# Using quantum smoothing for optical phase estimation

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(PhysOrg.com) -- "There are many situations where we need to measure the classical properties of a quantum system," Elanor Huntington tells *PhysOrg.com*. "Optical phase estimation is one of these techniques, and it is central to applications where quantum beams of light are used, such as for gravitational wave detectors, quantum computing and quantum key distribution. Greater precision in measurements is important in this area, and that is what we have been working on."

Huntington is a scientist at the University of New South Wales in Australia, as well as at the Centre for Quantum Computer Technology. She is part of a collaboration involving scientists from around the world, including the University of Tokyo; University of Waterloo and the Perimeter Institute (both in Canada); and the University of Queensland and Griffith University (both also in Australia). The group demonstrated the technique of quantum smoothing for use in quantum parameter estimation. Their results appear in *Physical Review Letters*: “Adaptive Optical Phase Estimation Using Time-Symmetric Quantum Smoothing.”

It is very difficult in practice to pinpoint the parameters seen in quantum systems. As a result, estimations are often used. In order to increase the precision of the estimates for a quantum beam of light in a coherent state, Huntington and her colleagues used a new data processing technique called quantum smoothing to enhance the precision of the parameter estimates.

“About six months ago, Mankei Tsang proposed quantum smoothing as a way to process the data received," Huntington explains. "Our collaboration offers the first experimental demonstration that this technique works. The nice thing about it is that you don't have to change the measurement device you are using. Instead, you change the way you process the data afterward.

"Normally, one would build a measuring device, and then process data to get the best possible estimates of parameter within the desired amount of time. This is good for real-time measurements, but if you care more about precision, you could do better," Huntington continues. "With quantum smoothing, you use data collected by the device both before and after the time period in question. You use data from times in the future, so that you have more data to look at, providing a more complete picture and more precise parameter estimates."

The experiment went smoothly, and agreed very well with Tsang's theory. "This really kind of worked right out of the box," Huntington insists. "We had been working on a phase estimation experiment already, and so we decided to try the quantum smoothing as part of it. It was relatively straightforward to get things to work."

Going forward, Huntington says the collaboration will continue to work with optical phase estimation. "I'm just one part of this great worldwide collaboration, and we are hoping to do more. At the moment, we are looking at applying the quantum smoothing technique to estimating the phase of other types of optical beams. We used a coherent state for this experiment, but there are lots of other states that are just as, if not more, interesting."

**More information:** T.A. Wheatley, et. al., "Adaptive Optical Phase Estimation Using Time-Symmetric Quantum Smoothing," *Physical Review Letters* (2010). Available online: link.aps.org/doi/10.1103/PhysRevLett.104.093601