Record measurement of extremely small magnetic fields

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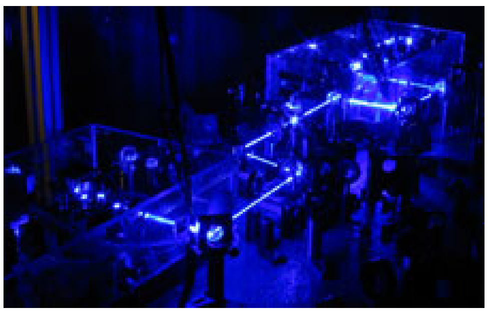

QUANTOP laboratorie with laser light

Researchers at the research center QUANTOP at the Niels Bohr Institute at the University of Copenhagen (Denmark) have constructed an atomic magnetometer, which has achieved the highest sensitivity allowed by quantum mechanics. Sensitive magnetometers could be used to measure electrical activity in the human brain and heart. The results have been published in *Physical Review Letters*.

The ultimate sensitivity of any measurement is determined by the laws of quantum mechanics. These laws, normally most noticeable at the atomic level, become relevant for larger objects as the sensitivity of measurements increase with the development of new technologies.

Atoms as magnetic sensors

Atoms have a fundamental property called spin, which makes the atoms act like small magnets that are sensitive to external magnetic fields and can be used as magnetic sensors. But each of the atomic spins has a quantum uncertainty, which sets the fundamental limit on the smallest external magnetic fields that the atom can sense.

Conventional atomic magnetometers are usually built with a very large number of atoms, because the overall sensitivity of billions of atoms is much greater than that of a single atom. But on the other hand, it is much more difficult to reach the limit of sensitivity given by quantum mechanics.

Ultimate sensitivity

However, researchers at the QUANTOP Center have constructed an atomic magnetometer with the ultimate sensitivity allowed by quantum mechanics.

“Moving towards the goal we had to ensure that our method made it possible to suppress not only sources of technical errors, such as fluctuations in the magnetic field due to public transportation, radio waves and so on, but also to eliminate a number of errors of pure quantum mechanical origin”, explains professor Eugene Polzik, Director of the QUANTOP Center at the Niels Bohr Institute.

From brains to explosives

As a result, the magnetometer can measure in a second a field, which is a hundred billion times weaker than the Earth’s magnetic field.

The magnetometer has a wide range of possible uses, because where there is an electric current, there is also a magnetic field.

Measurements of magnetic fields can reveal information about the electrical activity in the human brain and heart, the chemical identity of certain atoms, for example, explosives, or simply indicate the presence or absence of metal.

The new quantum magnetometer functions at room temperature, which makes it a good alternative to the expensive commercial superconducting magnetometers (the so-called ‘Squids’).

“Our quantum magnetometer functions at room temperature which makes it a good alternative to the expensive commercial superconducting magnometers (the so-called ‘Squids’). It has the same sensitivity with a cheaper and simpler instrument”, explains Eugene Polzik.

More information: Paper: prl.aps.org/abstract/PRL/v104/i13/e133601

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