SQUID detection scheme: Towards quantum-limited detection

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One of the most recent detection techniques highly sensible to the position of a mechanical resonator is the SQUID detection, when one of the arms of a SQUID loop is suspended, and the position is detected by the variation of magnetic flux through the loop [1]. First, we will show that even in the classical case the SQUID detector creates back-action which modifies the frequency and the quality factor of the resonator. This back-action effect has been observed experimentally. Then, we will turn to the discussion of quantum-limited detection. The coupling between the mechanical resonator and the SQUID is typically weak, and this is why the shift of quantized levels of the SQUID (qubit) due to this coupling is of the second order and is too small to be measured. Typically, the plasma frequency of the SQUID is several orders of magnitude higher than the frequency of the resonator. However, the plasma frequency is tunable by the bias current and external magnetic field. If the two frequencies are brought to the degeneracy point by magnetic flux, they exhibit an avoided crossing as a function of the bias current. The value of the level splitting is of the first order in the coupling [2], and the observation of this avoided crossing can serve as a proof of quantum nature of mechanical oscillations. Then we will discuss a phenomenon of phonon blockade. If a non-linear oscillator is coupled to an optical or microwave cavity, it can only absorb one photon from the cavity since its quantum energy level are not equidistant. We will present the results on the dynamics of photon occupation number for the Kerr Hamiltonian, based on the solution of the Lindblad equation [3].

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[2] S. Pugnetti, Ya. M. Blanter, and R. Fazio, SQUID Detection of Quantized Mechanical Motion, arXiv:0910.3900 (accepted for publication in Europhysics Letters).
[3] N. Didier, S. Pugnetti, Ya. M. Blanter, and R. Fazio, Detecting phonon blockade with photons, arXiv:1007.4714.