Title:

Nonhermitian Quantum Optics Studied Using an Analytically Solvable Harmonic Model

Abstract: The goal of the present research project is to study an interaction of atoms with the quantum electromagnetic field within the framework of nonhermitian quantum mechanics (NHQM). NHQM offers an elegant and extremely powerful mathematical formalism for describing phenomena involving metastable atomic states (which possess a finite lifetime due to spontaneous emission), such as e.g. photon-atom scattering. More specifically, within the present research we take a model harmonic oscillator ("harmonic atom") coupled to a quantum electromagnetic field, and bring NHQM into the game by applying the complex scaling transformation on the photonic momenta. Subsequently, we aim at resolving analytically the associated quantum dynamics, via converting our nonhermitian Hamiltonian into a separable normal mode form. An explicit construction of such nonhermitian normal modes represents the most challenging and most important hard core topic of this project, as well as a conceptually novel contribution to NHQM per se. Everything is done analytically, without the need of any numerical calculations and without the use of perturbation theory. The nonhermitian normal modes, constructed successfully within this project in a systematic and self contained manner, enable us to study a large variety of highly relevant physics phenomena, such as: light induced quantum dynamics, Caldeira-Leggett theory of quantum dissipation, quantum theory of dampened oscillators or the theory of quantum thermodynamics. Selected subset of such physical applications will be elaborated on explicitly in a forthcoming MSc. thesis which is intended to be composed as a direct continuation of this project.