Analysis of spin-squeezing generation in cavity-coupled atomic ensembles with continuous measurements

Gianluca Bertaina
A. Caprotti, M. Barbiero, M. G. Tarallo, M. G. Genoni

Istituto Nazionale di Ricerca Metrologica, Strada delle Cacce, 91, Torino 10135, Italy
University of Vienna, Faculty of Physics, Vienna Center for Quantum Science and Technology, Boltzmanngasse 5, 1090 Vienna, Austria
Dipartimento di Fisica "Aldo Pontremoli", Università degli Studi di Milano, via Celoria 16, I-20133 Milano, Italy

g.bertaina@inrim.it

The Standard Quantum Limit of atomic clocks can be surpassed by introducing quantum correlations. Our theoretical work focuses on the generation of spin-squeezed states by coupling three-level atoms to an optical cavity and continuously measuring the cavity transmission in order to monitor the evolution of the atomic ensemble [1]. We perform microscopic simulations of the full conditional dynamics, and show that one can achieve significant squeezing even without the continuous feedback that is proposed in previous approaches [2]. We characterise the different regimes for spin squeezing generation and describe its scaling dependence on the atomic ensemble size, even when the adiabatic removal of the cavity field is not feasible [3].

References

[1] A. Caprotti, M. Barbiero, M. G. Tarallo, M. G. Genoni, G. Bertaina, in preparation
[2] L. K. Thomsen, S. Mancini, and H. M. Wiseman, Phys. Rev. A 65, (2002) 061801
[3] Z. Li, B. Braverman, S. Colombo, C. Shu, A. Kawasaki, A. F. Adiyatullin, E. Pedrozo-Peñafiel, E. Mendez, and V. Vuletić, PRX Quantum 3, (2022) 020308

Figures

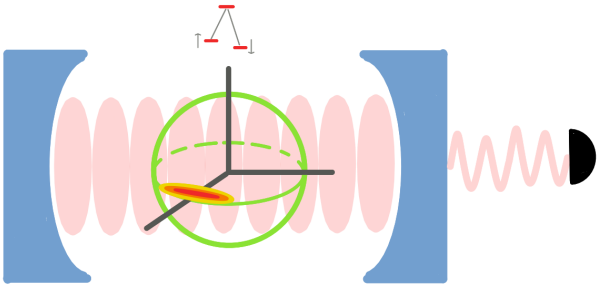

Figure 1: Schema of the modelled system.

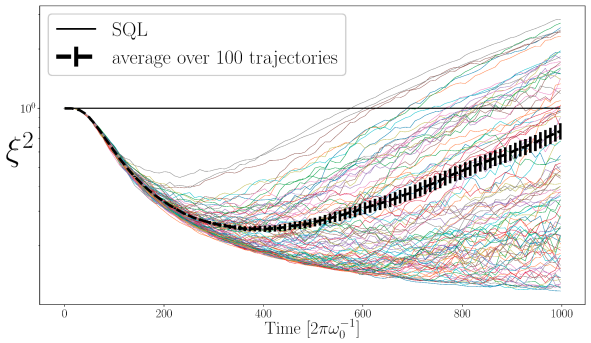

Figure 2: Spin squeezing parameter for an ensemble of trajectories conditioned on measurement of the transmitted light, and its average