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Spectroscopy studies at millimeter wavelengths:
constraining the evolution of the Universe with CMB spectral distortions

Abstract

The ESA Voyage 2050 Senior Committee report highlights the need for a large space mission on high-precision spectroscopy of the Cosmic Microwave Background (CMB).
The current best observational limits set in the 1990s by COBE-FIRAS experiment revealed that the average CMB spectrum is extremely close to a perfect black-body with present-day temperature $T_0 = 2.7260 \pm 0.0013$ K and with possible distortions $< 10^{-5}$. Departures of the CMB frequency spectrum from a pure black body encode information about the thermal history of the early Universe, representing an information channel still to be exploited and delivering novel information that complements past, present and future efforts with CMB anisotropy, large-scale structure and redshift-survey studies. Precision spectroscopy would not only provide key tests for processes expected within the cosmological standard model but also open an enormous discovery space to new physics.
The main goal of this project is to study the experimental design and the observational strategy of a small national mission devoted to CMB spectral distortions, paving the way for a future ESA Voyage 2050 large program.
This will be pursued through a two-staged program. The first part will be devoted to the exploitation of current datasets, from e.g. the Planck satellite, to improve the constraints on CMB temperature evolution, T_0 and the monopole of y-type distortion of the CMB spectrum from measurements of the Sunyaev–Zeldovich effect, thus advancing the state-of-the-art and improving the definition of the science requirements for future missions. Then, the second part is aimed at developing a simulation tool to forecast the expected science results from a space mission devoted to CMB y-type distortions, thus allowing to study different observational and instrumental configurations to optimize the concept design in the case of both small and large mission profiles.
The ASI-SSDC has significant expertise in the field of CMB spectral distortions acquired thanks to the participation in relevant research programs, CMB missions (e.g. Planck satellite) and proposals (from SAGACE phase-A study to LiteBIRD). We expect this project to strengthen and further expand that scientific expertise, which is extremely important in view of the renewed interest of the international scientific community on CMB high-precision spectroscopy.