Dark stars meeting notes Jan 18

Review of Structure Formation in Dark Sector paper

Introduction

- Adopting the principles of star formation to the dark sector
- Model: dark electron and dark photon (massive boson)
  - Dark photon is massive to get the right structure formation
- Jurgens idea — use dark boson instead of dark electron

Section 2

- Assume QED regime to do pertubation theory
- Dont need Lagrangian
- Mean free path is important
  - sigma is the cross section of interaction (probability of interaction)
  - tells the distance a particle can travel without interaction
  - inversely related to number density
- If dark electrons scatter (self-interact) and photons escape, dark stars can cool and for stable configurations

    - The idea is to compute this possibility
- Equation of state for a fermi gas — ideal gas law
    - Eq 3.4 (13) is the ideal gas law for the dark electron
        - 1st term: ideal gas law with Kb=1
        - 2nd term: field theory interaction term

Section 3

- Jeans length for dark stars
- Hubble expansion not important for us
- Turnaround into non-linear regime

Section 4

- Eq 4.1 (28) Jeans condition to form dark stars

Section 4.2

- IMPORTANT equations for our project
- Lambda is a cooling rate: comes from a particle physics model
    - Eq 4.13 (40) BS cooling rate is exponentially suppressed
    - We can instead use the simpler Stefan-Boltzmann law
- Eq. 4.5 (32) is an energy balance equation
- Cooling time scale ansatz
    - we can use the ones in 4.12 (39) or choose out own
    - cooling form the surface — use Stefan-Boltzmann law
- Interested in cooling of dark star into a stable configuration
    - We will need to solve the TOV equations

Section 4.3

- Figure 5 shows number density and temperature over the evolution of dark model

    - Density increases, heat increases, cooling rate increases
    - Eventually the energy of compression matches the rate of photon emission
    - Balance of compression and cooling at the t_cooling=t_free fall time scale along jeans mass lines
    - This is the regime in which we can form stable configurations
    - Optically thick regime: star is so dense photons cannot escape anymore
    - Hierarchical fragmentation happens along the cooling line until the optically thick regime is reached
    - Will want to recreate Figure 5 with our model
- Figure 7 shows the mass of compact objects from fragmentation as a function of the dark electron and dark photon masses

Objectives for next meeting

- Reread Structure Formation paper focus on Sec 4
- Review hierarchical fragmentation from Ryden
- Solve the TOV for Boson stars
    - Create TOV solver code in dimensionless units
    - Equation of state for boson stars also in dimensionless units
        - Boson stars with self-interactions on slack Eq. 16
            - relation between pressure and energy
            - energy density as a function of pressure
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- Dimensionless TOV equations in Compact Stars chapter 4.3 (scaling solutions)
- Eq. 4.51 and 4.52
- Chapter 4.5 applied to Boson stars

- Create your own Dark Star!