected non-relativistic particle with minimal interaction with the Standard Model that dominates the mass budget of the universe.

We propose a phenomenological model where dark matter's pressure-to-energy ratio, or equation of state, w, evolves over time, enabling it to influence both the universe's expansion rate $_0$ and structure formation $_8$. The model reduces the $_0$ tension from ~5□ to ~3□ and the □8 tension from ~3□ to ~1□.

Moreover, this model explains the anomalously large Integrated Sachs-Wolfe (ISW) effect observed in cosmic voids, a key puzzle in large-scale structure analyses. Observations suggest an unexpectedly strong ISW signal from voids, which our model enhances by a factor of ~2. This provides a testable prediction and supports the idea that dark matter properties influence both small- and large-scale cosmology.
These results extend to unified or interacting dark matter-energy models, with void ISW signals offering a promising avenue for resolving cosmological tensions.

Primary authors: Dr NAIDOO, Krishna (University of Portsmouth); JABER, Mariana (CFT Polish Academy of Sciences)

Co-authors: BILICKI, Maciej (Center for Theoretical Physics PAS); HELLWING, Wojciech (Center for Theoretical Physics PAS)

Presenter: JABER, Mariana (CFT Polish Academy of Sciences)

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