SELF-LOCATING UNCERTAINTY IN THE COSMOLOGICAL MULTIVERSE WORKSHOP

August 26 – 27, 2021

Schedule (in Eastern Daylight Time)

Thursday, Aug 26

9:00 – 9:05	Welcome – Matthew W. Parker
9:05 – 9:45	"Paradoxical Probabilities in the Context of Cosmology" – Sylvia Wenmackers
9:45 – 10:05	Q&A
10:05 – 10:15	Break
10:15 – 10:55	"Eternal Inflation: When Probabilities Fail" – John D. Norton
10:55 – 11:15	Q&A
11:15 – 11:25	Break
11:25 – 12:05	"The Teacup Game: Probability and Permutation Invariance in an Infinite Universe" – Matthew W. Parker
12:05 – 12:25	Q&A

Friday, Aug 27

9:00 – 9:05	Welcome back – Matthew W. Parker
9:05 – 9:45	"The Born Supremacy" – Marie Gueguen
9:45 – 10:05	Q&A
10:05 – 10:15	Break
10:15 – 10:55	"The Problem of Researcher Degrees of Freedom in Multiverse Theory Testing" – Simon Friederich
10:55 – 11:15	Q&A
11:15 – 11:25	Break
11:25 – 12:15	Panel Discussion with all above presenters, led by Chris Smeenk

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Abstracts

Thursday, 26 Aug

9:05 EDT: "Paradoxical Probabilities in the Context of Cosmology"
Sylvia Wenmackers

Problems with uniform probabilities on an infinite support show up in at least two contexts in contemporary cosmology. First, in the context of inflation theory, where it complicates the assignment of a probability measure over pocket universes (see, *e.g.*, Guth, 2007, and Ijjas *et al.*, 2013). Second, in the context of central-time models, which crucially require an infinite phase space (Carroll and Chen, 2005; Guth, 2018). Both are instances of the measure problem, whereby it seems impossible to pick out a unique measure. These issues and associated paradoxes have been discussed by physicists, albeit without reference to earlier work on this topic.

The aim of this contribution is both to introduce philosophers of science to these recent discussions in cosmology and to familiarize cosmologists with relevant work by de Finetti (1972) and other probabilists. The analysis of the assumptions going into the paradoxes indicates that there exist multiple ways of dealing consistently with probabilities in cosmological theories (including non-Archimedean probabilities, Benci *et al*., 2013). By taking a pluralist stance towards the mathematical methods, we may remove at least some of the current obstacles.

10:55 EDT: "Eternal Inflation: When Probabilities Fail"
John D. Norton
Paper: https://sites.pitt.edu/~jdnorton/papers/eternal_inflation_no_pp.pdf

In eternally inflating cosmology, infinitely many pocket universes are seeded. Attempts to show that universes like our observable universe are probable amongst them have failed, since no unique probability measure is recoverable. This lack of definite probabilities is taken to reveal a complete predictive failure. Inductive inference over the pocket universes, it would seem, is impossible. I argue that this conclusion of impossibility mistakes the nature of the problem. It confuses the case in which no inductive inference is possible, with another in which a weaker inductive logic applies. The alternative, applicable inductive logic is determined by background conditions and is the same, non-probabilistic logic as applies to an infinite lottery. This inductive logic does not preclude all predictions, but does affirm that predictions useful to deciding for or against eternal inflation are precluded.

10:55 EDT: "The Teacup Game: Probability and Permutation Invariance in and Infinite Universe"
Matthew W. Parker

John Norton (2018 and forthcoming) has recently argued that the correct inductive logic for self-location in an infinite multiverse violates the probability axioms and is essentially useless for confirmation. This is due to a principle of permutation invariance: The chance of being in a set of worlds should remain the same under any permutation of worlds.

I argue that this leads to untenable conclusions about ordinary chance experiments like die rolls. Suppose, for example, a fair die has been rolled and covered with a teacup. What is the chance that, on lifting the teacup, you will find that the die has come up six? By a straightforward application of probability theory, it is 1/6. Yet, in an infinite multiverse, there may be infinitely many indistinguishable occurrences of this experiment. In that case, by Norton's logic, you are "as likely as not" to be in one of those

places where the die has come up six. These two perspectives appear to give conflicting predictions about what you should expect to see.

I consider attempts to reconcile the two perspectives and conclude that, if they succeed, then they also rescue inflationary cosmology from the confirmation problem. My tentative diagnosis is twofold: Permutation invariance is too strong a requirement, and we need not take self-location into account to confirm cosmological theories. The principle of mediocrity has been taken too seriously.

Friday, Aug 27

9:05 EDT: "The Born Supremacy"
Marie Gueguen

Suppose Alice uses textbook quantum mechanics, including the Born rule, in the course of testing quantum physics in her laboratory. Cosmologists have recently argued that Alice has to take into account not just the apparatus in front of her, but the indistinguishable doppelgängers that are purported to exist in an infinite multiverse. Once she does so, they claim, the familiar Born rule no longer suffices.

One version of this argument appears in a series of papers by Don Page (2007-2017). Granting that Alice does not know which laboratory to call her own, it is no longer possible to build a set of orthonormal projection operators, either for a single copy or for a "combined system" including all copies, that corresponds to a set of normalized probabilities. Hence the Born rule fails. Even worse, the negative argument is not supplemented with a new account of probabilistic methods that allow Alice to take her location into account. So can Alice reason probabilistically in an infinite universe?

Our aim is to identify the contentious assumptions regarding the application and interpretation of quantum mechanics needed for arguments of this sort to work. We regard them as a reductio of this particular set of commitments and show how much more plausible replacements allow Alice to continue applying the Born rule without worrying about infinite space.

10:05 EDT: "The Problem of Researcher Degrees of Freedom in Multiverse Theory Testing"
Simon Friederich

Can multiverse theories be tested? Some physicists say "yes". For example, Bousso et al. (2007) claim to narrow down values of the cosmological constant that observers in a multiverse setting can expect to detect to a narrow range around the observed value.

The strategy with which studies like (Bousso *et al*. 2007) extract predictions from multiverse theories even though other universes are unobservable is to interpret these theories as predicting what "typical" multiverse inhabitants will observe. To do this, an observer proxy is chosen, e.g., amount of baryonic matter converted into galaxies or entropy production in the "causal diamond." Different universes are compared with respect to the abundance of this proxy. A multiverse theory is treated as predicting that we will find ourselves in a universe where it is comparatively abundant.

Here I criticize this procedure as unreliable. In order to apply it, infinities must be regularized using a "cosmic measure." Unfortunately, there are no physically privileged choices of cosmic measure and observer proxy. Physicists react to this situation by empirically "testing" measures and proxies. However, "tested" measures and proxies are designed to deliver empirically favourable results, and tests of multiverse theories based on them are therefore unilluminating.

I illustrate this problem with a concept that researchers studying the replication crisis in the social sciences find useful, namely, "researcher degrees of freedom" (Simmons, Nelson and Simonsohn 2011). It refers to the types of freedom researchers have in data collection and analysis (e.g. when to stop collecting data, which data to exclude, which analytical tools to employ etc.) and which they (often unintentionally) exploit to obtain results as desired. Cosmic measure and observer proxy function as researcher degrees of freedom in multiverse theory testing, and this warrants pessimism concerning our prospects to convincingly test such theories.

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