Measuring quantum dimensions

June 18 2012

(Phys.org) -- A new study from the ICFO (Institute of Photonic Sciences) in Barcelona and the University of Bristol has demonstrated how the dimension of an unknown quantum system can be assessed from measurement data alone. The research is published today in *Nature Physics*.

In order to study a physical system, scientists usually assume it has a particular dimension. The theoretical models they use to describe experimental observations on such a system thus make an assumption about the dimensionality of the system under consideration.

Dr Martin Hendrych from ICFO and colleagues wanted to discover whether such an assumption about dimension is unavoidable or whether it is possible to experimentally estimate the dimension of a completely unknown system.

Dr Nicolas Brunner in Bristol's School of Physics, co-author of the research said: "We prepared photons in quantum states of various dimensions using both polarization and orbital angular momentum degrees of freedom. The photons were then subjected to several possible measurements.

"We then attempted to estimate the dimension of the photons using only the measurement statistics, that is, from the frequencies of obtaining certain measurement outcomes. This is done via a 'dimension witness', a mathematical tool designed to assess the dimension of an unknown system given measurement data only."

The researchers demonstrated another relevant feature of dimension witnesses, namely the ability to certify the quantum nature of a system while assuming knowledge about its dimension. This observation can be considered a novel situation in which quantum systems outperform classical ones.

Dr Brunner continued: “Remarkably, this 'quantum advantage' could prove to be extremely useful, in particular for information processing. Recent proposals have suggested novel approaches to cryptography and generating random numbers based on the concept of dimension witnesses.

“More generally, our work is likely to have profound implications for quantum information science, where the dimension represents a powerful resource.”

The work also represents one of the first demonstrations of device-independent quantum information which aims at characterising unknown quantum systems without making any assumptions on the measuring device used in the protocol.

Dr Hendrych and colleagues have demonstrated how the device-independent approach can be employed to experimentally estimate the dimension of an unknown system. In the future this may find important applications in the fields of quantum information and quantum technologies, where the estimation of quantum systems is a central task.

More information: ‘Experimental estimation of the dimension of classical and quantum systems’ by Martin Hendrych, Rodrigo Gallego, Michal Mičuda, Nicolas Brunner, Antonion Acín and Juan P. Torres in *Nature Physics*. www.nature.com/nphys/journal/v … /full/nphys2334.html

Provided by University of Bristol