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Independent Component Analysis Approach to Detect the Cosmic Microwave Background Radiation from Satellite Measurements

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The Cosmic Microwave Background (CMB) is a picture of the early Universe: as a consequence, the primordial inhomogeneities should appear in that picture as temperature anisotropies. Their observation is a central task in modern cosmology, because they are a unique sign of what happened soon after the Big Bang. Presumably, primordial perturbations originated during an era of accelerated expansion (called *inflation*, and driven by fundamental quantum particles), left their imprint on CMB anisotropies and successively grew by gravitational instability, thus becoming the structures we observe today (galaxies and clusters). CMB anisotropies were first detected in 1992 from measurements made by the COBE satellite. They are very small, if compared with the value of the CMB temperature: at the COBE resolution of about 10 degrees, the CMB anisotropy was found to be 10^5 times smaller than the average CMB temperature value.

CBM anisotropies should be mapped on sub-degree angular scales to obtain decisive information both on the composition of the cosmic fluid (dark matter, baryons ...) and on global properties of the Universe. To this purpose, the PLANCK Surveyor Satellite should be launched within a few years. The Low and High Frequency Instruments on board PLANCK will be able to yield all-sky maps at several frequency channels from 30 GHz to 857 GHz, with relative sensitivities of the order of 10^{-6}, and reaching angular resolutions of about $10'$.

These maps will suffer from contamination of several *foreground* radiations, having either a galactic or an extragalactic nature. Among them, we mention the galactic synchrotron emission, the thermal emission due to interstellar dust, the free-free emission from the ionized galactic gas, the effect of clusters of galaxies, the emission from infrared and radio extragalactic astrophysical sources. Such contaminations are also scientifically interesting by themselves, since they carry information on the physics of our galaxy and of extragalactic objects. The PLANCK data maps will be superpositions of the CMB and the foreground radiations, convolved by the specific antenna beam pattern for each channel, and corrupted by the instrumental noise, whose strength varies at each pixel, depending on the particular scanning strategy.

This work deals with the problem of separating the CMB signal from the foregrounds. Recently, some separation methods have been tested for this problem, such as the multifrequency Wiener filtering and the maximum entropy methods. However, in order to enable these methods to work, it is necessary to introduce prior knowledge on the frequency dependence of the signals and of their angular spectrum. This knowledge is not available in all cases, and its uncertainty is often too high. In addition, the amount of data to be analyzed for PLANCK will be higher than for all previous experiments, and defined on the whole sphere, so that more effective algorithms should be devised.

The strategy we propose to face the separation problem is called *Independent Component Analysis* (ICA). It does not make any assumption on the emission spectra of the sources, and is only based on their statistical independence. At present, we implement the ICA approach by means of a neural structure, whose totally blind and unsupervised learning algorithm minimizes the divergence between the statistical distribution of the output signals and a separable distribution that is characteristic of independent random variables. The learning strategy is only based on the input data samples and the current state of the network. In this presentation, the neural structure and the learning algorithm will be shown, as well as some preliminary experiments on simulated data.