From slitless spectrophotometry to the equation of state for dark energy with the StarDICE and LSST experiments

The nature of dark energy is one of the open questions in cosmology. The current decade will bring measurements of unprecedented precision on the expansion of the Universe, thanks to new wide-field cosmological surveys (Euclid, DESI, LSST, ZTF). The two wide-field cosmological surveys LSST (Chile) and ZTF (USA) are capable of scanning the entire sky every few days to gather as many transient astronomical events as possible, such as the explosion of type Ia supernovae. Type Ia supernovae are very bright stellar explosions that serve as standard candles for measuring distances in the Universe, making it possible to measure the properties of dark energy.

By 2030, the Hubble diagram (distance versus redshift) of type Ia supernovae will be populated by tens of thousands of high- and low-redshift measurements, thanks in particular to the LSST and ZTF surveys. However, the accuracy with which these data can be used to measure the properties of dark energy will be limited by the systematic uncertainties in the photometric calibration of the telescopes. To counter this limitation, the Ile-de-France laboratories IJClab and LPNHE have joined forces to 1) re-measure flux standard stars with the StarDICE project 2) develop slitless spectrophotometry to measure the atmospheric transmission of observatory sites, in particular with the LSST Auxiliary Telescope (AuxTel).

The subject of the proposed thesis is part of the LEMAITRE project (Latest Extended Mapping of Acceleration with an Independent Trove of Redshifted Explosions), the aim of which is to construct a Hubble diagram of supernovae made up of thousands of events that have never been published before, and thus to propose a new measure of the properties of dark energy, independent of previous records. It will include supernovae from the ZTF, SNLS and Subaru surveys. At the end of the thesis, it could be completed by the first sample of supernovae from the LSST survey. The thesis will have two parts. The first will be to demonstrate the ability of slitless spectrophotometry to measure the transmission of the atmosphere in Chile and at the Haute Provence Observatory. This technical work, which will plunge students into the heart of a cosmological survey, will take them to the observation sites to carry out these calibrations. A major expected result will be the publication of a brand new network of standard stars by StarDICE. The second stage will involve propagating these calibrations to the fluxes of the light curves of the ZTF and LSST supernovae. The Hubble diagram published at the end of the thesis will be the first diagram of cosmological distances calibrated in flux using StarDICE, shedding new light on the expansion of the Universe and the nature of dark energy.