Wave dark matter structure

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Collaboration with A.L. Maroto,

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Isotropy theorem (arbitrary spin)

Isotropy Theorem: The average Energy-Momentum tensor of a field of any spin minimally coupled to gravity is diagonal and isotropic if 1.- the field evolves rapidly with respect to the background metric evolution.

2.- $\phi^a{}_i$ and $\dot{\phi}^a{}_i$ are bounded.

Power-law theories:

$$\mathcal{H} = \left(\lambda^{AB} g_{00} \Pi^0_A \Pi^0_B\right)^{n_T} + \left(M_{AB}\phi^A \phi^B\right)^{n_V}$$

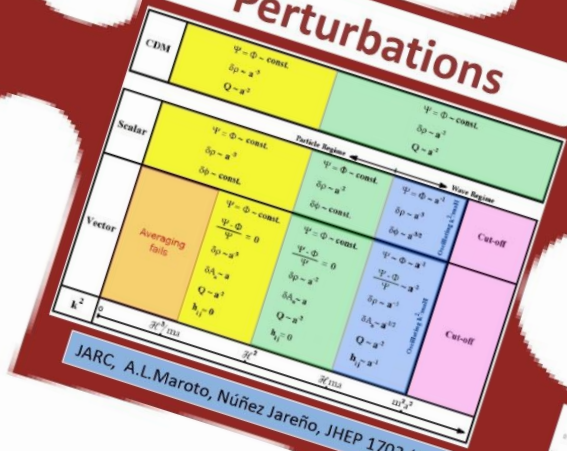
Average equation of state:

$$\omega = \frac{2\, n_V}{1 + \frac{n_V}{n_T}} - 1$$

JARC, Hallabrin, Maroto, Nunez Jareno, Phys. Rev. D86 (2012)

JARC, Maroto, Nunez Jareno, Phys. Rev. D87 (2013) 043523

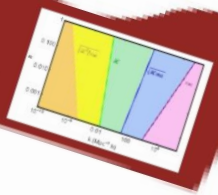
Perturbations



De Broglie wavelength: $\lambda_{dB} = \frac{1}{mv} = \frac{1}{mHr}$

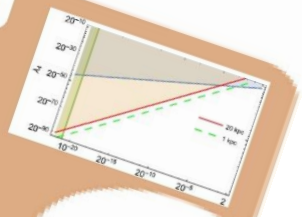
Localization in a sphere with radius: $r \geq \lambda_{dB}$, $r \geq \frac{1}{\sqrt{Hm}}$

JARC, A.L.Maroto, Núñez Jareño, JHEP 1702 (2017) 064



Repulsive Self-interactions

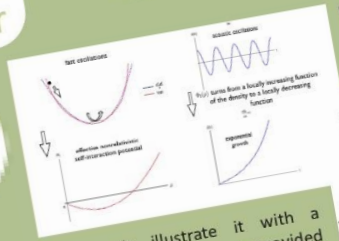
- Generic interaction: derivative and non-derivative terms.
- Low energy regime: nonrelativistic limit: conservation of matter + Euler equation
- Scalar field mass $10^{-21}\, eV < m < 10^{-4}\, eV$
- Negligible quantum pressure on cosmological and galactic scales
- Self-interaction generate a significant repulsive pressure.
- The hydrostatic equilibrium obtained by balancing the gravitational and scalar interactions imply that virialized structures have a solitonic core of finite size depending on the speed of sound of the dark matter fluid.

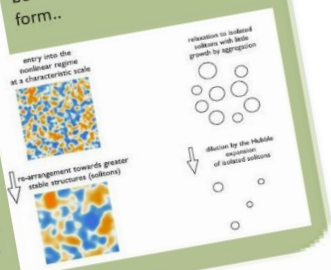


P. Brax, JARC, and P. Valageas, Phys. Rev. D 100, 023526 (2019) 2

Compact clusters as Dark Matter

-When the squared speed of sound of the scalar fluid becomes negative, an instability arises and the fluctuations of the scalar energy-density field start growing. They eventually become nonlinear and clumps form..





The clumps aggregate and reach a universal regime.

-They play the role of cold dark matter.

-We illustrate it with a particular example provided by a negative quartic interaction stabilized by a positive six term.

P. Brax, JARC, and P. Valageas, Phys. Rev. D 102, 083012 (2020) 8