
# BOSONIC DARK MATTER

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A 3 hours course to provide the basis to work with bosonic fields as dark matter candidates. The course will focus mostly on ultra-light scalars, but other bosonic fields will also be discussed.

**Overview:** The idea behind this course is to introduce the audience to bosonic fields and their role as dark matter candidates. A tentative program will be structured in 3 hours, spanning from more theoretical aspects, to the treatment of the specific equations of the model and their perturbed solutions. The first hour will be dedicated to provide a view on the open problems in cosmology and to show how bosonic fields might fill existing scientific gaps, explaining the current cosmological and astrophysical observations. Among others, the pivotal concept of dynamical friction will be introduced. The second hour will focus on modeling the core of dark matter halos through Newtonian Boson Stars (NBS). The relevant equations and their solutions will be discussed (i.e. how to go from the Einstein Klein-Gordon system to the Schrodinger-Poisson one). The basis for the linear perturbation treatment of scalar structures will be set. The third hour will exploit the results of the previous lecture, showing how to study dark matter halos through perturbation theory methods and which interesting results can be obtained through it, e.g. black holes and binaries within scalar environments.

**1st hour:** Open problems in Cosmology: Cusp-core problem, Missing-satellite, Dynamical friction.

How bosonic fields can be used to (tentatively) solve the dark matter puzzle: Fuzzy dark matter models, Scalar and Vector fields.

**2nd hour:** Newtonian boson stars: Post-Newtonian expansion of the Einstein Klein Gordon system and how to find their configurations.

Small perturbations applied to NBS: Validity of perturbation scheme, The gross fluxes, The perturber's fluxes, Free oscillations aka quasi normal modes, sourced oscillations aka External perturbers.

**3rd hour:** Static perturbations: A perturber sitting at the center, A black hole eating its host boson star, a semi-analytic example: A string absorptive at one end.

Dynamical perturbations: Low and High-energy binaries within boson stars, Scalar emission close to coalescence (analytic approach), The GW phase dependence in vacuum and beyond.

**Main references: [1–13]**

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