Abstract for an Invited Paper
for the DAMOP07 Meeting of
The American Physical Society

Mode-mashing and quantum interferometry with triphoton states

AEPHRAIM STEINBERG, CQIQC & Physics, University of Toronto

For a number of years, many proposals have observed that the resolution of interferometry could be vastly improved, reaching the "Heisenberg limit" of $\Delta\phi \approx 1/N$, if the particles in the interferometer could be in a maximally entangled state of all travelling one path or the other, |N,0> +|0,N>, or "N00N." This is a quadratic improvement over the shot-noise limit in classical interferometers, and might lead to significant improvements in metrology, and possibly even lithography. Unfortunately, given the nearly non-interacting nature of photons, such states have proved elusive for N>2. Recently, a new theoretical approach based on post-selective nonlinearity has paved the way to scalable generation of such states, which we have generated for N=3. In this talk, I review this approach, our experiment based on what we term "mode-mashing," and their future prospects and limitations. I also discuss the difficult issue of how to perform complete quantum characterisations of such multi-photon states, in which the particles are distinguished only by their polarisations, which are in a complicated entangled state. We have generalized the standard techniques of quantum tomography to take into account the potential presence of extra "distinguishing" information inaccessible to measurement, and discuss the resulting limitations on one's ability to fully describe a quantum state. In the limit of completely indistinguishable photons, we argue that the N-photon object should be thought of essentially as a single composite spin-N/2 particle, whose polarisation state may be described by a generalized Wigner quasiprobability distribution over the classical phase space which is the surface of the Poincaré sphere. We generate a variety of coherent, spin-squeezed, and maximally entangled states, and show the resulting Wigner functions and density matrices.

References

1. M.W. Mitchell, J.S. Lundeen, and A.M. Steinberg, Nature **429**, 161 (2004)
2. R.B.A. Adamson, L.K. Shalm, M.W. Mitchell, and A.M. Steinberg, Phys. Rev. Lett. **98**, 043601 (2007)
3. R.B.A. Adamson, P.S. Turner, M.W. Mitchell, and A.M. Steinberg, quant-ph/0612081