Constrained probability distributions of correlation functions

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Context: Two-point correlation functions are used throughout cosmology as a measure for the statistics of random fields. When used in Bayesian parameter estimation, their likelihood function is usually replaced by a Gaussian approximation. However, this has been shown to be insufficient.
Aims: For the case of Gaussian random fields, we search for an exact probability distribution of correlation functions, which could improve the accuracy of future data analyses.
Methods: We use a fully analytic approach, first expanding the random field in its Fourier modes, and then calculating the characteristic function. Finally, we derive the probability distribution function using integration by residues. We use a numerical implementation of the full analytic formula to discuss the behaviour of this function.
Results: We derive the univariate and bivariate probability distribution function of the correlation functions of a Gaussian random field, and outline how higher joint distributions could be calculated. We give the results in the form of mode expansions, but in one special case we also find a closed-form expression. We calculate the moments of the distribution and, in the univariate case, we discuss the Edgeworth expansion approximation. We also comment on the difficulties in a fast and exact numerical implementation of our results, and on possible future applications.

Comments:	13 pages, 5 figures, updated to match version published in A&A (slightly expanded Sects. 5.3 and 6)
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