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Book Review

MICHAEL SILBERSTEIN, W. M. STUCKEY, AND TIMOTHY MCDEVITT
BEYOND THE DYNAMICAL UNIVERSE: UNIFYING BLOCK UNIVERSE PHYSICS AND TIME AS EXPERIENCED
Michael Silberstein, W. M. Stuckey, and Timothy McDevitt, *Beyond the Dynamical Universe: Unifying Block Universe Physics and Time as Experienced*. Oxford University Press, 2018, £55, ISBN 9780198807087

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This is a very ambitious book. Silberstein, Stuckey and McDevitt claim to solve the measurement problem and non-locality problem in quantum mechanics; the renormalization and gauge invariance problems in quantum field theory and the black hole firewall paradox; the puzzle of the origin of the universe in general relativity and the flatness, horizon and low entropy problems; the problem of change and the special nature of the present; and the hard problem of consciousness. They claim to do so by adopting an explanatory paradigm based on adynamical global constraints, as opposed to the explanatory paradigm based on dynamical laws that has dominated physics since Newton.

Can they deliver on all these promises? Probably not. Does it matter? Not at all. Their explicit advocacy of an adynamical approach crystalizes an idea that has been implicit in the foundations of physics for a while. It is important to make this approach available to scrutiny because it promises to lead to progress on at least *some* of the issues just mentioned—and progress on *any* of them would be significant. If it cannot instantly sweep away *all* the problems in the foundations of physics (and elsewhere), then this is only to be expected.

The approach itself is simple. A schematic account of explanation and prediction in physics goes as follows: construct a mathematical representation of the initial state of the system under consideration, time-evolve that state using a dynamical law, and read the explanandum or prediction off the final state. This has been the dominant mode of physical explanation, but it is not the only one. One can also explain or predict using a broadly Lagrangian approach: describe the space of possible space-time *trajectories* of the system between two end-points, and then use a global constraint to fix which of these trajectories is realized. For example, the trajectory of a baseball can be explained as the path of least action between two points, and the path of a light-ray can be explained as the path of least time.

It is worth briefly defending the latter strategy as genuinely explanatory, since there is sometimes some confusion on this score. If you want to explain or predict the final position of the baseball, you might think that the adynamical approach can't deliver, either because the adynamical approach has to *assume* the final position of the baseball in fixing the trajectory, or because the final position of the baseball can be no part of the explanation of the (earlier) trajectory in getting there. But these objections confuse two senses of explanation: the epistemic sense, which is logically just the same as prediction, and the physical sense, which is the story about what is allowed to happen in the world. Keeping these separate, there is no problem. Physically, the least-action constraint entails that the allowed path of the baseball between any two points is a parabola. Epistemically, we can plug in the known values for the parameters of this parabolic trajectory to derive the unknown values. In particular, if we know the initial position and velocity of the baseball, we can derive its position at any later time. The epistemic explanation proceeds from past to future, because we typically know less about the future. But the physical explanation exhibits no such asymmetry.

There is a lightly-trodden path in the foundations of quantum mechanics according to which the measurement problem can be solved without non-locality by denying the independence of particle properties from the measurements later performed on them (e.g. Price 1996). This approach is typically described as *retrocausal*: later measurement events can *cause* earlier particle properties. But filling in the details of this approach to construct a full theory of the quantum world has proven difficult. What Silberstein, Stuckey and McDevitt suggest is that the failure here is a result of moving some way towards an adynamical mode of explanation, but not *all* the way. That is, the retrocausal account is temporally symmetric, but it still maintains vestiges of the dynamical mode of explanation, in that particles carry traces of (past and future) dynamical interactions (Price 1996), or wave functions evolve (both forwards and backwards) in time (Kastner 2013). What Silberstein, Stuckey and McDevitt suggest is that these problems dissipate if we move to a fully adynamical physical picture.

This is a promising move. The idea is to give up the search for forward-acting and backward-acting dynamical laws that can somehow "fit together" in a consistent way to yield quantum phenomena. Rather, we derive quantum phenomena directly from a global constraint, without any appeal to the dynamical evolution of particle properties or wave functions. In classical physics, we can move back and forth at will between dynamical and adynamical explanation; the lesson of quantum mechanics, Silberstein, Stuckey and McDevitt suggest, is that there are phenomena for which there is an adynamical explanation, but no dynamical counterpart.

This is, plausibly, a direction in which the foundational problems of quantum mechanics might be solved—and that is no mean achievement. But the way is not altogether clear. Classical adynamical techniques, such as least-action calculations, output a determinate trajectory between two points. But quantum adynamical techniques, such as Feynman's path-integral calculation, output a *probability value* based on a *sum* over all possible trajectories between the two points. Which trajectory does the particle take? And what does the probability represent?

Silberstein, Stuckey and McDevitt take this situation to point to *direct action* between the source and the detector: the requirement of a particle traveling along a determinate trajectory is a holdover from the dynamical paradigm, and instead we should just think in terms of a quantum event connecting the source and detector. But what of the probability? A global constraint that rules out non-parabolic baseball trajectories is easy to comprehend. But it is harder to figure out how to understand a *probabilistic* global constraint. What is constrained, exactly? The *frequency* of this kind of event?

Despite these concerns, the adynamical approach holds significant promise of providing a novel resolution to debates in the foundations of quantum mechanics. A nice feature of the approach is that it doesn't suffer from the problems with generalization to the relativistic setting that plague dynamical approaches such as Bohm or GRW. In fact, the situation is quite the reverse: adynamical constraints look more natural in a general relativistic setting in which the global topology of space-time is part of the explanatory apparatus. In particular, Silberstein, Stuckey and McDevitt stress the flexibility of the global constraint approach in dealing with cosmological puzzles; the precise nature of the constraint can be reverse-engineered to fit the observed cosmological data, without the need for mysterious "dark energy" or "dark matter". If this works, it is progress indeed.

International Journal of Quantum Foundations **5** (2019) 110 - 114

Why do I say, then, that it is unlikely that Silberstein, Stuckey and McDevitt's adynamical approach can solve *all* the problems they claim it can? In some cases, it is because I am not convinced there is a problem to be solved. For example, they cite the problem that a dynamical approach to cosmology must always rely on initial unexplained conditions: what explains the big bang? Under an adynamical approach, on the other hand, they note that we can pick any point in space-time as the starting point for computational purposes, and hence that the explanatory priority of initial conditions disappears. But of course, for *computational* purposes, we can pick any point as the starting point of our dynamical explanations too. If the complaint is that the dynamical approach doesn't explain *everything*, then that is too tall an order. No approach, dynamical or adynamical, can explain its own laws and constraints, or explain why this particular solution of the laws and constraints is instantiated rather than some other. It's worth noting that many physicists *do* take the lack of explanation of initial conditions to be a problem for cosmology. But I remain to be convinced that there's a problem here that the adynamical approach can do better at solving.

In other cases, it looks to me that any solution to the problem in question is achieved via means other than the adynamical approach. For example, Silberstein, Stuckey and McDevitt's solution to the hard problem of consciousness is to posit a neutral monism: at bottom, there is no physical-mental distinction. But there is at best an indirect connection between neutral monism and their adynamical program. The idea seems to be that the "block universe" four-dimensionalism required for adynamical explanation introduces a *special* problem for temporal experience, and that neutral monism is the best way to solve this problem. But if neutral monism is the solution, then the *experience* of temporal passage and *physical* temporal passage are two aspects of the same thing—which seems to presuppose that we can identify temporal passage in the physical world in a block universe. If we can do that, then it's not clear to me how neutral monism as such is doing the work.

The usual way to introduce a controversial idea in philosophy is to be as conciliatory as possible concerning everything *except* the idea in question. This is not Silberstein, Stuckey and McDevitt's style. In addition to denying the physical-mental distinction, they deny any hard distinction between classical and quantum properties, between space and time, and between space-time and matter, and also endorse a form of anti-reductionism they call "contextual emergence". It's not that each move isn't discussed and motivated; it's that given so many moving parts, it's hard to see which parts are doing the work in any particular case. Call me conservative, but I prefer small steps to giant leaps. The step to adynamical explanation is, on some measures, a small one: Lagrangian techniques are nothing new. And it promises big new insights into quantum mechanics, relativity, and their conjunction. As will be apparent, there is a *lot* going on in this book—I have hardly scratched the surface—but it is here that I think it will have its biggest influence. I heartily recommend it.

References

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