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Primordial Black Holes from Stochastic Tunneling

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If the inflaton gets trapped in a local minimum of its potential shortly before the end of inflation, it escapes by building up quantum fluctuations in a process known as stochastic tunnelling. In this work we study cosmological fluctuations produced in such a scenario, and how likely they are to form Primordial Black Holes (PBHs). This is done by using the stochastic-N formalism, which allows us to reconstruct the highly non-Gaussian tails of the distribution function of the number of e-folds spent in the false-vacuum state. We explore two different toy models, both analytically and numerically, in order to identify which properties do or do not depend on the details of the false-vacuum profile. We find that when the potential barrier is small enough compared to its width, $V/V < {}^2/M_{Pl}^2$, the potential can be approximated as being flat between its two local extrema, so results previously obtained in a "flat quantum well" apply. Otherwise, when $V/V < V/M_{Pl}^4$, the PBH abundance depends exponentially on the height of the potential barrier, and when $V/V > V/M_{Pl}^4$ it depends super-exponentially (i.e. as the exponential of an exponential) on the barrier height. In that later case PBHs are massively produced. This allows us to quantify how much flat inflection points need to be fine-tuned. In a deep false vacuum, we also find that slow-roll violations are typically encountered unless the potential is close to linear. This motivates further investigations to generalise our approach to non-slow-roll setups.

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