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Generic isocurvature fluctuations of scalar spectators

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Light scalar fields acquire isocurvature fluctuations during inflation. While these fluctuations could lead to interesting observable signatures at small scales, they are strongly constrained on large scales by cosmic microwave background (CMB) observations. When the mass of the scalar is much lighter than the inflationary Hubble scale, $m \ll H_I$, the spectrum of these fluctuations is flat. Meanwhile, if $m \gg H_I$, the fluctuations are suppressed. A blue-tilted isocurvature spectrum which exhibits enhanced structure on small scales but avoids observational constraints on large scales therefore requires a coincidence of scales $m \sim H_I$ for a free massive scalar. In this talk, I will show that if a scalar field possesses a nontrivial potential, its inflationary dynamics naturally cause this condition to be satisfied, and so a blue-tilted spectrum is generically expected for a large class of potentials. Specifically, if its potential V exhibits a region which satisfies the slow-roll condition $V'' < H_I^2$ the scalar will spend most of inflation close to the boundary of this region, so that its effective mass is typically close to H_I. Depending on the length of inflation, this can generically lead to an isocurvature spectrum with an $\mathcal{O}(0.1)$ blue tilt, regardless of the initial inflationary conditions of the scalar or its final mass in the late universe. If the scalar is long-lived, this mechanism leads to an attractor prediction for its relic abundance. In particular, a scalar field with quartic self-interactions can achieve the correct abundance to constitute all of the dark matter for a wide range of masses, while avoiding isocurvature constraints and exhibiting enhanced structure on small scales.

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