Optical Quantum Process Tomography in Warm Atomic Vapors

M. Kopciuch[1,2], **A. Miranowicz**[1]

[1] *Institute of Spintronics and Quantum Information, Faculty of Physics and Astronomy, Adam Mickiewicz University, 61-614 Poznań, Poland*

[2] *Marian Smoluchowski Institute of Physics, Jagiellonian University in Kraków, 30-348 Kraków, Poland*

In this work, we highlight these limitations through the study of an open atomic ensemble with two hyperfine levels (F = 1 and F = 0). Using the effective operator method, we compare the eigenvalue spectra obtained from a non-Hermitian Hamiltonian to those derived from the full Liouvillian superoperator. This comparison allows us to investigate both Hamiltonian and Liouvillian exceptional points, as well as diabolical points.

We find that, for atomic systems, non-Hermitian Hamiltonians alone are often insufficient to fully reproduce the system's spectral characteristics. While NHHs can provide accurate predictions under certain conditions, a complete description typically requires the Liouvillian formalism, which governs the Lindblad master equation and explicitly accounts for quantum jumps. Including quantum jumps can qualitatively change spectral behavior: we identify cases where the existence, location, or order of spectral degeneracies differ markedly between the two approaches, illustrating scenarios where the NHH framework fails.