The End of the Beginning?
On a methodological tension in early universe Cosmology

Abstract

I am concerned about a potential methodological tension in early universe Cosmology. In particular, I am concerned with the employ of the so-called dynamical systems approach to resolving the apparent fine-tuning of the universe's initial state. I will show that solutions such as inflation—my argument applies, as well, to many of inflation's competitors—undermine the motivation for doing cosmology. More specifically, inflation solves the fine-tuning problem by erasing the very contingency that is necessary for using astrophysical observations to probe Planck regime physics.

Evidently, in order to have a universe anything like the one we now observe, the initial state could have differed from what it was by no more than about 1 part in 10^{120}, by some estimates. Moreover, this value is thought to be incredibly unlikely, and so the fine-tuning problem is looks to be a pressing problem indeed. Inflation comes to the rescue, by positing an attractor dynamics. The inflaton field drives exponentially accelerated expansion of the early universe, which eliminates dependence on an unlikely initial state, giving an elegant and parsimonious answer to the fine-tuning problem.

The tension that I'm worried about concerns an important aspect of cosmology, viz. that it is an investigation of the past. Reflecting on historical investigations, it's clear that, on the one hand, contingency—in the sense of sensitive dependence of later states on earlier ones—adds to the complexity and uniqueness of history. And it is just this that high energy physicists are trying to eliminate. On the other hand, contingency is an epistemic blessing, for only when the present sensitively depends on the past is the present a source of empirical constraints on theories concerning the past. Nature does not always cooperate, in this regard, as information loss is common. But when she does cooperate, contingency is an epistemic blessing. When information loss has not dashed all epistemic hopes of knowing the past, the degree of sensitivity on earlier states grows rapidly the further back in time one probes.

From this perspective, the apparent fine-tuning of the initial state is surprising in what it tells us, but is an epistemic bounty the likes of which historical scientists dream. Given that one of the primary motivations for doing cosmology is to use astrophysical observations to probe energy scales vastly beyond those experimentally accessible, nature has bestowed upon cosmologists an incredible epistemic gift. If the motivation for doing cosmology is to probe Planck regime physics, sensitive dependence on the state of the universe at Planck time is crucial. But inflation undermines all fo this. Its touted success is that the universe could have had any initial state whatever, and inflation will drive the system into a state compatible with what we observe. Inflation, then, makes the later state necessary and erases contingency by diluting everything prior completely away. Inflation, then, pulls the plug on the poor man's accelerator too soon, cutting off access to the Planck regime. It therefore undermines the motivation for doing early universe cosmology in the first place.