On the statistics of the degraded CMB Maps

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1 Introduction

Over the last 35 years, since the launch of NASA's first satellite called the Cosmic Background Explorer (COBE, https://lambda.gsfc.nasa.gov/product/cobe/), on the 18th November 1989, the measurement of the Cosmic Microwave Background (CMB) anisotropies has significantly advanced in terms of accuracy and angular resolution. This progress has been notably propelled by missions such as NASA's Wilkinson Microwave Anisotropy Probe (WMAP, https://map.gsfc.nasa.gov/) in 2001, and the European Space Agency's (ESA) Planck mission in 2009.

The originally obtained CMB maps have undergone extensive study, both past and ongoing, from a statistical perspective, among other aspects. One crucial area of investigation concerns the behaviour the two- and three-point correlation functions behaviour [1—3]. The computational demands and resources required for such analyses are closely linked to the number of points (pixels) needing processing.

To mitigate this challenge, particularly when dealing with a significantly large number of pixels, the scientific community often resorts to a process known as map degradation. This involves reducing the number of pixels from the original map to create a downgraded version.

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2 Methods and Results

2.1 CMB maps degradation

The most commonly pixelation methodology for a spherical-based measurement involves subdividing the spherical surface, ensuring each pixel covers the same surface area as every other. This methodology is utilised by the software package HEALPix originally developed in early 1997 by Krzysztof M. Górski. HEALPix has become a standard tool in the CMB field and other subdisciplines within Astrophysics. It is possible to combine different routines of the aforementioned software package to reduce the CMB map resolution.
Initially, we developed a set of codes integrating the aforementioned routines, utilising various techniques. These codes generate a pair of downgraded maps from an original one. Additionally, alternative downgraded maps are produced using different methods, including the application of neural networks.

2.2 Statistical analysis of downgraded maps

Finally, a statistical study is conducted. Various statistical tools are employed to compare the downgraded maps, including distribution fits and estimators. Furthermore, a novel evaluation technique, that has been used to characterise image textures, based on permutation entropy [4], is incorporated. The results of comparing these different techniques across the downgraded maps are presented.

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References

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