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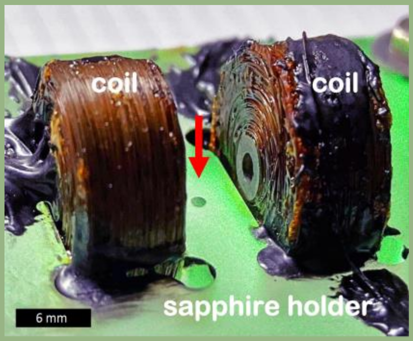
Levitated Particle Meets Inertial Sensor

From theory to experiment, from optics to magnetism... Let's see what the researchers from iQLev have achieved, after three years of exploring the field of inertial sensing based on levitated particles

Magnetically Levitated Accelerometer

Aspelmeyer Group, Uni Wien

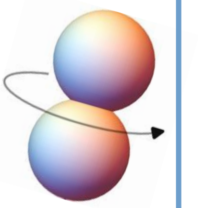
High-performance inertial sensing requires high mass to boost the sensitivity. To increase mass of a trapped particle, Uni Wien developed a platform using magnetic force to levitate superconducting microspheres. The core part of the setup is shown in the picture on the right, where two coils glued into a sapphire holder. The hole in the middle (indicated by the red arrow) between the coils is the bowl where the particle gets trapped by magnetic gradient force.



This magnetic levitation setup demonstrates the remarkable properties of levitated micro-spheres for highly precision acceleration sensing. To optimize performance crucial factors are accordingly: low temperatures at a cryogenic temperature of 15mK (which is about -273 °C), low particle's oscillation frequencies around 210 Hz, a relatively large mass, as compared to optical levitation for instance, of 5 µg, as well as ultra-low damping (implying a high quality factor of approximately 30 million). Magnetic traps are exceptional in all of these parameters. In the end, the device's thermal resolution limit is then $a_{min} = 9 \cdot 10^{-12} \mathrm{g}/\sqrt{\mathrm{Hz}}$. For comparison commercial MEMS typically reach $10^{-5} \mathrm{g}/\sqrt{\mathrm{Hz}}$, micromagnetical levitators have reported sensitivities as low as $3 \cdot 10^{-8} \mathrm{g}/\sqrt{\mathrm{Hz}}$.

Let's Rotate !

Photonics Laboratory, ETH Zurich



Two architectures of gyroscopes using optically levitated nanoparticles are demonstrated by ETH Zurich.

The first, a vibratory gyro-gyro-scope, is based on amplitude transfer between two translational degrees of freedom. The rotation detection sensitivity of this gyroscope reaches $0.2\ \mathrm{rad/s}/\sqrt{\mathrm{Hz}}$. The second gyroscope is based on a levitated spinning anisotropic nano-particle. The extremely high rotational speeds (reaching several GHz) helps boost the rotation detection sensitivity.

Moreover, the ETH Zurich team have introduced new tools for controlling the rotational degrees of freedom of optically levitated objects.

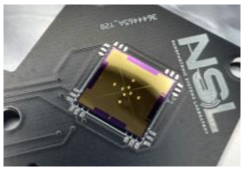
Towards Quantum

Romero-Isart Group, Uni Innsbruck

The team at the University of Innsbruck focused on the theoretical perspective to explore new exciting opportunities for high-performance inertial sensing using quantum (e.g. squeezed) states of mechanical degrees of freedom. They are also building a theoretical toolbox to model quantum dynamics of largely squeezed quantum states and their optimization.

Levitation on Chip

Nanophotonic Systems Laboratory ETH Zurich



To have a a compact and robust trapping platform for acceleration sensing, the team from ETH Zurich developed a hybrid chip combining optical and electrostatic trapping potentials. With trapped 415 nm particles at 10^{-6} mbar, the current platform can reach an acceleration sensitivity of the order of 50 $\mu\mathrm{g}/\sqrt{\mathrm{Hz}}$.

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