Dynamics in a model for quantum measurements and insight in the quantum measurement problem

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The talk will advocate our Dreimännerarbeit or Opus Magnum on the quantum measurement problem [2]. This work presents an extensive overview of the literature in the field and then elaborates on the dynamical solution of the Hamiltonian model for a quantum measurement presented in Ref. [1].

Quantum measurements have confronted theorists with many fundamental questions, such as: What determines the basis in which the collapse takes place? Why do Schrödinger cats disappear? What is the minimal interpretation of quantum mechanics? The deepest question is the so-called quantum measurement problem: Can quantum mechanics, despite its probabilistic nature and wave aspects, explain the fact that individual measurements produce individual outcomes?

We shall answer these questions by solving the dynamics of a fairly realistic Hamiltonian model for a quantum measurement: a spin 1/2 is measured by an Ising magnet coupled to a bath. In this process Schrödinger cat terms disappear quickly while producing small multiparticle correlations, which themselves disappear. The magnetization will go from zero in the initial metastable paramagnet to +/- m_F in the final up- or down ferromagnetic state. This transition is triggered by the measurement. The solution to the quantum measurement problem will be related to the irreversible dynamics, which brings the magnet to one of its stable states. The tested spin is coupled to it and will thus also go to a unique state, correlated with the state of the magnet.

A specified version of the statistical interpretation arises as the minimal one. Since it is easy to grasp for students, it will be advocated as the primary one for teaching.

[1] A. E. Allahverdyan, R. Balian and Th.M. Nieuwenhuizen, Curie-Weiss model of the quantum measurement process, Europhys. Lett. 61, 453 (2003)

[2] A. E. Allahverdyan, R. Balian and Th.M. Nieuwenhuizen, Understanding quantum measurement from the solution of dynamical models, Physics Reports, to appear; arXiv:1107.2138. 161 pages, 15 figures, various proverbs