to the team, even weak light emissions from typical organic dyes – which cannot compensate for the absorption of the waveguide – can be used to control the group velocity of the optical signal from ultraslow to beyond the speed of light.

[3] Phys. Rev. Lett. **97**, 223902 (2006)

Blue laser regulates 'super-accurate' atomic clock

Boulder (USA) – Time and frequency standards have many applications. For instance, ultra-precise clocks can improve synchronization in navigation and positioning systems, telecommunications networks, and wireless and deep-space communications. Better frequency standards can be used to further improve probes of magnetic and gravitational fields for security and medical applications, and to measure whether "fundamental constants" used in scientific research might be varying over time – a question that has enormous implications for understanding the origins and ultimate fate of the universe. Using a highly stable blue laser to manipulate strontium atoms trapped in an optical lattice, scientists at JILA, a joint institution of the US National Institute of Standards and Technology (NIST) and the University of Colorado at Boulder, have produced the most precise "ticks" ever recorded in an optical atomic clock [4]. Although the new strontium clock currently is less accurate overall than NIST's mercury ion clock, it is among the best optical atomic clocks described to date in the published literature. And because it produces much stronger signals, its "resonant" frequency was measured with higher resolution than in the mercury clock. The strontium lattice may have applications in precision measurements of high frequencies and quantum computing. JILA scientists described their clock design as a candidate for next-generation atomic clocks operating at optical frequencies, which divide time into much smaller and more precise units than the microwaves used in today's standard atomic clocks.

[4] Science **314,** 1430 (2006)

Laser cooling of a micromechanical oscillator

Garching (Germany) – A team at the Max Planck Institute of Quantum Optics (MPQ) has recently succeeded in cooling a micromechanical oscillator consisting of more than 10^{14} molecules from room temperature down to 11 Kelvin. The novel method reported in [5] is related to a laser cooling technique that is widely used in atomic physics. The experiment demonstrated unambiguously that the temperature reduction was purely caused by the radiation pressure of the photons. With this new method it could become possible to reach the quantum mechanical ground state of the system where its eigen-oscillations are reduced to the fundamental quantum mechanical limit. The method could also be used to enhance the performance of atomic force microscopes where thermally driven cantilever vibrations reduce sensitivity.

In the experiment a lithographically fabricated, chip based toroidal microcavity with a diameter of 50 micrometer is used (see Figure). It behaves like a microscale tuning fork with a mechanical resonance frequency of 60 MHz. A 600 nm thin glass fiber feeds laser light into the cavity. The light is "red-detuned", i.e., its frequency is adjusted to slightly below the resonance frequency. The photons are trapped in the cavity and undergo many reflections. Since they strive to be in resonance with the system, they absorb energy when they collide with the wall most of the time. Thus the resonator's energy – and its temperature – is reduced. From the experimental results and their comparison to analytical model predictions the scientists were able to conclude that the cooling is caused by radiation pressure alone, thermal effects contributing less than 1%. While the resonator temperature of the resonator is still far above the temperature of its quantum mechanical ground state temperature, which corresponds to 3 mK, the merit of the experiment lies in being able to quantitatively asses this new cooling mechanism and to compare it to the theoretical predictions. Moreover, the demonstrated cooling technique could allow in combination with standard cryogenic cooling procedures to achieve here-to unattainable temperature regimes, for example to cooling oscillators to their ground state, thus crossing the border to a regime where macroscopic objects behave as in quantum mechanics.

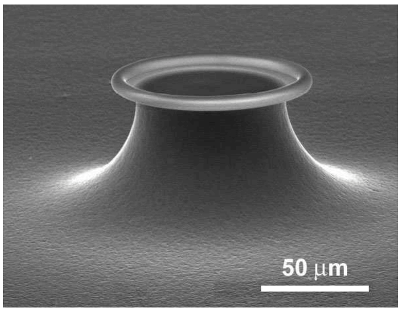

Figure: Scanning electron image of a micromechanical resonator consisting of a toridal microcavity on a chip. Cooling of the radial breathing mode of the resonator to 11K is achieved via cavity-enhanced radiation pressure. (copyright 2006, MPQ, Garching)

[5] Phys. Rev. Lett. **97**, 243905 (2006)

For more information visit:
www.mpq.mpg.de

Tea leaf reading in quantum noise

Free fermion anti-bunching with non-interacting atoms released from an optical lattice

Mainz (Germany) – A fundamental effect of quantum physics has been demonstrated for the first time to gain insight from random noise patterns