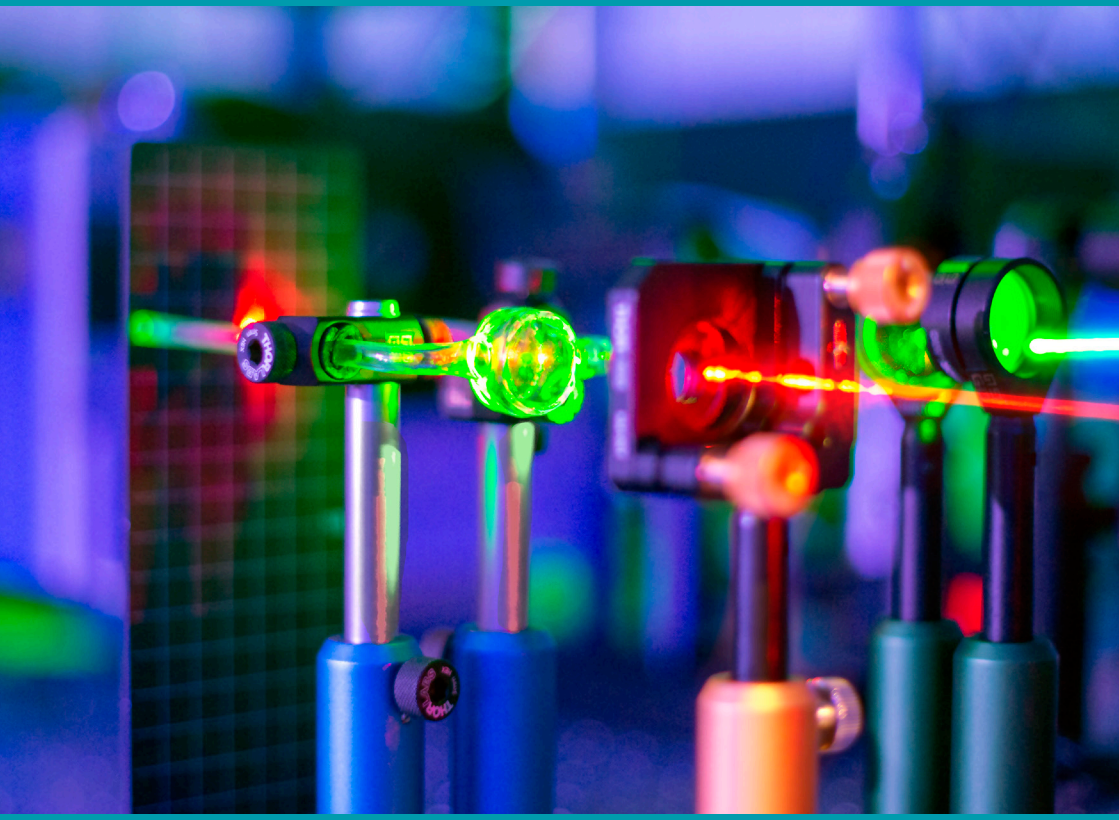
NANOPARTICLE COATINGS FOR ALKALI-METAL VAPOUR CONTAINERS

Boosting applications across a range of quantum optical technologies including quantum computing, ultra-sensitive magnetometry, and precision spectroscopy.



UNIVERSITY OF BATH

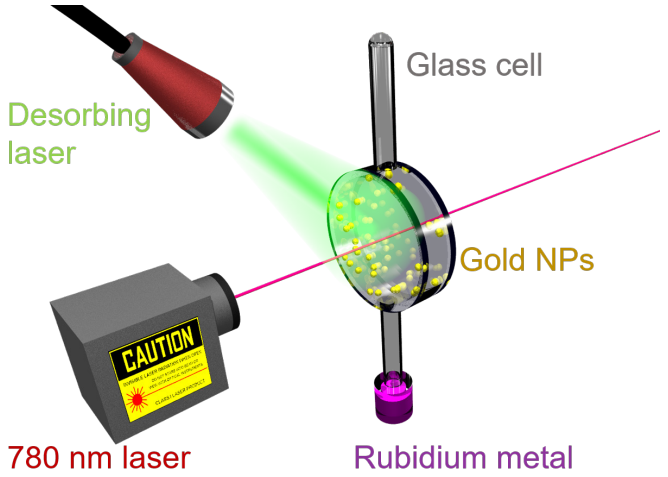
TECHNOLOGY

The University of Bath, UK has patented a technique to stabilise the density of alkali metal vapour in confined geometries using gold nanoparticles (GB2580299A). This nanoparticle coating allows fast and reproducible external control of the vapor density and related optical depth which is crucial for applications in quantum optics including quantum computing, atom cooling and precision measurements[1].

Alkali metal vapours, including lithium, sodium, potassium, rubidium and caesium, allow scientists to access individual electrons, due to the presence of a single electron in the outer 'shell' of alkali metals. This has great potential for a range of applications, including logic operations, storage and sensing in quantum computing, as well as in ultra-precise time measurements with atomic clocks, or in medical diagnostics including cardiograms and encephalograms.

However, a serious technical obstacle has been reliably controlling the pressure of the vapour within an enclosed space, for instance the tube of an optical fibre. The vapour needs to be prevented from sticking to the sides in order to retain its quantum properties, but existing methods to do this, including directly heating vapour containers are slow, costly, and impractical at scale.

Researchers from the University of Bath have developed a cost-effective method of controlling the vapour by coating the interior of containers with gold nanoparticles. When illuminated with green laser light the nanoparticles rapidly absorb and convert the light into heat, warming the vapour and causing it to disperse into the container more than 1,000 times faster than possible with current methods. The process is highly reproducible and the new nanoparticle coating was found to preserve the quantum states of alkali metal atoms that bounce from it.

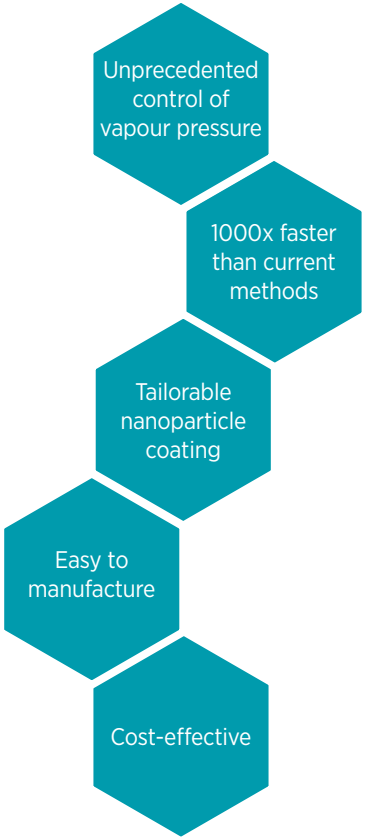


Schematic diagram for controlling atomic vapour pressure without external heating. Gold nanoparticles (NPs) illuminated at the localized surface plasmon frequency heat up the inside of the cell walls.

[1]Rusimova et al, Atomic dispensers for thermoplasmonic control of alkali vapor pressure in quantum optical applications. Nature communications, 2019.

BENEFITS

- Unprecedented control of the atomic vapour density facilitated through quick increase/decrease of the number of atoms in the sensor
- 1,000 times quicker than current industrial methods, such as external heating and even light-induced atomic desorption
- Reduces technological complexity by bypassing current approaches that require bulky external heating setups:
  - → Allows for smaller and lighter sensors
  - → Reduces power consumption
  - → Increases precision by removing undesired magnetic fields caused by heating elements
- Cheap and easy to manufacture
- Nanoparticle coating can be tailored to suit application by tuning particle size, material composition and polymer
- Coating can be applied to any vapour cell shape



COMMERCIAL APPLICATIONS

- Ultra-sensitive magnetometers capable of measuring magnetic fields of human brains used for cardiograms and encephalograms
- Atomic clocks, i.e. highest precision time-keeping devices
- Frequency stabilized high precision lasers, e.g. used for detecting gravitational waves
- Precision spectroscopy
- Atomic traps (some of the largest quantum objects known to man)
- Gates and memories for photonic quantum computers

CONTACT

The University of Bath is looking for partnerships to help develop this technology for a variety of sectors. If you are interested to discover more then please get in contact.

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