Abstract

My master thesis concerns the formulation and validation of a statistical model of atmospheric emission in the context of ground-based observations of the cosmic microwave background radiation (CMB).

The cosmic microwave background radiation is a relic signal composed of photons that were involved in Thomson scattering events occurring in the primordial plasma until the recombination epoch, about 380 000 years after the Big Bang, and have been propagated in the expanding Universe since then.

The characterization of the polarized component of the CMB signal is one of the most important goals in observational cosmology. The so called *B-modes*, the curl component of the CMB polarization field, are thought to have been generated by gravitational waves propagating in the primordial Universe. The presence of primordial gravitational waves is one of the prediction of the inflationary paradigm.

The predicted intensity of the B-modes signal is at the level of fraction of µK. Therefore, its detection requires the development of experiments characterized by extremely high sensitivity. In addition, the sky signal in the CMB frequency range is dominated by other brighter radiations, such as galactic foregrounds and atmospheric emission.

Atmospheric effects represents a major concern for ground-based CMB polarization experiments. Despite being almost unpolarized, atmospheric emission increases the optical loading on the detectors, amplifying their white noise level. In addition, its fluctuations, which depend on both the sky scanning strategy and the properties of the atmosphere at the time of observations, such as wind speed and water vapour content, introduce spatial and temporal correlations between detected signals.

The *Large Scale Polarization Explorer* (LSPE) is a next generation CMB polarization experiment. It has been funded by the *Italian Space Agency* and aims to provide a smaller upper limit to the intensity of B-modes. The Strip instrument is the ground-based telescope of the LSPE project. It will be deployed to the "Observatorio del Teide", in Tenerife, by the end of 2022.

In my thesis I have followed a novel approach to produce a statistical model of the atmospheric emission, starting from climate reanalysis provided by the *European Centre for Medium-Range Weather Forecasts* and atmospheric vertical profiles acquired by balloon probes. This model can be used to simulate the atmospheric brightness temperature and its seasonal variations at an arbitrary observation site. It can be stored in a ∼2 MB

`.fits` file and can be easily integrated into simulation pipelines for CMB experiments.

By applying this method to the observing site of LSPE/Strip, I have produced a forecast of the median daily and annual excursion of the atmospheric brightness temperature at 43 GHz for the Q-band polarimeters of the Strip telescope.

In addition, I have compared my numerical results with atmospheric brightness temperatures measured during the years 2012-2015 by the *Multi-Frequency Instrument* (MFI) of the QUIJOTE project, which have been installed to the same site of LSPE/Strip by the "Instituto de Astrofísica de Canarias". Through the use of a calibration technique based on atmospheric vertical profiles acquired on site, I obtain simulated values of atmospheric brightness temperatures at 11 GHz, 13 GHz, 17 GHz and 19 GHz, which are compatible with MFI data at a 95 % confidence level.

The statistical model of atmospheric emission I present in my thesis is just the starting point to provide a complete representation of the atmosphere in the microwave range. More meteorological parameters, such as wind speed components and liquid water content, must be included into the model in order to take accounts of the atmospheric turbulent structure and the resulting correlated noise contribution. The aforementioned `.fits` file already contains the whole set of the relevant parameters. In addition, the code I have used to perform my simulations already implements the Kolmogorov-Taylor model for atmospheric turbulence. Therefore, I am confindent that accurate simulations of atmospheric observations by arbitrary instruments could be performed in future works.