Opinion
Volume 11:3, 2023

Journal of Astrophysics & Aerospace Technology

ISSN: 2329-6542
Open Access

Millicharged Lightweight Particles with Strong Interactions

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Introduction

A candidate for ultra-light fermionic dark matter with a baryon number is the subject of our consideration. If dark matter has an asymmetry that is equal to or opposite to that of the visible universe and has a small charge under the standard model baryon number, this will naturally occur. A dark Quantum Chromo-Dynamics (QCD) theory of dark baryons of a non-Abelian gauge group is a prototypical model. The inner region of dark matter halos is naturally at "nuclear density" for dark baryon masses below eV, allowing for the formation of exotic states of matter similar to neutron stars. Strong short-range self-interactions, cooling via emission of light dark pions, and the Cooper pairing of dark quarks at densities that are high relative to the (ultra-low) dark QCD scale all break the Tremaine-Gunn lower bound on the mass of fermionic dark matter, or dark baryons. Using the equation of state for dense quark matter, we develop the astrophysics of these Strongly-interacting Ultra-light Millicharged Particles (STUMPs) and discover halo cores that are consistent with observations of dwarf galaxies. These centres are kept from centre breakdown by strain of the 'neutron star', which recommends super light dull QCD as a goal to canter cusp issue of collision less cold dim matter [1].

Direct detection, collider signatures, and superconductivity-related phenomena such as Andreev reflection and superconducting vortices set the model apart from ultra-light bosonic dark matter. Very little is known about dark matter's nature. A possible indication of a maximum characteristic density for dark matter is the conflict between the predictions of the collision less cold dark matter paradigm and the properties of dwarf galaxies that have been observed. Another possible clue about the properties of dark matter is the origin of the observed matter-antimatter asymmetry. This is one of the few signs of physics outside of the standard model because the CP violation of the model is not enough to have caused the asymmetry [2].

Description

A dark matter candidate with a standard model baryon number and self-interaction through dark Quantum Chromo-Dynamics (QCD) is a straightforward possibility that links these disparate threads: a Millicharged Ultralight Particle with Strong Interaction (STUMP). Self-interacting dark matter and ultra-light bosonic dark matter share characteristics with this. In a universe that is baryon-symmetric and in which the dark matter is "millicharged" under the visible baryon number, this is by definition the case: the crossing out of the noticeable area imbalance requests a high dull matter number thickness, and consequently a little dim matter mass, as more routinely connected with axions and bosonic dim matter. Ultralight dark QCD, in which dark matter takes the form of dark baryons, is discussed in this letter. The dark baryons (STUMPs) defy both the Tremaine-Gunn bound on ultralight fermionic dark matter and the limits on collisionless cold fermionic dark matter because the dark matter is interactive and can form Cooper pairs [3].

The model predicts centers to dull matter coronas, with a tension and thickness profile represented by the situation of condition of thick quark matter, undifferentiated from neutron stars. The model we propose as a solution to the core-cusp issue is supported by the discovery of cores that are in line with observations of dwarf galaxies. Through superconductivity phenomena like superconducting vortices and Andreev reflection at the core-halo boundary, we clarify the key features that set this model apart from ultralight bosonic dark matter. We provide additional information and model-related details in appendices A through F. The QCD-like dark matter mode is the subject of a great deal of research. The observation that the cosmological abundances of dark matter and visible matter differ by is largely responsible for these; assuming one places that dim matter is a close duplicate of noticeable QCD, this happenstance recommends a cogenesis of apparent and dull matter-antimatter deviations, and a Weakling like composite dim matter up-and-comer of mass like the proton. Baryogenesis models can be used to make predictions about dark matter searches in this way [4].

Last but not least, the dark sector may have been formed as a quark-gluon plasma, hadrons, or a quark condensate during the genesis of the dark baryons (STUMPs), which was carried out in accordance with an existing cogenesis scenario (e.g., decay of scalar carrying baryon number). The initial state is likely to be thermal plasma if it occurs with highly relativistic particles. One might anticipate a dark pion-covered relic background in this instance; however, the dark pions may decompose into standard model particles, as suggested in. In contrast, if the genesis results in a state with a large chemical potential and is located below the diagonal of the initial state will be a condensate, which will later re-enter the condensate phase in dense structures after moving through the hadronic phase as the universe expands. A third possibility is that the DM begins as heavy hadrons and eventually breaks down into light dark baryons. Consistency with the cosmic microwave background is expected to limit these numerous possibilities; however, the late universe will be the focus of this research [5].

Self-interacting dark matter (SIDM) and ultralight dark matter meet in the middle with the proposed STUMP model. In light of those scenarios, it is reasonable to anticipate the formation of cores in the inner regions of galaxies, where the density of quark matter reaches its maximum, analogous to that of neutron stars. This solves the core-cusp problem of collisionless cold dark matter, which states that observations favor cored halos with a maximum density rather than the cuspy halos predicted by collisionless cold dark matter, in which the density peaks at the halo's center. We note that STUMPs are recognized from past chips away at cored dim matter coronas from light fermions by the (solid) communications. Similar to SIDM, the halo can cool as it becomes denser by emitting light pions, which are parametrically lighter than baryons. Dark quark matter forms a dense core as a result [3].

QCD physics, which has been examined in the context of neutron stars, determines this core's density and pressure. We anticipate that the cores will have a long lifespan because, in contrast to SIDM, the pressure of the condensate phase prevents the cores from collapsing. The STUMP scenario for dark matter, based on the physics of neutron stars, proposes that dark matter is an ultralight fermion charged to the standard model baryon number. Near-constant density cores in dark matter halos are predicted by this model, which begins with a flaw in the Tremaine-Gunn bound on fermionic dark matter. As a millicharged dark baryon, it fits the model of asymmetric dark matter [5].

Conclusion

It is simple to distinguish this ultralight dark matter candidate from its bosonic relatives. Superconductivity, such as the existence of superconducting vortices and rotons, and Andreev reflection, both of which arise during galaxy mergers, distinguish the gravitational and astrophysical signatures from ultra-light axions. Particularly, a transfer of angular momentum from the infalling galaxy to the host galaxy is caused by dynamical friction, indicating that the host galaxy spontaneously produces superconducting vortices. Similar to electrically millicharged dark matter and dark matter superfluids, other substructures, such

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Received: 02 March, 2023, Manuscript No. jaat-23-92663; **Editor Assigned:** 03 March, 2022, Pre QC No. P-92663; **Reviewed:** 16 March, 2023, QC No.Q-92663; **Revised:** 21 March, 2023, Manuscript No.R-92663; **Published:** 28 March, 2023, DOI:10.37421/2329-6542.2023.11.260

as a "dark disk," may also emerge in this scenario and be detectable through strong lensing.

These associations make expectations for both direct recognition and collider looks for dull matter. We anticipate that direct detection searches for ultralight dark matter based on the interaction with electromagnetic fields (such as resonant cavities) will yield nothing. Positively, we anticipate "semi-visible jets" as the collider's signature. Some visible QCD jets will become dark QCD jets as a result of the interaction with visible QCD. These dark QCD jets will then pass through the detector undetected; making the visible QCD jets "semi-visible." To take into account the ultralight dark baryon regime of this phenomenon, additional research will be required.

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How to cite this article: Alexander, Stephon. “Millicharged Lightweight Particles with Strong Interactions.” *J Astrophys Aerospace Technol* 11 (2023): 260.