Laboratoire de Physique de Clermont (LPCA) – Cosmology Team

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Title of internship subject

Dark Energy measurement with SNe Ia in LSST

Summary :

The Vera C. Rubin Observatory is located on the Cerro Pachon (2680 m) in North Chile. It will conduct the Legacy Survey of Space and Time (LSST), a synoptic astronomical survey of large étendue (more than 20000 deg2) starting late 2025. A systematic scan of the celestial sphere will be performed for ten years, leading to the largest astronomical catalog ever compiled (83 pB) with 17 billions of stars and 20 billions of galaxies.

Type Ia Supernovae (SNe Ia) are transient astronomical events resulting from a powerful and luminous explosion of a white dwarf. They are identified from their light curves (measured flux versus time) which display a characteristic brightness evolution (luminosity peak about 15 days after explosion; slow decrease lasting up to several months). SNe Ia are cosmological probes that can be used as standardisable candles to estimate distances. These measurements are used to estimate cosmological parameters (w_0,w_a) (dark energy equation of state). With a high cadence of observation and a high étendue, LSST will observe an astounding number of SNe Ia (more than 800000 after ten years) including a large number (more than 200000 after ten years) of SNe Ia with accurate cosmological distances. Considerable efforts have been made to increase the number of well-measured SNe Ia at higher redshift ($z \gtrsim 0.8$), a sample critical to measure (w_0,w_a) parameters with high accuracy.

All the studies with SNe Ia in LSST have been performed with the ΛCDM (w_0=-1,w_a=0) cosmological model as a theoretical framework. But recent results from DESI (Dark Energy Spectroscopic Instrument), combined with data from the cosmic microwave background and supernovae, suggest a preference for dynamical dark energy (DDE) models ($w_a \neq 0$ or oscillating dark energy). The goal of the internship is to include DDE models in the simulation pipeline of SNe Ia to assess the impact on the number of SNe Ia used to estimate cosmological parameters. This study will use the latest observing strategy simulations available.

This work is also one of the items for further investigation of a phD thesis that will be proposed in 2026.