Contribution ID: **71**

Type: **Invited**

Tracking correlations in the Optical Bloch Equations: Dynamics, Energetics

Tuesday 3 June 2025 14:45 (30 minutes)

Optical Bloch Equations (OBEs) describe the dynamics of atoms that are classically driven on the one hand and coupled to thermal baths on the other, situations ubiquitous in quantum optics, quantum thermodynamics and quantum technologies. OBEs have given rise to consistent thermodynamic analyses, where work (heat) flows from the drive (the bath), yet, in these descriptions, the role played by the correlations between the atom and the field has remained elusive.

At the fundamental level, the OBEs can be derived from the Hamiltonian evolution of closed and isolated emitter-field systems captured by a Collision Model (CM), where the fields encompass both drives and baths. In Ref. ["Tracking light-matter correlations in the Optical Bloch Equations: Dynamics, Energetics", S.P. Prasad, M. Maffei, P.A. Camati, C. Elouard, A. Auffèves, arXiv:2404.09648], we used the CM description to explicitly keep track of the atom-field correlations formed during single collisions and exploit this model to shed new light on the energy exchanges between atom and field.
From a dynamical viewpoint, our model yields a splitting between effective Hamiltonian processes and correlating processes in the dynamical equations respectively ruling the atom and the field evolutions. On the atom side, we single out a self-driving term proportional to the atom coherences in the energy basis. On the field side, we show that Hamiltonian and correlating processes leave their respective imprints on the field amplitude and fluctuations, which can be measured through dyne or spectroscopic measurements.

We then define work-like (heat-like) flows as the energy changes stemming from the effective Hamiltonian processes (the correlating processes). This novel sorting gives a tighter expression of the second law, an effect that we quantitatively relate to the extra knowledge acquired on the field state and that could lead to better energy management at fundamental scales.

Theme

Primary author: MAFFEI, Maria (Dipartimento di Fisica, Universita di Bari)

Presenter: MAFFEI, Maria (Dipartimento di Fisica, Universita di Bari)

Track Classification: Theme 1. Energy advantage and cost of quantum technology