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Canada assumes weighty mantle

Instrument to help redefine the kilogram makes a transatlantic move.

In the mission to define the kilogram more sensibly, only two of the instruments known as 'watt balances' have proven good enough to tackle the job. And one of them is currently in pieces, having been sold and shipped from the United Kingdom — the birthplace of this type of device — to Canada.

The move has some UK scientists saddened by their loss, and Canadians excited by their gain. It also has metrologists around the world holding their breath. "Taking it all apart, shipping it, putting it back together — the worrisome thing is that something will break," says Richard Steiner, who works with the other top watt balance at the US National Institute for Standards and Technology (NIST) in Gaithersburg, Maryland. "It's very fragile, and a lot of it is pretty old." The Canadian lab expects to receive the package by the end of August.

The kilogram is the only unit of measure still defined by a single object — a lump of platinum-iridium held in a vault near Paris. Over time, as atoms accrete or fall off this particular kilogram, its mass changes. Metrologists are thus aiming to redefine the kilogram on the basis of something more stable — such as Planck's constant, the value that quantifies the relationship between the energy and frequency of light, and which can be related to mass through equations of quantum physics and electromagnetism.

The best way to pin down the value of Planck's constant is with a precision watt balance. Canada's device, which is about the size of a minivan, contains a metre-long balance beam, with a precisely known mass at one end and a 30-centimetre-wide metal coil in a magnetic field at the other. Running a current through the coil creates an electromagnetic force that balances the gravitational force on the other side. Further measurements are made to eliminate hard-to-measure factors and produce a value for Planck's constant.

The watt balance was thought up in 1975 at the National Physical Laboratory (NPL) in Teddington, UK. Ian Robinson, who helped to develop that first instrument and worked with its successor for more than 30 years, disassembled his life's work this summer. More than 500 items, including the 1-tonne magnet, were stowed in some 50 wooden crates to be shipped. Robinson packed the precision coil himself: "If anyone was going to bust it," he says, "it had to be me."

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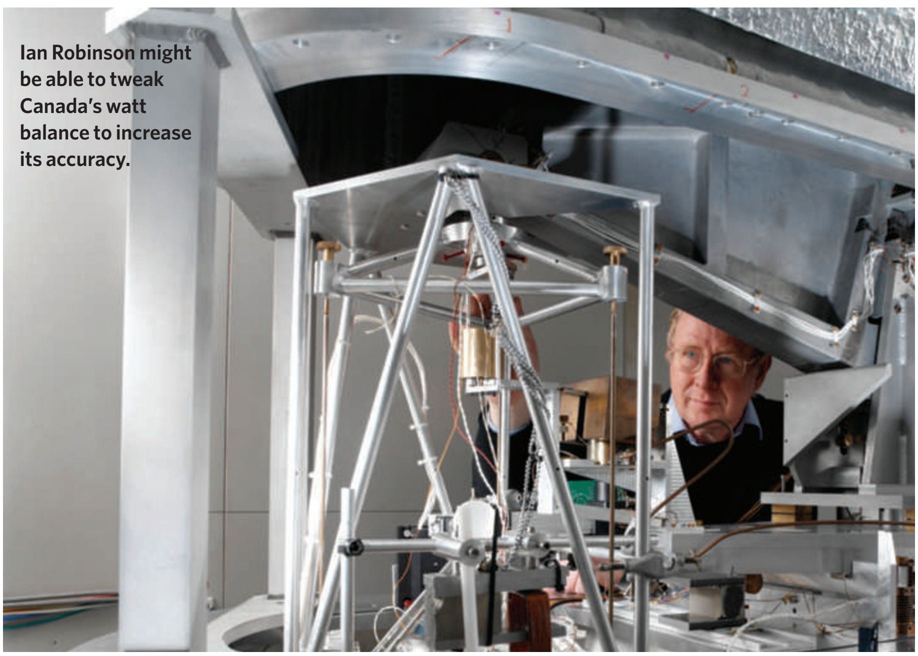
NPL research director Kamal Hossain says they decided to discontinue the watt-balance work because they already had some good results from the device and wanted to focus on more practical areas, such as nanometrology.

"It was a bit of a surprise when the NPL decided to roll this up," says Alan Steele, head of metrology for the Institute for National Measurement Standards in Ottawa, Ontario. The machine will both stretch the metrological science done in the lab and give Canada an entrée into the kilogram scene.



NPL

Ian Robinson might be able to tweak Canada's watt balance to increase its accuracy.

Pursuit of accuracy

Another approach to redefining the kilogram involves more accurately calculating the Avogadro constant — the number of atoms or molecules in one mole of a substance — by determining the number of atoms in a near-perfect silicon sphere. Should the watt-balance project win out, national labs with watt balances will have an advantage in measuring exact masses and maintaining mass standards. Watt balances are being built and tested in Switzerland and France, but have not produced published results to prove their precision.

Thus far, the NIST watt balance and the one from the NPL do not quite agree on the value of Planck's constant. Although each has an uncertainty of tens of parts in a billion, the difference between the two most recently published values is ten times larger than that. The team working on the silicon-sphere approach, meanwhile, say they have data that are in fairly good agreement with NIST's value for Planck's constant, although these have not yet been published. The goal is to iron out discrepancies in time to redefine the kilogram in 2011.

Steele says his team plans to start reassembling the watt balance this October, with Robinson's help. They hope that the Ottawa lab, which is vibration-free and shielded from magnetic interference, will prove an ideal spot for the sensitive instrument. Moving the device should help to create a third, independent, set of data to help pin down Planck's constant, says Steele: "The equipment is so complex, just taking it apart and reassembling it is equivalent to doing a novel experiment." Robinson says he has possibly identified a small flaw in the experiment that he intends to fix once it is reassembled. If that creates agreement with the NIST value, then consensus should be easy.

Robinson, whose work was plagued by magnetic interference from a train line near the NPL, agrees that the Canadian lab is a real improvement. Although he says he is sad not to be able to continue his work in Britain, he adds that the important thing is that someone — anyone — will keep it running: "The main thing is that it doesn't get thrown away." ■

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