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### Physicists show that quantum ignorance is hard to expose

*The quantum world allows you to answer questions correctly when you don't even have all the information you should need*

**Singapore, 31 July 2011** – No-one likes a know-it-all but we expect to be able to catch them out: someone who acts like they know everything but doesn't can always be tripped up with a well-chosen question. Can't they? Not so. New research in quantum physics has shown that a quantum know-it-all could lack information about a subject as a whole, yet answer almost perfectly any question about the subject's parts. The work is published in *Physical Review Letters*.

“This is something conceptually very weird,” says Stephanie Wehner of the Centre for Quantum Technologies at the National University of Singapore, who derived the theoretical result with PhD student Thomas Vidick at the University of California, Berkeley, United States. It's a new phenomenon to add to the list of philosophical conundrums in quantum physics – as strange as the quantum superposition or the quantum uncertainty principle. But the work also has practical motivation: understanding how information behaves in the quantum context is important in emerging technologies such as quantum cryptography and quantum computation.

To frame the problem, consider the example of someone answering questions about a book they have only half-read. If someone has incomplete knowledge about a book as a whole, one expects to be able to identify the source of their ignorance somewhere in the book's pages.

Wehner and Vidick simplify the situation to a book with two pages. They invite the usual quantum players, Alice and Bob, to collaborate. Alice reads the book and is allowed to give Bob one page's worth of information from it.

If Bob only has classical information, it is always possible to work out what he doesn't know. “We show that classically things are, well, sane” says Wehner. In other words, Bob's ignorance can be exposed. Imagine that Bob is a student trying to cheat in an exam, and the notes from Alice cover half the course. An examiner, having secretly inspected Bob's crib notes, could set questions that Bob couldn't answer.

The craziness comes if Bob gets one page's worth of quantum information from Alice. In this case, the researchers show, there is no-way to pinpoint what information Bob is missing. Challenge Bob, and he can guess either page of the book almost perfectly. An examiner could not expose Bob's ignorance even having seen his notes as long as the questions cover no more than half the course – the total amount of information Bob can recount cannot exceed the size of his notes.

It is an unexpected discovery. Researchers had been trying to prove that quantum ignorance would follow classical intuition and be traceable to ignorance of details, and finding that it isn't raises new questions. "We have observed this effect but we don't really understand where it comes from," says Wehner. An intuitive understanding may be forever out of reach, just as other effects in quantum theory defy mechanistic description. However, Wehner and Vidick have begun to design experimental tests and are already formulating a range of ways to explore this strange new frontier. In this work, they devised a means of encoding the quantum information from two pages into one that gave Bob, the quantum know-it-all, the ability to recount all but one bit of the information on either page (the last bit Bob would have to guess). They plan to test whether other encodings would be equally good.

**Journal reference:** T. Vidick and S. Wehner, "Does Ignorance of the Whole Imply Ignorance of the Parts? Large Violations of Noncontextuality in Quantum Theory", *Physical Review Letters* **107**, 030402 (2011); <http://prl.aps.org/abstract/PRL/v107/i3/e030402>. A free preprint is available at <http://arxiv.org/abs/1011.6448>.

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**Centre for Quantum Technologies at the National University of Singapore**

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