

The Physics of Nothing: Are virtual particles an exception to the causal productive principle?

by Agustín Moreno

In his study about the principle of sufficient reason (PSR), Arthur Schopenhauer famously argued that such a principle, in its four possible expressions, is essential to our cognitive faculties. According to Schopenhauer, one of the expressions of PSR is the causal principle according to which any event requires a cause. Schopenhauer's understanding of the causal principle was largely dependent on his overall Kantian understanding of causation as a transcendental, a priori category of thought which applied to the empirical world; and was thus vulnerable to standard criticisms of Kantian metaphysical categories in general. Eventually, and for many other reasons unrelated to Kantian philosophy, including common interpretations of quantum phenomena, the causal principle in particular and even PSR itself became subject to such strong criticisms that many analytic philosophers today think that any version of PSR is plausibly false.

However, recent defenses of PSR have demonstrated that a very modest version of PSR is plausible¹. In my opinion, the most defensible, empirically confirmed and intuitively obvious version of PSR is the causal productive principle, which states that “whatever begins to exist has a cause”. Recently, this principle has been much discussed in the philosophical literature, especially in philosophy of religion and particularly in discussions about the so-called Kalam Cosmological Argument for God's existence.

Some participants in this debate have argued that quantum physics provides a decisive counter-example to that version of the causal principle. In particular, the rejoinder is that the spontaneous emergence of the so-called virtual particles from the “quantum vacuum” provides a decisive refutation of the causal productive principle, because – so the objection goes – virtual particles come, or are produced, spontaneously “from nothing”.

¹ For a contemporary discussion and sophisticated defense of the principle of sufficient reason, see *The Principle of Sufficient Reason: A Reassessment* (Cambridge University Press, 2010) by Alexander Pruss. More recently, philosopher Michael Della Rocca has also skillfully defended PSR on different grounds, see his paper “PSR”, *Philosophers' Imprint*, Volume 10, Nro. 7, July 2010.

Is this objection a sound one? I hope to show that it is not. In fact, I will argue that this objection is based upon an egregious misrepresentation of science and rests, in fact, on a logical fallacy of equivocation.

A first aspect of the problem that we have to consider carefully is exactly what the causal productive principle affirms. The principle “whatever begins to exist has a cause” refers exclusively to *things* – objects, substances, particulars – which begin to exist, not to events or changes in things. This modest version of the causal principle that we are considering is pretty consistent with events or changes in things being fully spontaneous or non-causal. The principle only requires that *things* don’t begin to exist out of nothing. The negation of this principle implies that the proposition “something began to exist out of nothing” is true. Therefore, any exception to the causal principle we are considering implies affirming the latter proposition. And certainly, on metaphysical, empirical and commonsensical grounds, the version of the causal principle defended here seems to be more plausibly true than the proposition that something began to exist from nothing.

A second aspect that we have to keep in mind is what we mean philosophically by “nothing”. Literally, “nothing” is not-anything, or more exactly and technically, nothing is “the absence of being”. When we say that any exception to the causal principle would imply that the proposition “something began to exist out of nothing” is true, we are not saying that “something” (let us call it “X”) came into being from another existing thing called “nothing”. Rather, we mean that such “X” came into being without any causal connection whatsoever with another being.

Having clarified the key terms, we are in position to assess the rejoinder that virtual particles emerging from the quantum vacuum are an exception to the causal productive principle.

The underlying assumption of this objection is that the “quantum vacuum” is the same as “nothing”. And this assumption is based upon a fallacy of equivocation. In physics, sometimes the “quantum vacuum” is called “nothing”, but just metaphorically. Professional physicists fully know that the “quantum vacuum” has a physical structure of energy, which is describable by science. This physical structure is composed of fluctuating energy from which virtual particles emerge. Therefore, the quantum vacuum is *something*. It is a certain kind of entity, even if a basic or fundamental one. It is endowed with physical properties, described by the laws of quantum mechanics.

The objection we are considering subtly equivocates “nothing” – in the physical sense of quantum vacuum *qua* basic physical structure of fluctuating energy – with “nothing” in another sense, namely, in the metaphysical sense of not-anything or non-being. Only the latter, metaphysical sense of “nothing” is relevant to the causal principle that we are discussing, because as we have seen the causal productive principle implies that any being which begins to exist comes from another being and any counterexample would have to prove that something began to exist out of nothing.

It is clear, then, that if virtual particles came from the quantum vacuum, and the latter is *something*, then it is impossible that the emergence – spontaneous or not – of such a virtual particles be an example of something coming into being out of nothing in the relevant sense required by the objection and therefore a proven counterexample or exception to the causal productive principle.

Appealing to quantum mechanics in general and virtual particles in particular as proven exceptions to the causal productive principle is bad science and bad philosophy².

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Email: philojuris@gmail.com

² It is not to suggest that quantum mechanics is entirely irrelevant to other versions of the causal principle. For example, counterexamples coming from quantum physics, like the cases of the spontaneous decay of atoms, could be relevant for the version of the causal principle according to which “every event requires a cause”. But other versions of the causal principle, as the one discussed in this essay, are immune to that putative counterexample.