Multiparticle Quantum Interferometry

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The quantum interference of many particles on the one hand raises many foundational questions and on the other hand it is an active area of quantum technology development. While the latter has gained momentum with the ever-larger demonstrations of boson sampling, the former have not been explored so much. And yet, we believe that answering some of the foundational questions may lead to better understanding of the requirements and characteristics of quantum technologies that exploit multiparticle interference.

In recent and ongoing work, we were able to show theoretically and experimentally that the outputs of a multiparticle interferometer that occur with zero probability (they are suppressed) can be derived from a surprisingly simple law, which is based on the underlying symmetries of the unitary describing the interferometer [1]. In further theoretical work we extended the notion of wave-particle duality to the multiparticle case [2].

To realize these kinds of experiments, the sources of single photons need to be made as good as possible in terms of brightness and photon indistinguishability. Furthermore, we need to efficiently route the single photons to the desired interferometer inputs. In both areas we have been able to achieve significant improvements [3].

[1] Dittel, G. Dufour, M. Walschaers, et al., *Totally Destructive Many-Particle Interference,* Phys. Rev. Lett. **120**, 240404 (2018), https://doi.org/10.1103/PhysRevLett.120.240404; J. Münzberg, C. Dittel, M. Lebugle, et al., *Symmetry Allows for Distinguishability in Totally Destructive Many-Particle Interference,* PRX Quantum **2**, 020326 (2021), https://doi.org/10.1103/PRXQuantum.2.020326

[2] Dittel, G. Dufour, G. Weihs, et al., *Wave-Particle Duality of Many-Body Quantum States,* Phys. Rev. X **11**, 031041 (2021), https://doi.org/10.1103/PhysRevX.11.031041

[3] Münzberg, F. Draxl, S. Filipe Covre da Silva, et al., *Fast and efficient demultiplexing of single photons from a quantum dot with resonantly enhanced electro-optic modulators* (2022), https://arxiv.org/abs/2203.08682