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back to namelist

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Probing “surreal” elements of quantum physics using weak measurements

While many authors write about the strange features of quantum mechanics and its various interpretations, Englert, Scully, Süssmann, and Walther (ESSW) went further, arguing that the description afforded by the Bohmian picture was not merely strange but “surreal.”
The de Broglie-Bohm model of quantum mechanics is famously realist and deterministic, providing each particle with a definite trajectory. ESSW studied a case in which they argued that these trajectories contradicted clearly observable properties of the system, concluding that rather than describing reality, such trajectories were “surreal.” In collaboration with Wiseman, who proposed a technique for directly observing quantum trajectories using weak measurement, we have now implemented a scenario based on ESSW's, and I will present experimentally extracted surreal trajectories. We use our observations to demonstrate the intrinsic nonlocality of the Bohm model, and show how a proper consideration of these nonlocal effects resolves any seeming paradoxes.
I will go on to describe two other experiments using weak measurement to expose surprising or surreal features of quantum mechanics. In one, due to the striking effects of “post-selective” measurements, a measurement of photon number can yield a value much larger than one, even when it is carried out on a single photon. I will say a few words about possible practical applications of this “weak value amplification” scheme. In another experiment, still ongoing, I will explain how it should be possible to measure “where a particle has been” as it tunnels through a classically forbidden region – and our expectation that it will make it from one side of the barrier to the other without spending any significant time in the middle.

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