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Dark matter across scales: ultralight fields, Bose-star signatures, and massive compact composites

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Light scalar and pseudoscalar fields—such as axion- and dilaton-like particles—are well-motivated dark-matter candidates. Their couplings to Standard-Model fields can induce tiny, stochastic modulations of atomic transition frequencies. A statistical framework for clock-based searches is developed, showing that higher-order statistical moments of the measured fluctuations (e.g., skewness, kurtosis, intermittency) can provide distinctive signatures of ultralight scalar and pseudoscalar dark matter.

Astrophysical implications of self-gravitating bosonic configurations (“Bose stars”) are also examined. In certain regimes, their interaction with the interstellar medium may seed high-metallicity molecular clouds, offering an indirect observational handle on this scenario.

Separately from the ultralight sector, models of modified gravity with extra dimensions—such as the Arkani-Hamed–Dimopoulos–Dvali framework—admit extremely compact massive composite objects made from quarks or antiquarks. Detection strategies for these heavy composites will be discussed.

References:

- V.V. Flambaum, Phys.Rev.D 112 (2025) 1, 015003
- V.V. Flambaum and I.B. Samsonov, Phys.Rev.D 110 (2024) 10, 103016
- V.V. Flambaum and I.B. Samsonov, Phys.Rev.D 108 (2023) 7, 075022

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