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Multi-Photon Quantum Interferometry

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Based on the investigation of multi-photon entanglement, as produced by stimulated parametric down-conversion, a technique is presented to create heralded "noon" states. The relevance for interferometry will be discussed. Furthermore we explored the use of photon-number resolving detectors in Mach-Zehnder type of interferometers. Our current detectors can distinguish 0, 1, 2, to7, photon impacts. Although the overall collection and detection efficiency of photons is well below unity (about 0.3) the photon number resolving property is still very useful if combined with coherent input states since those state are eigenstates of the photon annihilation operator. First we analyze the coherent state interferometer with a single photon-number resolving detector, revealing the strong non-linear response of an interferometer in the case of Fock-state projection. Second, we use two such detectors together with a Baysian phase estimation strategy to demonstrate that it is possible to achieve the standard quantum limit independently from the true value of the phase shift. This protocol is unbiased and saturates the Cramer-Rao phase uncertainty bound and, therefore, is an optimal phase estimation strategy. As a final topic it will be shown how quantum interferometry combined with micromechanical structures can be used to investigate quantum superpositions and quantum decoherence of macroscopic objects.