Contribution ID: **62** Type: **Invited talk**

Galactic-Scale Superfluidity: True Macroscopic Condensation with Long-Range Interactions?

Tuesday 3 September 2024 09:40 (40 minutes)

Dark matter, an integral component of the perceived mass-energy content of the Universe, is usually modelled as a collection of collisionless particles through the established cold dark model (CDM). Despite its impressive success in reproducing large-scale features, increasing evidence is indicating potential shortfalls on shorter (< galactic) scales. An alternative model, "Fuzzy Dark Matter"(FDM), has been gaining increasing attention in the cosmological community: this model postulates the existence of an ultralight bosonic particle exhibiting galactic-size de Broglie wavelengths, facilitating a wave description: central to this model is the suppression of small-scale gravitational collapse due to quantum pressure, which leads to galaxies containing "solitonic cores" . Here I will outline the links between such a cosmological model, laboratory condensates and astrophysical observations, critically discussing implications and open questions.
Using established tools from finite-temperature non-equilibrium condensates [1], I will present a picture of a coherent self-bound galactic-scale solitonic condensate (balancing gravitational attraction against quantum pressure), surrounded by a halo of partially-incoherent particles resembling a quasi-condensate state with spatiotemporally-localised regions of enhanced coherence and a quasi-equilibrium turbulent vortex tangle [2]. Drawing on the standard two-fluid model and atomic bimodal distributions, I will present an extended theory which allows both incoherent and coherent degrees of freedom to be fully self-consistently coupled, in a manner incorporating both the cosmological CDM and FDM models, and also existing cold-atom kinetic and stochastic models [3]. Moreover, by contrasting our findings to astrophysical observations, I will critically analyse the viability of such models [4,5].
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References

[1] N P Proukakis et al. (Eds), Quantum Gases: Finite Temperature and Non-Equilibrium Dynamics (Imperial College Press, 2013)
[2] I-K Liu, N P Proukakis, G Rigopoulos, Coherent and Incoherent Structures in Fuzzy Dark Matter Haloes, Monthly Notices of the Royal Astronomical Society 521, 3625 (2023).
[3] N P Proukakis, G Rigopoulos, A Soto, Unified Description of Corpuscular and Fuzzy Bosonic Dark Matter I and II, Phys. Rev. D 108, 083513 (2023) [and follow-on preprint].
[4] M Indjin, I-K Liu, N P Proukakis, G Rigopoulos, Virialized Profiles and Oscillations of Self-Interacting Fuzzy Dark Matter Solitons, Phys. Rev. D 109, 103518 (2024).
[5] N P Proukakis, G Rigopoulos, A Soto, Hybrid Model of Condensate and Particle Dark Matter: Linear Perturbations in the Hydrodynamic Limit, Phys. Rev. D (In Press) (2024).

Short bio (50 words) or link to website

https://orcid.org/0000-0003-0126-5820
https://scholar.google.com/citations?user=YTPCd_AAAAAJ&hl=en
https://www.ncl.ac.uk/maths-physics/people/profile/nikolaosproukakis.html

Relevant publications (optional)

NP Proukakis, Universality of Bose-Einstein Condensation and Quenched Formation Dynamics, Encyclopedia of Condensed Matter Physics (Elsevier, 2nd Edition), arXiv:2304.09541

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