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Optical Atomic Clocks: A Quantum Leap in Precision Timing

Driving the next generation of portable atomic clocks using nanotechnology and microcombs

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Every time you use sat-nav or high-speed broadband, you are relying on the precision of ticking of atoms. Since their invention in the 1950's, atomic clocks, also known as quantum clocks, have been used in an ever-increasing range of applications as the demands of technology increase. These range from the clocks in GPS satellites, earthquake detection, global trading in stocks, and maintaining the stability of the national electrical grid.

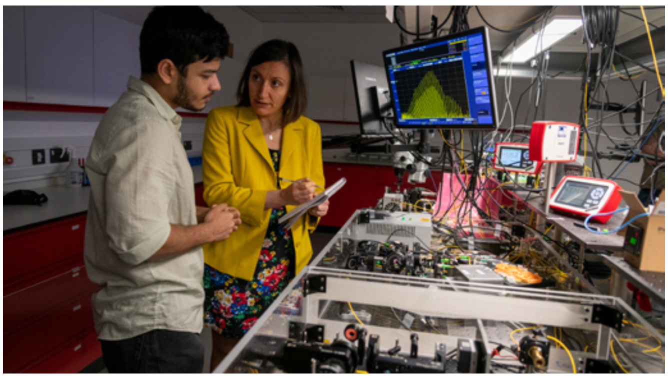
Even more advanced optical clocks could one day make a significant difference both in everyday life and in fundamental science. Optical atomic clocks tick over one hundred trillion times per second and can be thousands of times more accurate than existing microwave clocks.

Currently, such optical atomic clocks are massive devices – weighing hundreds of kilograms – which need to be housed within specialised laboratory conditions.

Researchers at Loughborough University's Emergent Photonics Research Centre and the Experimental Quantum Optics & Photonics group at the University of Strathclyde are developing the next generation of timing devices with the ambition to make these devices more compact, portable and lower cost than traditional clocks.

Loughborough researchers are developing micro-lasers known as microcombs, which serve as the 'counter' for future portable atomic clocks. Based on electronic compatible optical microchips, microcombs are the best candidates to miniaturise the next generation of ultraprecise timekeeping. Microcombs are cutting-edge laser technology sources, made up of ultraprecise and evenly spaced laser frequencies that resemble the teeth of a comb, and are crucial for optical timekeeping.

Strathclyde researchers will focus on the miniaturisation of the core part of the clock, the time reference, which consist of an ultraprecise atomic transition oscillating at optical frequency. Targeting a robust system that can operate in realistic environments, they will develop a high performance thermal optical clock. A key element will be the development of a novel, compact, ultra-low noise hybrid laser system to manage the atomic states.



KEY BENEFITS

- A portable and ultra-accurate time clock is critically needed for the current and next generation of telecommunication (5 and 6G+ and fibre communication), network synchronization and will reduce dependence on GPS.
- Microcombs are an ultra-precise link between optical and microwave frequency ranges. They will allow transferring the precise reference of time to fibre links, which use many different colours to transfer as much information as possible, or to microwave radiation, revolutionising the telecommunication networks.
- Develop reduced size, weight, power & cost practical optical clocks that will operate robustly in realistic environments.

APPLICATIONS

- Navigation – improving GPS measurements and improving autonomous vehicle navigation
- Geodesy – improving measurements of the Earth's shape and gravity variations
- Environmental sensing – potential to detect underwater earthquakes and ocean currents
- Communication – synchronizing of high-speed networks

MEET OUR INVESTIGATORS

Alessia Pasquazi, Professor in Loughborough University's Department of Physics, is an expert in nonlinear optics. She has been MELS fellow (Quebec, Canada), EU Marie-Curie Fellow, Ernest Rutherford Fellow and ERC Starting Grant Laureate). Alessia is lead researcher in Loughborough University's Emergent Photonics Research Centre.

Paul Griffin is Professor at the University of Strathclyde's Department of Physics and is part of the part of the Experimental Quantum Optics and Photonics group. He has been awarded fellowships from the Royal Society of Edinburgh and Marie Skłodowska-Curie Actions and has held a Strathclyde Chancellor's Fellowship.

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