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Dark matter candidate emerging from 3-form gauge theory

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Current astrophysical observations such as the rotational curves of galaxies, galaxy structure formation, gravitational lensing and the cosmic microwave background have all pointed towards the existence of a new type of matter, known as dark matter (DM). DM is believed to only interact appreciably through gravity alone and makes up around 85% of the known matter in our universe. The nature of this DM is unknown and a wide variety of candidates have been proposed, ranging from new hypothetical particles (such as WIMPs, axions and dark photons), primordial black holes and modified gravity theories.

In this work, I propose a novel approach to explaining DM through a 3-form gauge theory. A 3-form gauge field in vacuum only has a static solution that behaves like a cosmological constant. However, if we couple this 3-form gauge field to a cosmological medium, then through the Anderson-Higgs mechanism the gauge field gains an effective propagating degree of freedom. This results in a massive 3-form gauge field that can act as the role of DM.

We demonstrate that this coupling between the 3-form gauge field and the cosmological medium generates a mass source. We analyse the phenomenology of the theory assuming that the massive 3-form gauge field is dust-like and is the major source of cold dark matter in the Universe. We also show that in the very low coupling limit where the mass is very small, the dynamics of the 3-form gauge field becomes wave-like and becomes a possible candidate for warm dark matter. If this theory of DM were to be realised, it would imply that many of the current searches of DM may be unfeasible and new approaches to DM detection would need to be considered.

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