Contribution ID: **14** Type: **not specified**

Quantum weirdness under control

Tuesday 24 July 2018 13:30 (30 minutes)

Duality was the first weirdness of quantum mechanics, and one can argue it is the most central. It can't be dodged by mathematical sophistications, and an acceptable wording has never been agreed on for rationalizing the conceptual impossibility of duality. It remains as weird today as in the 1920s. Analytical discussion of the duality dilemma has never stopped [1] and it is accurately referred to as the wave-particle paradox. Attention to the paradox has moved through several stages of increasing sophistication [2], but after ninety years of reflection following Bohr's invention of complementarity, there has been no resolution. Here we are reporting the discovery of a resolution [3,4].

It is noteworthy that the resolution we report reveals itself through the classical analog, the ray-wave dilemma of optics. This is appropriate. The operational foundation of coherence in a physical state lies in the interpretation of interference effects, whether they are quantum or classical wave mechanical. Since optical physics and single-particle quantum mechanics are theories erected on linear vector spaces, they share almost everything, and in this way optics can be called equally weird. Ironically, in reaching the resolution that we will present, the other conceptually challenging weirdness of quantum theory, i.e., entanglement, will be shown to be in control of duality's weirdness. By control we mean that we establish an identity through which entanglement prescribes exactly the degree of duality (the combined amount of waveness and particleness or waveness and rayness) that is possible to record in a two-path coherence experiment.

[1] N. Bohr, Atomic Theory and the Description of Nature (Cambridge Univ. Press. 1934), p. 10, and A. Whitaker, Einstein, Bohr and the Quantum Dilemma, 2nd Edition (Cambridge Univ. Press, 2006).

[2] See W.K. Wootters and W.H. Zurek, Phys. Rev. D {19}, 473 (1979); D. M. Greenberger and A. Yasin, Phys. Lett. A {128}, 391 (1988); L. Mandel, Opt. Lett. {16}, 1882 (1991); G. Jaeger, A. Shimony, and L. Vaidman, Phys. Rev. A {51}, 54 (1993); B.-G. Englert, M.O. Scully and H. Walther, Sci. Am. {271}, 86 (1994); S. Dürr and G. Rempe, Am. J. Phys. {68}, 1021 (2000); F. Gori, M. Santarsiero and R. Borghi, Opt. Lett. {31}, 858 (2006); R. Menzel, D. Puhlmann, A. Heuer and W.P. Schleich, PNAS {109}, 9314 (2012); F. De Zela, Phys. Rev. A {89}, 013845 (2014) and Optica {5}, 243 (2018).

[3] X.-F. Qian, A.N. Vamivakas and J.H. Eberly (under review, 2018).

[4] See hints by P.L. Knight (1998) and Jakob and Bergou (2003).

Presenter: Prof. EBERLY, Joseph (University of Rochester)