

Large-Scale Anomalies in the Cosmic Microwave Background Current Status, Future Prospects, and Possible Explanations

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Even though the current observational data show an extremely high level of agreement with predictions of the standard model of cosmology, Λ CDM, the cosmic microwave background (CMB) temperature fluctuations measured by the WMAP and Planck satellites have shown a number of persistent anomalous features on large-angular scales that are unexpected or extremely unlikely in Λ CDM cosmology. These anomalies, which are properties of the observed sky and not instrumental artefacts, are all related to violation of statistical isotropy, and even though they could, individually taken, be statistical flukes, they may also be hints of new physics beyond the standard cosmological model. In this talk, after providing a critical review of the CMB large-angular-scale anomalies, their history and their current status, I will discuss some of the existing explanations for the features, ranging from the fluke hypothesis and astrophysical foregrounds within Λ CDM to different physical models beyond the standard picture, in particular the possibility that the Universe has a non-trivial topology, and will review phenomenological expectations for each explanation. I will argue that, in addition to the new perspectives on existing data that the powerful and continuously advancing computational and statistical techniques may provide, it is also essential to investigate the anomalies further with upcoming and future high-precision cosmological data, including observations of the CMB polarisation and the cosmic large-scale structure. This is because any observations of similar or related anomalies in any data sets other than the CMB temperature sky will ameliorate concerns about look-elsewhere penalties for the a posteriori statistical characterization of the CMB temperature anomalies while dramatically increasing the statistical significance of the features to a level which will inevitably force us to revise or rethink the standard model of cosmology. Finally, I will discuss potential connections between the CMB anomalies and the recently reported tensions in the measured values of the cosmological parameters of the Λ CDM model and argue that a combination of these tensions and anomalies may provide a smoking gun for the existence of new physics beyond the standard model of cosmology.

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