Composite particles and non-Hermitian Hamiltonians

Aurélia Chenu

Department of Physics and Materials Science, University of Luxembourg, 1511 Luxembourg, G.D. Luxembourg

In the first part, I will present some recent research using the composite particle formalism developed by Monique Combescot. First, I will present the Shiva diagrams, and how to find signatures of composite bosons in the interference pattern of atomic dimer condensate [1]. Then, I shall detail the physics of photons strongly coupled to the excitonic excitations of a coupled quantum well, in the presence of an electric field [2]. We show how, under a field increase, the hybrid polariton made of a photon coupled to hybrid carriers lying in the two wells transforms into a dipolariton made of a photon coupled to direct and indirect excitons. We also show how the cavity photon lifetime and the coherence time of the carrier wave vectors that we analytically handle through non-hermitian Hamiltonians affect these polaritonic states. While the hybrid polaritons display a spectral singularity where the eigenvalues coalesce, known as an exceptional point, that depends on detuning and lifetimes, we find that the three dipolaritonic states display an anticrossing without exceptional point due to the interaction between photons, direct, and indirect excitons.

In the second part, I shall focus on dynamical control schemes that extend the formalism of shortcuts to any arbitrary dynamics [3]. This is possible by using non-Hermitian Hamiltonians. I will show applications for the fast thermalization of a harmonic oscillator [4], and a scheme to generate squeezed thermal states [5].

[1] S. Shiau, A. Chenu, and M. Combescot NJP 21:043041 (2019)
[2] A. Chenu et al., PRB 105, 035301 (2022)
[3] S. Alipour, A. Chenu, A. Rezakhani, A. del Campo Quantum 4:336 (2020)
[4] L. Dupays, I. Egusquiza, A. del Campo, A. Chenu, PRR 2 :033178 (2020)
[5] L. Dupays and A. Chenu, Quantum 5:449 (2021)