"Filtering of the Absolute Value of Photon-Number Difference for Two-Mode Macroscopic Quantum Superpositions"

Dr. Magdalena Stobinska
University of Gdansk, Poland

We discuss a device capable of filtering out two-mode states of light with mode populations differing by more than a certain threshold, while not revealing which mode is more populated. It would allow engineering of macroscopic quantum states of light in a way which is preserving specific superpositions. As a result, it would enhance optical phase estimation with these states as well as distinguishability of “macroscopic” qubits. We propose an optical scheme, which is a relatively simple, albeit non-ideal, operational implementation of such a filter. It uses tapping of the original polarization two-mode field, with a polarization neutral beam splitter of low reflectivity. Next, the reflected beams are suitably interfered on a polarizing beam splitter. It is oriented such that it selects unbiased polarization modes with respect to the original ones. The more an incoming two-mode Fock state is unequally populated, the more the polarizing beam splitter output modes are equally populated. This effect is especially pronounced for highly populated states. Additionally, for such states we expect strong population correlations between the original fields and the tapped one. Thus, after a photon-number measurement of the polarizing beam splitter outputs, a feed-forward loop can be used to let through a shutter the field, which was transmitted by the tapping beam splitter. This happens only if the counts at the outputs are roughly equal. In such a case, the transmitted field differs strongly in occupation number of the two modes, while information on which mode is more populated is non-existent (a necessary condition for preserving superpositions).