euresis journal

euresis
Association for the Promotion of the Scientific Endeavour

Letter from the Editors

Dear reader,

This sixth issue of Euresis Journal is our first not directly related to a San Marino Symposium. Although the experience of the Symposia were the driving force behind the Euresis Journal initiative, since the very beginning we planned to present independent topical issues, in an attempt to expand the experience of interdisciplinary dialogue started in San Marino. Having experienced the potential and fruitfulness of focusing the discussions each time around specific themes of particularly broad scope and cultural relevance, as has been the case with the subjects treated in San Marino, we decided to follow the same structure for these new topical issues, which should from now on make up for one of our two releases every year.

The topic of this inaugural volume is "Quantum Mechanics and the Nature of Physical Reality". Quantum Mechanics is one of the cornerstones of modern physics and the radically new worldview it has introduced, with a highly counterintuitive and surprising description of the subatomic world, has shaped not only physics, but has also pushed new breakthroughs in mathematics and greatly influenced philosophical thought within and beyond the natural sciences. Late 20th Century technology and economy are completely dominated by Quantum Mechanics, which has been the key to the development of computers and the key to the digital era. Pushing the boundaries of our understanding of Quantum Mechanics has also lead to the development of the largest experiments ever build by mankind, such as the Large Hadron Collider at CERN in Geneva, which also represents one of the biggest multicultural collaborative enterprises in human history, a research infrastructure that in its microcosm is a fully realized image of the cooperative, global world.

Aware of these extraordinary realties that sprang up from the discovery of the nature of the sub-atomic world, we decided nevertheless to focus this volume on a scientific outlook of the very foundations of Quantum Mechanics as currently understood, where novelties still lie to be discovered and where new ideas are still being explored and debated by researchers. When faced with the systems and entities of the quantum world, one becomes readily aware that the nature of reality is a "fleeing" image, continuously escaping from our grasp at every time a new result comes through, and the models and ideas one previously had must give place to a new plethora of questions. The nature of physical reality is a "mysterious other", and as such, it matters little how big a jump in knowledge one just gave, our sense of understanding remains fleeting.

The six articles which compose this issue give a sense of where are the current frontiers of knowledge in Quantum Mechanics, and a glimpse of the impact they can have on a future worldview still to be shaped. Quantum Mechanics brings about a fundamental philosophical question, which is still unresolved and upon which an ultimate viewpoint on the theory necessarily depends. "Is nature ultimately deterministic or is there an inherent random component in the way things work?" The place of randomness in Quantum Mechanics is an active line of research, both theoretical and experimentally, but in what terms should we understand it: Is quantum randomness any different from the classical concept we have of it, of "throwing dice"? Antonio Acín explores this question in his contribution and speculatively concludes that, although still not well understood, randomness in Quantum Mechanics could very well be not a feature resulting from lack of knowledge of the systems or any hidden variable theory, but directly linked with the free will of the observers themselves.

This inherent random character of Quantum Mechanics represents a Pandoras box in the philosophical debate. What are the implications of quantum phenomena to our brain and neuronal processes? That is, what are the implications of the randomness in quantum systems for the human mind and in the long run to human free will? According to José Ignacio Latorre, the *idea of quantum will should be treated with great care, since randomness does not necessarily imply that will is at place, and warns for the necessity of a robust experimental elucidation of the matter. Randomness is also the subject of Gennaro Aulettas paper, in particular the connection between ontology and information and its implications for our understanding of causality: Are these strange properties of Quantum Mechanics a sign that it is not a complete theory still, but some form of "effective" theory? The until now apparent incompatibility of Quantum Mechanics with the geometrical theory of Gravity proposed by Einstein remain one of the challenges to settle this debate, as physicists look for a deeper, unifying theory.*

In face of the recent impact of high-energy physics and the discoveries by CERN, in particular last years confirmation of the Higgs mechanisms by the LHC, a second part of the volume is dedicated to Quantum Mechanics at high-energies. Lucio Rossi, a leading experimental physicist from CERN, discusses the history and development of large particle accelerators that have become the physicists toolbox to explore fundamental physics. In another contribution, Stefano Forte presents the interesting point that many of the delicate interpretative issues related to Quantum Mechanics never seem to arise when one deals with high-energy phenomena, such as in particle accelerators. He in fact shows that the scale separation provided by fundamental interactions ensure that decoherence effects can be unambiguously separated from the random quantum events, and the theory becomes much clearer to describe, and basically interpretation-free. What does this teach us when we look back into the less clear low-energy limit of the theory and its complex phenomenology?

The English mathematician and philosopher Alfred Whitehead remarked that not a single major concept has been left unchanged or unchallenged by Quantum Mechanics. Such a deep revolution in the natural sciences as witnessed by the early 20th Century physicists can only be compared to the fall of the heliocentric system at the doorstep of the Modern Era; but even then, its surprising character and the radical novelty of its unexpected properties are unlike anything seem before in the physical world, so much so that the only certainty we have of its truthfulness is not so much how much we understand the theory, but rather that it works in practice. In fact, as John Polkinghorne proposes in his concluding article, this unexpected form of rationality that Quantum Mechanics introduces in the natural word is the greatest lesson the theory can teach us, suggesting it is not for us to lay down beforehand the shape of an acceptable account of the nature of physical reality.

The Editors.