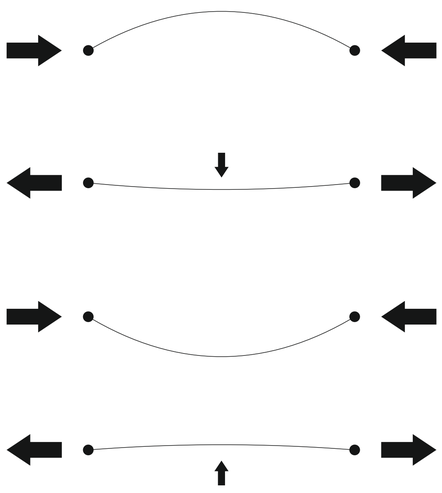
Physics Lab 3+4

Parametric Resonance

**This table-top experiment is a copy of a setup that was used to study highly nonlinear parametric physics [PRL, 117, 214101 (2016)].
It serves to illustrate the fundamental parametric aspect of many projects at ETH, some of which are shown below.**

What is parametric resonance?



for an introduction, see:
M. C. Lifshitz and R. Cross
Nonlinear dynamics of nanomechanical and micromechanical resonators
in Reviews of Nonlinear Dynamics and Complexity (Wiley-VCH, 2009)

• What is a parametric resonator?

When the potential term (e.g. the spring constant) of any resonator is modulated at about twice the resonance frequency itself, oscillations are amplified or damped depending on their phase relative to the modulation. If the modulation is strong enough, the resonator experiences negative linear damping and is forced to undergo large oscillations.

• How is this implemented in our experiment?

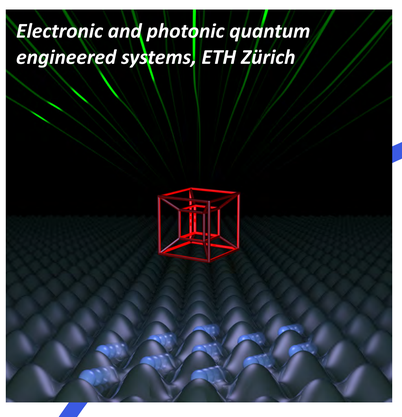
The parametric guitar is parametrically driven through modulations of the tension along the string. The modulation is controlled with an electromagnetic motor that acts on one clamping point.

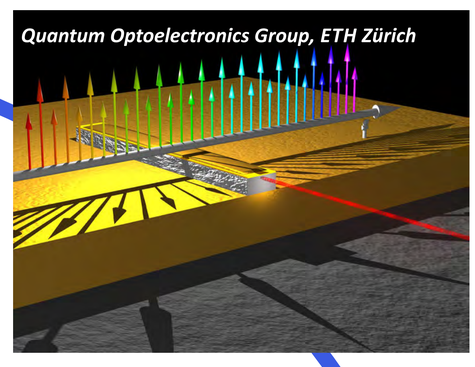
• What does this have to do with anything?

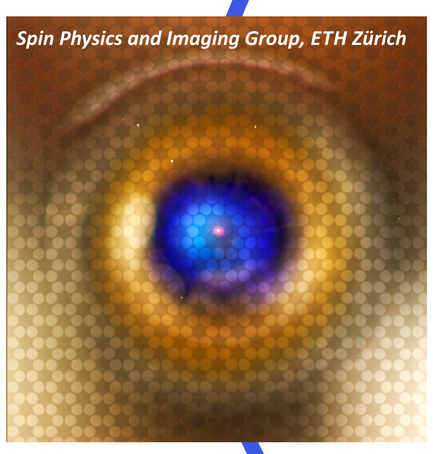
Parametric resonators play an important role in many aspects of physics research and quantum technology. Applications range from quantum computers, electrical amplifiers and quantum cryptography to ultrasensitive detectors for nanoscale magnetic resonance microscopy and to thermoacoustic phenomena in power combustion engines and rockets.

Lock-in amplifier

This experiment uses a highly sensitive lock-in amplifier from Zurich Instruments, the MFLI. Lock-in amplifiers are very useful in experimental physics because they allow differentiating small signal from large noise backgrounds. This is achieved by mixing (multiplying) the signal with a local oscillator and by keeping only the part that has exactly the correct periodicity.

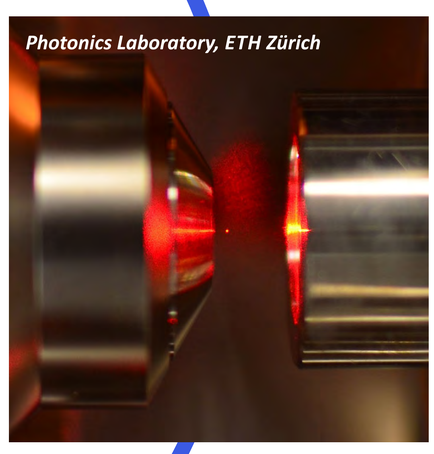


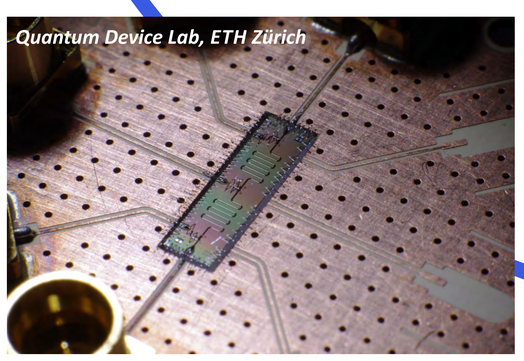


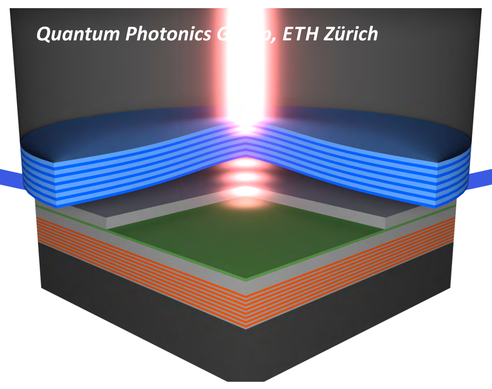


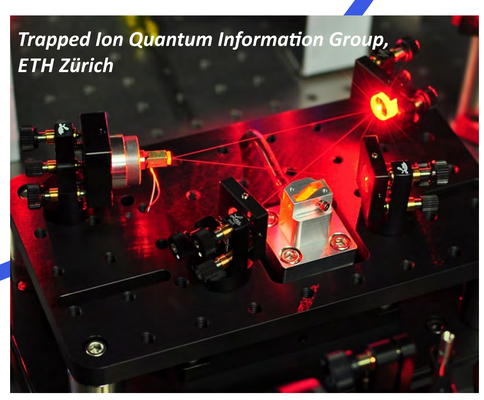
Parametric Phenomena

appear in a wide variety of systems and are being used for a plethora of applications, such as driving of resonators, signal amplification, noise squeezing, frequency conversion, or coupling of diverse degrees of freedoms.









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