New Frontiers in Quantum Measurement: Protective Measurement, Genetic Quantum Measurement and Robust Weak Measurement

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Measurement has a crucial role in quantum mechanics, because of features like the wave function collapse (after a "strong" measurement) or the fact that measuring a quantum observable erases the information on its conjugate. Nevertheless, quantum mechanics allows for different measurement paradigms, e.g. weak measurements, i.e. measurements performed with an interaction sufficiently weak not to collapse the original state. These measurements result in weak values [1–5], exploited for research in fundamental physics [6–10], as well as in applied physics being powerful tools for quantum metrology [7, 11–14]. Another example is given by protective measurements (PMs) [15], a new technique able to extract information on the expectation value of an observable even from a single measurement on a single (protected) particle [16]. In addition, other novel measurement protocols have stemmed from these measurement paradigms. It is the case of genetic quantum measurement (GQM), presenting analogies with the typical mechanisms of genetic algorithms [17] and yielding uncertainties even below the quantum Cramér-Rao bound for prepare-and-measure schemes. Recently, we have also been exploring a new technique named robust weak value measurement (RWM), able to extract a weak value 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 my poster, I will show these new measurement paradigms: PMs, GQM and RWM. In particular, I will present the first experimental implementation of PM [16], showing unprecedented measurement capability and demonstrating how the expectation value of an observable can be obtained without statistics. Furthermore, I will introduce the GQM paradigm, illustrating its features and advantages, verified by the experimental results obtained in our proof-of-principle demonstration. Finally, I will present RWM and show the results achieved by our experimental implementation of such protocol.

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