INTRODUCTORY REMARKS TO COSMIC BACKGROUND PARALLEL SESSIONS*

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These are promising times for the study of cosmic microwave background and foregrounds. While, at the date of this meeting, WMAP is close to release its final maps and products, *Planck* early and intermediate results have been presented with the first release of the compact source catalog, and the presentation of the first cosmological products is approaching. This parallel session is focussed on the astrophysical sky as seen by *Planck* and other observatories, and on their scientific exploitation, regarding diffuse emissions, sources, galaxy clusters, cosmic infrared background, as well as on critical issues coming from systematic effects and data analysis, in the view of fundamental physics and cosmology perspectives. At the same time, a new generation of CMB anisotropy and polarization experiments is currently operated using large arrays of detectors, boosting the sensitivity and resolution of the surveys to unprecedented levels. Mainstream projects are observations of the polarization of the CMB, looking for the inflationary B-modes at large and intermediate angular scales, fine-scale measurements of the Sunyaev-Zel'dovich effect in clusters of galaxies, and the precise measure of CMB spectrum.

Keywords: cosmology, cosmic background radiation, galaxy clusters, active galaxies, primordial galaxies, Milky Way, Zodiacal Light.

1. Introduction

After only few decades from its discovery, the cosmic microwave background (CMB) allowed to test the basic assumptions of the modern cosmological model and to study key topics in cosmology and fundamental physics. Far from being only undesired emissions to be subtracted from microwave surveys to extract the cosmological infor-

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mation, astrophysical foregrounds are becoming important tools to study physical and evolutionary properties of astrophysical structures at different cosmic epochs and scales, thus providing a complementary way to address cosmological problems.

These are promising times for the study of CMB and foregrounds. At the date of this meeting, the WMAP[a] team is close to release its final maps and products. Early and intermediate results from the *Planck* mission[b,c] have been presented with the first release of the compact source catalog, and the presentation of the first cosmological products is approaching[d]. The new generation of CMB anisotropy and polarization experiments, currently operating or in course of realization, is based on large arrays of detectors, boosting the sensitivity and resolution of the surveys to unprecedented levels. Mainstream projects are observations of the polarization of the CMB, looking for the inflationary B-modes at large and intermediate angular scales, fine-scale measurements of the Sunyaev-Zel'dovich (SZ) effect in clusters of galaxies, and the precise measure of CMB spectrum. Crucial aspects common to all these projects are the control and reduction of systematic effects and data analysis methods for both separating the various components from the overall signal and characterizing them through compressed estimators linked to the theoretical models.

A wide set of astronomical observations at different frequency domains is usually exploited to complement the information from microwave to sub-millimeter surveys, in a multifrequency approach to the astrophysical sky interpretation, from its diffuse emissions to Galactic and extragalactic sources, from galaxy clusters to cosmic infrared (IR) background.

2. Parallell session scope and outline

Without the ambition to exhaustively cover a so wide set of topics, this parallel session is aimed at providing a view of the state of the art in the astrophysical exploitation of microwave surveys, and, in particular, of recent *Planck* results[e], and to illustrate, through representative examples, future perspectives in CMB cosmology and fundamental physics, so complementing the plenary session presentations about CMB results and next projects, going deeper into specific themes.

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[a] http://lambda.gsfc.nasa.gov/product/map/current/

[b] www.rssd.esa.int/Planck

[c] *Planck* is a project of the European Space Agency - ESA - with instruments provided by two scientific Consortia funded by ESA member states (in particular the lead countries: France and Italy) with contributions from NASA (USA), and telescope reflectors provided in a collaboration between ESA and a scientific Consortium led and funded by Denmark.

[d] During the finalization of this paper both the final WMAP release and the first *Planck* cosmological results have been presented. The reader interested in the nominal (i.e. two surveys) temperature *Planck* analyses can refer to the papers available at project web site and to [1] for a summary.

[e] The talks and papers of this session are based largely on the *Planck* Early Release Compact Source Catalogue and publicly available publications by ESA and the *Planck* Collaboration, for what concerns the related aspects. Any material presented here that is not already described in *Planck* Collaboration papers represents the views of the authors and not necessarily those of the *Planck* Collaboration.

The impact of systematic effects may be in principle critical for any experiment. This aspect is even more subtle in the study of cosmic backgrounds, since the extreme weakness of signals to be extracted to discriminate between different models and the complexity of the analyses required to reprocess the data, involving sophisticated statistical approaches. With the improvement in sensitivity of on-going and future experiments, the main experimental challenge comes the necessity to reject spurious signals originated by systematic effects down to acceptable levels and to properly treat them in order to prevent the achievement of results with small statistical errors, but potentially biased. Any kind on non-ideality in the experiment, often unavoidable, introduces systematics. They can be both controlled and rejected during the project development and reduced or possibly suppressed during data analysis. Also, they can be modeled and taken to account in the subsequent steps of data analysis and interpretation. These topics are discussed in the presentation by *Aniello Mennella*, taking the case of the *Planck* mission as reference.

After the production of the so-called frequency maps, at nine frequencies in the case of *Planck*, a fundamental step is the separation of the various types of emissions contributing to the global sky signal. In fact, the observed microwave sky is a superposition of local (solar system) and Galactic emissions, of extragalactic sources and of diffuse backgrounds, mainly the cosmic infrared background (CIB) and the CMB. Both the different frequency dependence of the various kinds of emissions and their spatial properties projected into the sky surface are exploited to this aim. Maps and catalogs at different frequencies, particularly, but not only, in the radio and IR, are also considered in this separation process. They are also ingested to construct a realistic model of the sky emission, useful for testing different separation algorithms and for applications to real microwave surveys, allowing to extend the considered frequency coverage where some classes of emissions can be better mapped. The theoretical framework and the different approaches developed in these fields are reviewed in the presentation by *Jacques Delabrouille*.

Planck key astrophysical (*non-CMB*, i.e. not strictly based on CMB maps and related products) projects regard wide areas, including themes like those delineated below.

(i) The CIB, through the measurements of its angular power spectrum and the analysis of the contributions by galaxies at different redshifts. This topic is discussed in the presentation by *Guilaine Lagache*. After careful cleaning, based on suitable templates and *Planck* maps, CIB anisotropy maps reveal structures produced by the cumulative emission of high-redshift, dusty, star-forming galaxies. A model that couples dusty galaxy parametric evolution and halo models has been developed to properly fit the measured CIB anisotropy angular power spectrum.

(ii) Extraction and studies of SZ selected sources: measurements of the Comptonization parameter y in more than 10^3 galaxy clusters, cosmological evolution of clusters to $z \sim 1$, combination with X-ray measurements, implication for cosmological parameters, gas properties, bulk velocities on scales larger than ~ 300 Mpc. All these topics are discussed in the presentations by *Marian Douspis* and *Etienne Pointe-*

couteau, focussing on the statistical properties of the *Planck* cluster catalog and on its astrophysical interpretation. The possibility to use SZ clusters to constrain cosmological and fundamental physics parameters, and, in particular, the neutrino mass, is discussed in the presentation by *Yoel Rephaeli*.
(iii) Extragalactic sources and backgrounds: spectral energy distribution of IR and radio galaxies, active galactic nuclei, quasars and blazars, number counts and evolution of galaxies to $z > 1$, links with astrophysical extragalactic backgrounds. This wide set of topics is discussed in the presentation by *Luigi Toffolatti*, emphasizing some of the main results achieved by the *Planck* satellite during the first 1.6 full-sky surveys, including the steepening of the mean spectral index of bright radio sources observed above 70 GHz and the evidence of cold dust, below 20 K, in nearby dusty galaxies. A dedicated analysis of WMAP data to put light on the M31 halo rotation is presented by *Francesco De Paolis*.
(iv) Maps of the Milky Way and solar system emissions in the frequency range 30–1000 GHz: dust properties, clouds and cirrus morphology, star forming regions, cold molecular clouds, Galaxy-scale distribution of gas and dust, polarisation-based science, e.g. Galactic magnetic fields, solar system emissions by moving sources and diffuse dust grains. Galactic emissions are critically discussed with attention to the synergy between *Planck* data and information coming from other surveys in the presentations by *Rodney D. Davies* and *Francois Pajot*, with emphasis to low and high frequencies, respectively. The way to distinguish the weaker solar system diffuse emission, dust grain properties and possible implications for CMB analyses is discussed in the presentation by *Michele Maris*.

Three very different topics in CMB cosmology are presented in this parallel session. Far for being exhaustive of the richness of physical and cosmological information carried out by the CMB, they allow to focus, through specific examples, on the relevance of three CMB complementary lines of research.

In the presentation by *Paolo Natoli* an interesting connection between the results expected in next times from the *Planck* mission and fundamental physics is discussed. The emphasis is posed on the statistical properties of the CMB pattern that may be used to constrain parity symmetry, a powerful tool to investigate on Parity violations predicted in several models.

The information on primordial power spectrum at extremely high wavenumbers disappears in CMB anisotropies because of Silk damping. On the other hand, it could be derived from next generations of CMB spectrum missions, as discussed in the presentation by *Rishi Khatri*. It is intriguing how absolute measures of the CMB monopole, i.e. at the largest angular scale, are linked to small scale phenomena. In this case, the coherent energy density contained in density fluctuation waves is dissipated and transferred into spectral distortions.

Finally, the polarization imprints induced by galaxy clusters and filaments is particularly relevant for the analysis of future high resolution ground-based experiments, as discussed in the presentation by *Guo Chin Liu*. Two types of secondary polarization effects arising from single scattering of the CMB photons by ionized gas are considered, the CMB quadrupole induced polarization, which couples the gas density with the CMB quadrupole component, and the polarization induced by the gas motion transverse to the line of sight.

The reader interested in an overall review of the topics presented in this parallel session can refer to [2] , written by chairpersons and all first authors of the above presentations that kindly provided their contributions.

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