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Alumno: Por definir

TITLE: Comparison between dynamical dark energy models and the standard cosmological model

MOTIVATION

Current observational data provide strong evidence that we live in a spatially flat Universe expanding at an accelerating rate. The origin and nature of dark energy, the component that currently dominates the evolution of the Universe and drives its acceleration, is still uncertain, and it comprises one of the biggest mysteries and challenges in modern theoretical Cosmology.

It is easy to verify that Einstein's theory with radiation and non-relativistic matter only cannot lead to accelerating solutions. A positive cosmological constant is a simple and economical model, which overall is in a very good agreement with a great deal of current observational data. Due to a couple of problems, however, such as the cosmological constant problem, and the tension regarding the value of the Hubble constant, H0, other alternatives have been analyzed in the literature over the years.

Many dark energy models predict very similar expansion histories, and therefore all of them are still in agreement with current data. In order to discriminate between different dark energy models it is necessary to compute new quantities appropriately defined. To this end one option would be to study the so-called statefinder parameters, r, s , which are expressed in terms of the third derivative of the scale factor with respect to the cosmic time. Those parameters may be computed within a certain model, and they can be very different from one model to another even if they predict very similar expansion histories.

A phenomenological description is simpler and more convenient. In that approach the Hubble parameter as a function of red-shift, H(z), may be easily obtained. First, upon comparison with available supernovae data, such as the Union2 compilation for instance, making use of the luminosity distance , the free parameters of the model may be determined. After that, all quantities of interest can be computed in terms of H(z), and a direct comparison with the ΛCDM model can be made.

WORK PLAN (Weekly Video meetings)

1. The student first will have to study the literature (a couple of reviews and a few representative articles in the field covering the required material)

(The main reference article will be: "Growth index and statefinder diagnostic of Oscillating Dark Energy", by Grigoris Panotopoulos and Ángel Rincón, Phys. Rev.D97(2018)no.10,103509.)

2. Be familiar with concepts commonly used in cosmology, such as normalized density, red-shift, luminosity distance, etc.

3. Be able to find exact analytical solutions to the Friedmann equations in a few simple cases (e.g. radiation era o matter era).

4. For a given dark energy parameterization, he must be able to obtain the Hubble parameter as a function of red-shift, H(z).

5. Given the previous function, he must be able to compute all the quantities of interest, such as deceleration parameter, luminosity distance, and statefinder parameters.

6. As a first application, he must be able to show graphically the comparison between the standard cosmological model (based on a positive cosmological constant) and some other simple dark energy parameterization commonly used in the literature.

7. Familiarize himself with the basics of linear cosmological perturbations for a single fluid and two fluid components.

8. Be able to find exact analytical solution to the equation for matter perturbation during matter era.

9. Be able to numerically integrate the equation for matter perturbation at recent times when cosmological constant is present.

10. As a second application, given the solution previously obtained, he must be able to compute other quantities of interest, such as growth index or the combination A(z) related to red-shift space distortion data.

11. Be able to integrate numerically the equations for the perturbations of two fluids (matter and dark energy) taking into account appropriate initial conditions.

12. Finally, as a third, **realistic and challenging application**, he should be able to compute the growth index as well as the combination A(z) assuming a certain dark energy parameterization, and show graphically the comparison to the standard cosmological model.