CFEL SCIENCE

SEMINAR

20th February 2012 - 14:30

FLASH HALL (28c) - Seminar Room

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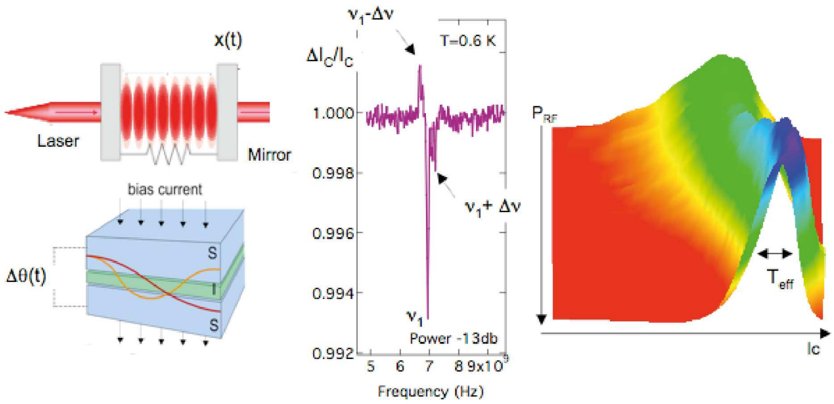
MICROWAVE COOLING OF THE JOSEPHSON PHASE

The "friction of light" has been used for cooling atoms, ions and recently mechanical oscillators.Indeed, the radiation pressure in a Fabry-Perrot interferometer in which one of its two mirrors vibrates can reduce the Brownian motion of the vibrating mirror and hence its effective temperature. This is because the radiation pressure on the mirror depends on its position so that the mirror motion and the field in the cavity are dynamically coupled. Negative and positive detuning lead to higher and lower damping of the mirror oscillations, respectively. As a consequence detuning acts on the mirror amplitude oscillations. Surprisingly, increasing the optical power introduced in the cavity can substantially "cool" or "heat" its vibrating mirror. Although less intuitive the phase difference of the wavefunctions of two weakly coupled superconductors is also a macroscopic degree of freedom. When coupled with a high quality cavity, the oscillations of the Josephson phase produce sidebands in the cavity modes (Fig.b). Vice versa, the intracavity field (Fig.a) in return acts on the phase dynamics as the radiation pressure does on a vibrating mirror. Therefore, negative or positive detuning lowers or increases the phase effective temperature, respectively (Fig.c). In our experiments the phase effective temperature is obtained directly by measuring the width of the distribution of the junction critical current. As shown in Fig.c the width of the histograms is reduced, and hence the phase temperature by increasing the microwave power in the negative sideband.



a) b) c)

J. Hammer, M. Aprili, and I. Petkovic Phys. Rev. Lett. **107**, 017001 (2011)

Figure. Sideband cooling of the Josephson phase associated to an extended Josephson junction which supports electromagnetic cavity modes in the insulating barrier. a) Artistic view of the junction and of a Fabry-Perot interferometer. b) The relative change in the switching current Is was measured as a function of the externally imposed microwave frequency around the first cavity mode. This cavity spectroscopy shows sidebands. c) Shrinking of the switching histograms with increasing microwave power at negative sideband. Narrower histograms reveal the induced cooling, T_{eff}, of the Josephson phase through anti-Stokes scattering of the microwave photons.

Host: A. Cavalleri, MPSD-CFEL