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Statistics of coarse-grained cosmological fields in stochastic inflation

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We present a generic framework to compute the one-point statistics of cosmological perturbations, when coarse-grained at an arbitrary scale R, in the presence of quantum diffusion. Making use of the stochastic-δN formalism, we show how it can be related to the statistics of the amount of expansion realised until the scale R crosses out the Hubble radius. This leads us to explicit formulae for the probability density function (PDF) of the curvature perturbation, the comoving density contrast, and the compaction function. We then apply our formalism to the calculation of the mass distribution of primordial black holes produced in a single-field model containing a "quantum well"(i.e. an exactly flat region in the potential). We confirm that the PDFs feature heavy, exponential tails, with an additional cubic suppression in the case of the curvature perturbation. The large-mass end of the mass distribution is shown to be mostly driven by stochastic-contamination effects, which produce black holes more massive than those naively expected. This work bridges the final gap between the stochastic-inflation formalism and the calculation of the mass distribution of astrophysical objects such as primordial black holes and opens up various prospects that we finally discuss.

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