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CONJECTURING THE MATHEMATICAL AXIOM THAT PROVIDES A UNIFIED THEORY OF RESONANCE AND DECAY AND CONNECTS IT TO CAUSAL TIME EVOLUTION

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Abstract. Combining the ideas of causality and the phenomenology of resonances and decaying states, we modify standard quantum theory by changing one of its axioms. The first step was taken decades ago when Dirac kets were given a mathematical meaning as functionals on a Schwartz space, which led to a Gel'fand triplet in which observables were represented by an algebra of continuous operators. The second step, motivated by the analytic continuation to complex energies for the S-matrix and the two Lippmann-Schwinger kets, distinguishes between prepared in-states-vectors and detected out-vectors. This leads to the pair of Gel'fand triplets realized by Hardy functions of the upper (for prepared states) and lower (for detected observables) complex energy plane. Replacing the Hilbert space axiom of quantum mechanics by the Hardy space axiom, one obtains a mathematically consistent theory that unifies resonance and decay phenomena and that has a causal, asymmetric time evolution.

1. Introduction

Time asymmetry is the most prevalent feature of our world. In physics it has not been ignored, but it has been neglected. In quantum physics, it has been unjustly neglected. One usually considers situations that are too idealized, and one investigates problems for which the directedness of time and for which irreversibility do not play a prominent role. An example is classical mechanics, where one deals mostly with conservative forces and treats friction as an addendum.

Quantum mechanics falls into roughly two categories.

I. Spectra and structure of micro-physical systems in stationary states.
It uses the Hilbert space boundary condition for the dynamical equation (Schrödinger or Heisenberg). As a consequence, the dynamical evolution is described by the reversible unitary group evolution.