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Novel measurement protocols: from Protective Measurements to Robust Weak Measurements

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Measurements are crucial in quantum mechanics, because of features like the wave function collapse after a "strong"(projective) measurement or the fact that measuring a quantum mechanical observable completely erases the information on its conjugate.
Nevertheless, quantum mechanics allows for different measurement paradigms including weak measurements (WMs), i.e. measurements performed with an interaction sufficiently weak not to collapse the original state. These measurements result in weak values [1-6], exploited for research in fundamental physics [7-13], as well as in applied physics being powerful tools for quantum metrology [14-20].
A second example is given by protective measurements (PMs) [21], a new technique able to extract information on the expectation value of an observable even from a single measurement on a single (protected) particle [22].
In addition, other novel measurement protocols have stemmed from these measurement paradigms. It is the case of genetic quantum measurement (GQM), a recursive measurement paradigm where some analogies with the typical mechanisms of genetic algorithms [23] appear, yielding uncertainties even below the level fixed by the quantum Cramer-Rao bound for the traditional prepare-and-measure scheme.
Recently, we have been exploring a new technique named robust weak value measurement (RWM), where, in principle, weak values can be extracted not as an average on an ensemble of weakly measured particles, but even from a single particle (provided it survives the whole measurement process).
In this talk, we present the first experimental implementation of PM [22], showing unprecedented measurement capability and demonstrating how the expectation value of an observable can be obtained without any statistics.
Afterwards, we introduce the GQM paradigm, illustrating its features and advantages, verified by the experimental results obtained in our proof-of-principle experimental demonstration.
Finally, we will present RWM and show the preliminary results achieved by our experimental implementation of such protocol.

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