Instantaneity beyond time

Silvia De Bianchi

More than 2,000 years ago, Aristotle developed a specific concept of temporality connected to change that informed Western culture for centuries.

Today, we are accustomed to associating an imaginary arrow with time or depicting it as a line 'flowing' with a direction. After the advent of quantum mechanics and the formulation of the CPT theorem in 1951,[1] we also agreed to allow this line not to have *a priori* a unique direction. This primitive representation is so intimate to our need to visualise time that even the most revolutionary thinkers tried to justify it rather than question it. Even the fathers of quantum mechanics inexhaustibly tried to reconcile the new physical theory with the past. Their heirs continued using the Hamiltonian, a mathematical tool that cannot contrast the mainstream interpretation of a flowing time.

General relativity and beyond

However, the history of physics offers a new radical conception of time embedded in the spacetime concept of general relativity (GR). In it, we find the roots for a real change of paradigm in our way of depicting time. First, there is no time but spacetime as an object. Time is not associated with an external parameter to describe the system. Second, this theory tells us that what counts is the dynamics of spacetime and matter. We cannot think of one without the other and need new mathematical objects, e.g. tensors, to talk about the universe and describe gravitation.

The revolution that GR introduced in physics is well known. However, its implications for our conception of time and the investigation of what we call 'atemporality' are still to be fully identified and developed. The relevance of this kind of investigation is deeply related to the new worldview potentially produced by the advent of quantum computation and applied topology to condensed matter physics.

These relatively new branches of physics are at the beginning of their development. We expect them to bring us into a new technological era that will govern our communication systems. Think of the phenomenon of spin-flip, for instance, which is fundamental in these fields. We cannot say that the flip happens in time; there is no duration that can be attributed to this. If a spin-flip occurs, there is an instantaneous transition.

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Instantaneity

Group field theory (GFT) gives another example of instantaneity in current physical theories, according to which there could have been a phase transition from a non-geometric to a geometric phase of the universe. Again, this transition cannot be known or thought of as being in time.

Therefore, another field in which 'atemporality' is still in need of clarification is quantum gravity. Within this framework, we find different methods and approaches to the quantisation of gravity or approaches that appeal to loop quantum gravity (LQG) or GFT. In both cases, these approaches revindicate the great revolution operated by Einstein's GR in thinking of time, but apart from saying that in their theories spacetime emerges, disappears or is not there yet, they are still unable to provide a cogent definition of 'atemporality'.

The PROTEUS project

The current stage of the art of the PROTEUS project suggests a notion of atemporality suitable for both examples previously mentioned. We must go back to Ancient Greece to understand how to overcome the lack of an appropriate definition.

In the Platonic dialogues, especially in the *Parmenides* and the *Timaeus*, we find the hint for a solution. Before Aristotle reduced the notion of instant to a part of time and dominated Western thought with such a postulation for two millennia,[2] Plato understood the problem of the generation of time and temporality in a different fashion. He thought that if temporality exists, then its contrary exists as well. Atemporality can be understood, as Aristotle and many Neoplatonic did, as eternity.

Today we still think of eternity as the opposite of time, e.g. time can be divided, whereas eternity cannot etc. However, under the concept of atemporality, Plato inserted another notion besides that of eternity, i.e. instantaneity. The latter is the condition of possibility for thinking of a transition or a sudden switch between opposites out of time. According to Plato, the instant is not at all a part of time, the instant is something that lies in the 'in between' and that theoretically justifies transitions that do not have duration and that happen all at once. In other words, in the instant there is no succession but just a switch from A to – A or from A to non-A. In the Platonic picture, we cannot exclude that even temporality is generated from eternity thanks to a sudden, instantaneous switch.

This alternative view—neglected for centuries—will be subject to deeper investigation by the PROTEUS research team in the next two years. Scientists, historians and philosophers will try to reflect upon a new definition of instantaneity that will serve as a conceptual reservoir for the future theory of quantum gravity, quantum information theory and cognates, thereby leading to a central role played by philosophy for future generations.

PROTEUS project partners

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1 The theorem states that any Lorentz invariant local quantum field theory with a Hermitian Hamiltonian must have charge, parity, and time reversal symmetry.

2 Today we still intuitively say that time is constituted by successive instants t0, t1, t2 and so forth.

PROJECT SUMMARY

PROTEUS studies the main strategies devised by Western philosophy in representing time in cosmology. It aims to modify current metaphysics and its relationship with cosmology in light of recent scientific debates in quantum gravity and quantum cosmology, thereby boosting a new research field in the history and philosophy of cosmology.

PROJECT LEAD

Dr De Bianchi received a PhD in Philosophy at the University of Rome "La Sapienza" (2010) and worked as a post-doc in the UK, Germany, France, and Spain. She is currently a Research Fellow at the University of Milan. In 2017 she received an ERC Starting Grant to investigate different cosmological and quantum gravity models to assess their implications for our notion of time. From 2021 the project's co-beneficiary institution is the Universitat Autònoma de Barcelona, where the PI is leading the activity of seven research team members.

PROJECT PARTNERS

The PROTEUS project is based at the Department of Philosophy of the University of Milan and at the Department of Philosophy of the Autonomous University of Barcelona (UAB). Its members collaborate with the Institute for High Energy Physics (IFAE). Other collaboration partners include groups from Rome (ILIESI and La Sapienza) and Munich (LMU).

CONTACT DETAILS

PROTEUS Research Team
Department of Philosophy, Building B,
Autonomous University of Barcelona 08193
Bellaterra Barcelona, Spain

+34 935868174

www.proteus-pmte.eu

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