Redefining the kilogram and the ampere

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New research using graphene presents the most precise measurements of the quantum Hall effect ever made, one of the key steps in the process to redefine two SI units.

Groundbreaking research by the National Physical Laboratory's (NPL) Quantum Detection Group and an international team of collaborators is underpinning the biggest change in the Système Internationale d'unités (SI Units) since the system began 50 years ago.

It has long been the goal of scientists to relate all of the unit definitions to fundamental constants of nature, making them stable and universal, and giving them closer links to each other and the quantities they measure.

Key units to be redefined are the kilogram (mass) and the ampere (electric current). Presently the kilogram is defined by a physical lump of platinum-iridium and the ampere is defined via the force produced between two wires.

The goal is to define the kilogram in terms the Planck constant h and the ampere in terms of the electron charge e.

Making this change relies on the exactness of the relationships that link these constants to measurable quantities.

The quantum Hall effect defines a relationship between these two fundamental physical constants. Experiments are needed to test the quantum Hall effect in different materials in order to prove whether or not it is truly universal.

Until recently the effect was exclusively observed in a few semiconductor materials. A few years ago the quantum Hall effect was also observed by the same team in graphene, a completely different type of material with a very different electronic structure.

This research directly compared the quantum Hall effect in graphene with that observed in a traditional semiconductor material. Graphene is hotly tipped to surpass conventional materials in many important applications, partly due to its extraordinary electrical properties.

The results confirmed that the quantum Hall effect is truly universal with an uncertainty level of 86 parts per trillion, supporting the redefinition of the kilogram and ampere. The quantum Hall effect in graphene is so good that it should be the material of choice for quantum resistance metrology.

The discovery was today highlighted in *Nature* as a leading piece of research.

JT Janssen, NPL Science Fellow and the lead author of the research, said: "Many metrology laboratories around the world have been striving to do this experiment and it is a real achievement that the NPL team and its co-workers were the first to get this key result. It turns out that the quantum Hall effect in graphene is very robust and easy to measure - not bad for a material that was only discovered six years ago."

More information: Read paper in *New Journal of Physics:* iopscience.iop.org/1367-2630/13/9/093026/

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