Early Career Physics Abstracts

April 11 –12, 2019

Laura Ruetsche, University of Michigan (Aristidis Arageorgis, John Earman): Keynote
"Additivity Principles for Quantum Probabilities"

Abstract: The question of whether *personal* probability functions should be countably or (merely) finitely additive has been extensively debated. We ask a different question: what additivity principles govern *physical*, specifically quantum mechanical, probabilities? Taking this to be a question about what quantum *states* are physically realizable, we present a "transcendental" argument in favor of countable additivity. In order for us to have evidence supporting quantum mechanics (the argument goes), the probability functions induced by quantum states must be countably additive. Otherwise, we could never prepare systems in specific quantum states, where such preparation is a precondition for collecting evidence confirming the theory. Although our focus is physical probabilities, reflecting on state preparation allows us to draw a few quick and polemical morals concerning rational credences about quantum events. First, the Principal Principle is otiose. Second, Bayesian personalists tempted by de Finetti's arguments in favor of merely finite additivity indulge that temptation at their peril. Finally, if Dutch bookies don't get you, the house will.

Neil Dewar, Munich Center for Mathematical Philosophy
Joshua Eisenthal, University of Pittsburgh
"A Raum with a View: Hermann Weyl and the Problem of Space"

A central issue in the philosophical debates over general relativity concerns the status of the metric field: should it be regarded as part of the background arena in which physical fields evolve, or as a physical field itself? In this paper, we approach this debate through its relationship to the so-called "Problem of Space": the problem of determining which abstract, mathematical geometries are candidate descriptions of physical space. In particular, we explore the way that Hermann Weyl tackled the Problem of Space in the wake of general relativity, and argue that Weyl's proposed solution reveals a "middle way" between bare-manifold and manifold-plus-metric accounts of spacetime.

John Dougherty, Munich Center for Mathematical Philosophy
"Fields, Loops, and the Strong CP Problem"

The strong CP problem is a fine-tuning problem with the Standard Model of particle physics. Richard Healey (2007, 2010) has argued that this problem rests on a misinterpretation of gauge transformations. The usual statement of the strong CP problem involves the claim that some so-called "large" gauge transformations are real physical symmetries: they relate distinct states of affairs that share some or all physical features. But on the received view of gauge transformations they are "surplus structure" in the mathematics of the theory and have no physical significance. Healey argues that the received view is vindicated by his loop-theoretic interpretation of gauge theories and that the strong CP problem therefore dissolves. In this talk I argue that large gauge transformations are indeed physical symmetries and that loop-theoretic formulations of gauge theories offer no special resources for the strong CP problem.

Benjamin H. Feintzeig, University of Washington
"Reductive Explanation and the Construction of Quantum Theories"

I analyze an explanatory constraint governing the construction of new quantum theories---that new quantum theories ought to be able to explain why their predecessors were successful. In particular, I take up the form of this constraint that requires quantum theories to explain why their preceeding classical theories had the state space they had. I give a general argument to justify imposing this constraint, and then I present two examples to show how the constraint can be useful. The first example shows a sense in which the constraint justifies the use of standard quantum mechanics in the (regular) Schrodinger representation over alternative (non-regular) representations of the Weyl algebra. The second example shows a sense in which the constraint justifies the charge superselection structure of the algebra of observables for the quantum theory of a particle moving in an external Yang-Mills gauge field.

Josh Hunt, University of Michigan
"Staying On-shell: Modern Methods in Particle Physics"

Feynman diagrams provide a traditional perturbative method for calculating scattering amplitudes in the Standard Model, but they introduce a host of interpretational difficulties. First, they generically use off-shell (virtual) particles to represent interactions, violating a key kinematic constraint of relativistic theories. Second, although the relevant Lagrangian and scattering amplitudes are gauge-invariant, Feynman rules are gauge-dependent, making intermediary calculation-steps difficult to interpret. In the past 15 years, physicists have developed new methods for calculating scattering amplitudes that avoid many difficulties faced by Feynman diagrams. Collectively known as on-shell recursion, this approach represents all particles as remaining on the mass shell, thereby eliminating any need to interpret virtual particles. Second, all quantities in an on-shell amplitude calculation are gauge-invariant, eliminating any need to choose a gauge. On-shell methods work primarily by deriving recursion relations that factorize scattering amplitudes involving n-many particles into products of scattering amplitudes with fewer than n-particles. For many theories—such as gluon scattering in quantum chromodynamics—the amplitudes ultimately reduce to scattering just three particles. Furthermore, these three-particle amplitudes are often fixed entirely by symmetries and other physical principles, such as little group scaling, locality, and dimensional analysis. I will discuss the new interpretive avenues that on-shell methods provide, along with general morals for understanding theoretical reformulations.

Qiu Lin, Duke University
"Émilie du Châtelet's Views on Space"

Abstract: TBA

Tushar Menon (James Read, and Niels Linneman), Oxford University
"Rotating Spacetimes and the Relativistic Null Hypothesis"

Abstract: TBA

Núria Munoz, Max Planck Institute for the History of Science
"The Role of Symmetry-Breaking in "More is Different""

Abstract: TBA

Sébastien Rivat, Columbia University
"Two Cheers for Effective Theories and Selective Realism"

Effective Field Theory (EFT) methods have become increasingly popular in physics since the 1980s. The Standard Model of particle physics and General Relativity are now widely believed to be best understood and formulated as EFTs; and, in recent years, EFT methods have found many successful applications outside of the strict framework of Quantum Field Theory in areas as varied as fluid dynamics and post-Newtonian gravitation. Despite this growing success, most of the philosophical work done on effective theories has been restricted to high energy physics. The goal of this talk is to make a small step towards a broader appreciation of the philosophical impact of the framework of effective theories.