Quantum feedback and adaptive measurements with atoms and cavities

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Résumé

In classical feedback loops, the sensor measures the system's state, the controller estimates the distance to the set-point and programs the actuator. In the quantum realm, the set-point is a quantum state. The measurement is performed by quantum sensors. The controller, a classical device, estimates the system's state and programs the actuator, which is either classical or quantum. Quantum feedback must face a fundamental difficulty with the back-action of the sensor's measurements.
We have realized a quantum feedback loop [1,2]. Photon-number states are prepared in a superconducting millimeter-wave cavity and protected against decoherence in the steady state. The sensors are circular Rydberg atoms extracting information about the photon number by a Quantum Non Demolition process involving the measurement of the quantized atomic light-shifts by a Ramsey interferometer. The actuator is either a classical source or atoms adding or subtracting individual photons during their resonant interaction with the cavity

Merely accumulating information provided by the sensor atoms leads to a projective QND measurement of the photon number [3]. The number of atoms required to complete the measurement is much larger than the minimum set by information theory. It is in principle possible to reach this minimum by adjusting the measurement parameters for each atom [4]. We have realized a first step in this direction and realized a fast adaptive QND measurement by setting in real time the phase of the Ramsey interferometer [5].

References

C. Sayrin et al, Nature(London) **477**, 73 (2011)

X. Zhou et al, Phys. Rev. Lett. **108**, 243602 (2012)

C. Guerlin et al, Nature(London) **448**, 889 (2007)

S. Haroche and J.M. Raimond, Exploring the Quantum, OUP (2006)

B. Peaudecerf et al, in preparation

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