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Enhancing Cosmic Microwave Background analysis: implementing frequency-correlated noise in component separation

This work focuses on enhancing the accuracy of Cosmic Microwave Background (CMB) data analysis by improving the treatment of noise correlations during component separation.
CMB temperature and polarization anisotropies are powerful tools for constraining cosmological models, providing fundamental information about the early stages of the Universe. Their measurement requires instruments with excellent sensitivity and control over systematic effects, as well as multifrequency observations in order to remove any contamination from astrophysical foreground emissions via component separation analysis.
For computational reasons, component separation codes currently assume uncorrelated noise between different channels, which is a reasonable approximation for past and ongoing experiments. However, including noise correlations is of potential key importance for future generations of CMB experiments measuring such a faint cosmological signal.
In order to assess the impact of cross-channel correlations on future data we developed a prototype pipeline that generates simulated maps of the microwave sky according to a given instrumental configuration and carries out a component separation analysis assuming different noise models.
Instrumental noise in microwave sky maps can very accurately be described as a zero mean Gaussian process, and its properties can then be fully described by a noise covariance matrix (NCVM).
Our pipeline allows to incorporate in the NCVM correlations between different channels, in addition to between map pixels and Stokes parameters.
Validation tests show an excellent agreement with the analytical maximum likelihood points for all the considered noise realizations.
Our preliminary results indicate that including noise frequency correlations reduces the uncertainty on the estimation of the spectral parameters, leading to sharper joint posterior distributions.
Furthermore, we are now upgrading Commander 2, a Bayesian component separation code, to take into account this more general noise model exploiting the native parallelized architecture to optimize the algebra.

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