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An Atomic Hong Ou Mandel Experiment

The quantum theory has introduced physicists to two major counter-intuitive concepts. On the one hand, there is wave-particle duality, which means that objects normally described as particles can also behave as waves, while entities primarily described as waves, such as light, can behave as particles. This revolutionary idea nevertheless relies on concepts borrowed from classical physics, either waves or particles evolving in an ordinary space-time. On the other hand, entanglement can lead to interferences between the amplitudes of multi-particle states, which happen in Hilbert space and have no classical counter-part. This fundamental feature has of course been strikingly demonstrated by the violation of Bell's inequalities. There is however, a conceptually simpler situation in which the interference between two-particle amplitudes entails a behavior impossible to describe by any classical model. This is the celebrated Hong Ou and Mandel experiment, in which two photons arriving simultaneously in the input channels of a beam-splitter always emerge together in one of the output channels. This effect has been extensively used to characterize the quality of non-classical light sources. In Palaiseau our group has realized a close analog to the Hong Ou Mandel experiment using atoms. I will discuss the experiment and comment on prospects for extending our methods to other, traditionally optical experiments such as the violation of Bell's inequalities with atoms.