Maximizing information obtainable by quantum sensors with the Quantum Zeno Effect.

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Abstract. A quantum sensor is a device to obtain information about its environment at the molecular or nanometric scales. We consider a 1/2-spin as a magnetic field sensor, subjected to periodic projective measurements. Coherent evolution of the quantum sensor, combined with projective measurements; induce an exponential decay. We demonstrate with quantum information theory that when an off-resonance alternating magnetic field is probed, the projective evolution magnifies information on the magnetic field's strength. We define the parameter regimes where this inference protocol outperforms the free evolution of the sensor. We show applications of the method for determining molecular structures with quantum sensors.

Keywords: Quantum Technologies, Quantum Sensing, Quantum Zeno Effect.

Quantum estimation theory can be exploited to use quantum systems as measurement devices. We have recently demonstrated that proper quantum dynamical control on a quantum sensor makes the estimation of the parameters that characterize its environment more efficient [1]. Projective measurements serve as a control tool, which turns a coherent oscillating evolution into an exponential decaying evolution, where the information of the coherent field is then codified into the decay rate, instead of the oscillation frequency. We demonstrate that when an alternating magnetic field is off-resonance with the sensor (Fig. 1), the projective evolution magnifies the information on the magnetic field's strength. Figure 1 compares the parameter regimes where projective evolution outperforms the free-coherent evolution of the sensor[2].

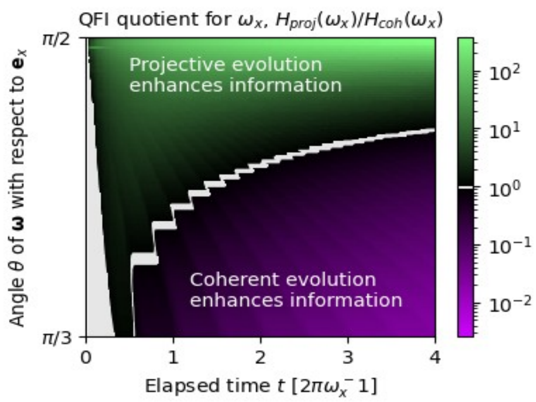

Figure *1* Ratio of the Quantum Fisher Information of an alternating magnetic field ω_x for the projective evolution and the coherent evolution. If the sensor is far from a resonance condition, i.e., large values of the offset ω_z, the exponential (incoherent) decay maximizes the magnetic field information and outperforms free evolution estimation inference process.

References

[1] A. Zwick, G. A. Álvarez, and G. Kurizki, Phys. Rev. Applied 5, 014007 (2016).
[2] B. Ronchi, A. Zwick and G. A. Álvarez, Maximizing information obtainable by quantum sensors with the Quantum Zeno Effect. In preparation.