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Morphological Characterization of Galactic Foreground Emissions

Accurate component separation of full-sky maps in the radio and microwave frequencies, such as the cosmic microwave background (CMB), relies on a thorough understanding of the statistical properties of the Galactic foreground emissions. These Galactic emissions include Galactic synchrotron, free-free, thermal dust emissions, Anomalous Microwave Emission (AME), etc. Extracting the morphological features of these emissions is crucial from the cosmological perspective as well as from the perspective of understanding the physical processes in our Galaxy. With this objective, we have studied the statistical properties, namely the nature of non-Gaussianity and statistical isotropy, of the 408 MHz Haslam synchrotron map using morphological statistics, such as Minkowski functionals (MFs) and tensors (MTs). Through a careful analysis of this map at different sky regions and angular scales, we have quantified the amplitude and nature of the non-Gaussianity of the synchrotron emission. Our study shows that the synchrotron non-Gaussianity is kurtosis-type towards small angular scales. Next, we extend this formalism to other synchrotron maps, mainly the ones given by Planck and WMAP. Here, our motivation is twofold –to understand the frequency dependence of the morphological features of synchrotron emission and to see how well the synchrotron maps given by the component separation pipelines in Planck and WMAP reproduce the Haslam results we got previously. By comparing different synchrotron maps, we also look into the efficiency of different component separation methods employed in CMB experiments. Next, we study the statistical properties of other Galactic emissions, namely free-free, AME and thermal dust. Here, we investigate whether the observed kurtosis nature of non-Gaussianity in synchrotron maps is a generic feature of foreground emissions or any random field with positively skewed probability distribution. In this talk, I will summarise the major findings of our analyses and discuss the new avenues the morphological characterization of Galactic emissions opens up in improving the component separation methods in CMB experiments.

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