Anomalous photon bunching

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The celebrated Hong–Ou–Mandel effect [1] tells us that two photons impinging on a 50:50 beam splitter are always detected together in the same output mode. Since such a bunching effect results from quantum interference, the complementarity principle dictates that it becomes less pronounced as soon as we are able to distinguish the photons and trace back which paths they have taken. Accordingly, if the two photons have orthogonal polarization, they behave like classical balls and are transmitted or reflected independently of each other with a probability 1/2. This interplay between photon bunching and distinguishability is commonly admitted to reflect a general rule: bunching must be maximum for fully indistinguishable photons and gradually decline if photons are made increasingly distinguishable.

Here, we disprove this common assumption and exhibit an instance of anomalous photon bunching in an interferometric circuit involving seven photons in seven modes [2]. By exploiting a recent counterexample [3] to a long open conjecture due to Bapat and Sunder on the permanent of the Hadamard product of matrices [4], we show that the probability for partially distinguishable photons to bunch into two output modes may surpass its value for perfectly indistinguishable photons. This very unexpected behaviour questions our understanding of multiparticle interference in the grey zone between ideal bosons and classical particles.

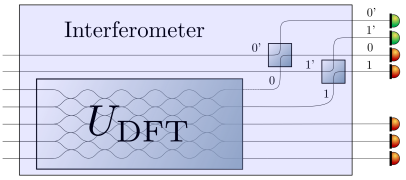

Fig. 1: Linear interferometer exhibiting anomalous photon bunching. Seven photons with an appropriate polarization pattern (see [2]) are sent into the seven input modes. The probability of detecting them all in the two output modes indicated with green detectors exceeds its value for indistinguishable photons (all with the same polarization) although the interferometer is polarization independent. This scenario can be generalized to n modes and results in a violation ratio growing linearly with n.

References

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