

Order out of Chaos

Probably the most fundamental problem in the whole of science is the origin of the universe. We have increasingly detailed theories of how the primordial energy generated in the Big Bang developed into atoms, molecules, stars, planets and living organisms. But a theory of the ultimate origin must explain how the cosmos emerged out of emptiness. Yet, how can nothing be a cause for something? Present-day cosmology evades the problem by viewing the origin of the universe as a mathematical "singularity", i.e. a point where time, space, and natural law cease to exist. This means that we cannot extrapolate backward to what came before the Big Bang.

At the level of quantum physics, we do not really need a cause, though. For example, consider a radioactive atom. At some random instant in time, it will disintegrate into smaller particles. What caused the atom to decay at that particular moment, and not at another one? According to quantum theory, it is impossible to say: there is a fundamental uncertainty built into such microscopic processes.

This uncertainty principle even applies to empty space, or what physicists call the "vacuum". By definition the total energy of the vacuum is zero, since there is nothing there to hold energy. Yet, according to quantum theory the local energy of the vacuum is actually uncertain, and for sufficiently short time intervals, it can take on arbitrarily large values. These unpredictable variations in energy are called "quantum fluctuations of the vacuum". They appear as virtual particle-antiparticle pairs. These are called "virtual" because they are so short-lived that we cannot directly observe them: the newly created particle and antiparticle almost immediately annihilate each other again.

To create a universe out of nothing, we need an additional mechanism: one that would separate particles and antiparticles, positive and negative energies, so that the zero-energy vacuum would acquire a differentiated structure. An example of such a mechanism is Hawking radiation: if the antiparticle is absorbed by a black hole, it can no longer annihilate its particle partner, which is now free to travel away. Therefore, black holes (harbouring negative energy) appear to emit or radiate particles (carrying positive energy). But this mechanism requires the existence of a black hole, and therefore it cannot explain the ultimate origin.

The quest is on to understand how a cosmos could emerge from the primordial chaos of the quantum vacuum. Such understanding will require a fundamentally new conceptualization of spontaneous creative processes. These are the processes that generate differentiation in an initially homogeneous medium, providing it with a meaningful structure. My own research in theoretical physics, systems theory and cybernetics has been focusing on such processes of "symmetry-breaking" or "self-organization", and the feedback mechanisms that fuel them. An example of self-organization is the formation of crystals in an initially homogeneous salt solution that evaporates.

The artistic work of Katarina Petrović is an exploration of such processes, conceptually as well as physically. For example, one of her installations, "Origin", attempts to create a physical vacuum in a glass container, while generating a sound through the feedback between a microphone and a loudspeaker. Another work, "Lexicon Liber Novus", uses an algorithm that generates an ever-expanding text from a few seed words. And "Cosmologicus" lets the cosmos produce its own poetic text, using a similar algorithm to convert intensities of radiation emitted by the planet Jupiter into words. In this way, Petrović probes the "heart of darkness", the no-man's land between science and art, philosophy and spirituality, where the ultimate origin remains hidden.

For more details:

Heylighen, F. (2010). The Self-Organization of Time and Causality: Steps Towards Understanding the Ultimate Origin. *Foundations of Science*, 15(4), 345-356. <https://pdfs.semanticscholar.org/bb79/dccdcc7c832badcae98ffdecf163945255ed.pdf>

Petrovic, K. (2018). On Cosmogony (ECCO Working Papers No. 2018-02). Retrieved from <http://katarinapetrovic.net/on-cosmogony.pdf>

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