SYQC 1: The Quantum-Classical Divide

Time: Thursday 10:30–12:30 Location: Audimax

Invited Talk SYQC 1.1 Thu 10:30 Audimax

Experimental tests of quantum macroscopicity — •Markus Arndt — Faculty of Physics, VCQ, University of Vienna, Boltzmanngasse 5, A-1090 Vienna, Austria

Quantum physics is often said to be the theory of the microscopic world, whereas classical physics is associated with our macroscopic experience. But what is actually the criterion for an experiment to be microscopic or macroscopic [1]? Are quantum superposition and coherence limited to small systems, in size, particle number, mass, state separation in real or phase space? We suggest that experimental matter-wave interferometry with high-mass (10^4-10^7amu) and ultrahigh-mass particles (10^8-10^{10}amu) can settle some of these questions, in the future. State of the art molecule interferometers [2, 3] are expected to corroborate or falsify spontaneous localization models[5]. Recent progress in optical cooling of nanoparticles [6,7] also gives hope for quantum experiments in the ultra-high mass range.

[1]S. Nimmrichter et al., Phys. Rev. Lett. 110, 160403 (2013). [2]S. Eibenberger et al., Phys. Chem. Chem. Phys. 15, 14696 (2013). [4]P. Haslinger et al., Nature Physics 9, 144 (2013). [5]S. Nimmrichter et al., Phys. Rev. A 83, 043621 (2011). [6]P. Asenbaum et al., Nat Commun 4, 2743 (2013). [7]N. Kiesel et al., Proc. Natl. Acad. Sci. USA 110, 14180 (2013).

Invited Talk SYQC 1.2 Thu 11:00 Audimax

From classical instruments to quantum mechanics and back — •Reinhard F. Werner — Leibniz Universität Hannover

In the early days of quantum mechanics Bohr and Heisenberg often referred to the indispensability of classical concepts for the quantum object. But increasingly this was applied only to the classical description of the measuring devices, emphasizing the rather obvious need for classical language to communicate the result of experiments. This is the starting point of the quantum axiomatics of Günther Ludwig, the operational approach to quantum physics, and, more recently, quantum information theory. It comes with a choice of "fundamental" concepts (states, observables and channels) in terms of which the whole theory is set up. With regard to Bell's theorem(s) I will show how this leads to a theory which automatically respects no-signalling locality, but gives up "classicality".

I will then briefly describe how one employs symmetries and other structures to fix some basic observables of the theory. As an illustration I will describe the salient formulation of the classical limit. A detailed description of the measurement process then requires the application of quantum theory to (parts of) the measuring instruments. I will briefly describe what one can hope to get out of this theory of measuring processes. One aim is a consistency statement, justifying the initial classicality assumptions about instruments, like the possibility of stable records, from quantum mechanics itself. The core of this problem is the emergence of classicality in much the same way as it is targeted by statistical mechanics.

Invited Talk SYQC 1.3 Thu 11:30 Audimax

Correlations and the quantum-classical border — •Dagmar Bruss[1], Alexander Streltsov[2], and Hermann Kampermann[1] — [1]Institut für Theoretische Physik III, Universität Düsseldorf, Germany — [2]ICFO, Castelldefels (Barcelona), Spain

There are several options to define the quantum-classical border for states of composite systems: First, classicality can be viewed as locality in the sense that all Bell-type inequalities are fulfilled; second, it can be defined via the possibility to create the state with local operations and classical communication; and third, via the existence of a local Hamiltonian that leaves the state invariant. Once we agree on where to draw the quantum-classical border, some counterintuitive phenomena near this border will be illustrated.

Invited Talk SYQC 1.4 Thu 12:00 Audimax

Why Physics Needs a Classical World...and How It Can Get One — •Tim Maudlin — New York University, Department of Philosophy

One basic question about a proposed fundamental physical theory is how it makes contact with empirical data. If a theory does not provide empirically testable predictions then it cannot be part of empirical science, and if the theory is supposed to be a fundamental physical theory then those predictions should be derivable from the account of the world provided by the theory itself. It has never been clear how quantum theory is supposed to meet this demand. Bohr's presentation of the theory had a "two-worlds" character: the microscopic world is represented by a mathematical quantum state, but the laboratory had to be described in "classical language". Bohr's approach provided (somewhat vague) rules for how to derive probabilistic predictions about the latter given a mathematical representation of the former, but did not even aspire to show how the laboratory equipment itself could be understood as a fundamentally quantum-mechanical system. John Bell proposed a general solution to this problem with what he called the "Theory of Local Beables". I will review Bell's general program and discuss several quite different concrete ways it can be realized.