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Quantum Perturbations in Bose-Einstein Condensate Dark Matter and Primordial Black Hole Formation

We investigate the formation mechanisms and cosmological implications of Primordial Black Holes (PBHs) within the framework of superfluid dark matter (SFDM), integrating quantum field theory with numerical simulations and gravitational wave predictions. Our theoretical framework, rooted in complex scalar fields ϕ_1 and ϕ_2, includes self-interactions and vortex dynamics, predicting a diverse PBH mass spectrum spanning from 10^{-12} to 10^5 solar masses. Numerical simulations using pseudospectral methods reveal that SFDM turbulence and quantum vortices significantly enhance small-scale density perturbations, crucial for PBH formation.

Initial simulations incorporating non-zero angular momentum configurations and vortex infusion demonstrate how SFDM dynamics modify density profiles, influencing PBH formation probabilities. The critical density threshold ρ_{crit} for PBH formation is altered by SFDM turbulence, which amplifies density fluctuations beyond traditional predictions.

Gravitational wave signatures originating from turbulent SFDM are examined through the transverse and traceless component of the anisotropic stress-energy tensor Π_{ij}. Utilizing Green's function techniques, we derive the gravitational wave solution contingent upon the spatial velocity distribution $\mathbf{u}(\mathbf{x})$ of the turbulent fluid.

This investigation underscores SFDM as a compelling candidate for illuminating the fundamental role of dark matter in early universe structure formation and advancing gravitational wave astronomy. Our findings contribute pivotal insights into PBH formation mechanisms and their consequential implications for observational cosmology.

Internet talk

No

Is this an abstract from experimental collaboration?

No

Name of experiment and experimental site

N/A

Is the speaker for that presentation defined?

Yes

Details

Swapnil Singh, Student, B.M.S College of Engineering, Bangalore, India - 560019

Author: Mr SINGH, Swapnil

Presenter: Mr SINGH, Swapnil

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