Hybrid Atom-Light Interferometers

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Conventional interferometers involve coherent splitting and recombination of waves of the same type, such as light wave, neutron and atom/molecule matter wave interferometers. A non-conventional interferometer utilizes nonlinear processes such as parametric processes to replace traditional coherent beam splitters for wave splitting and recombination, as shown in the figure. For non-conventional interferometers involving nonlinear processes, there are two important features that are different from conventional interferometers. The first one is that the nonlinear interaction leads to quantum noise correlation that can be used for noise reduction. The second one is that the nonlinear process couples waves of different type. So, the coherently split waves may not be the same type.

Figure (a) A conventional interferometer with linear coherent beam splitters (BS). (b) A non-conventional interferometer with parametric amplifiers (PA) as the beam splitting elements.

In this talk, we will review a specific interferometer scheme, the so called SU(1,1) interferometer [1-4], with parametric amplifiers as the beam splitters. A new paradigm for quantum interferometry is found that the signal of noise ratio of the interferometer is increased by the signal enhancement rather than the noise reduction in the squeezed state interferometry. We will discuss an experiment using the Raman process in Rb atom cell as the parametric amplifiers for the beam splitters in the construction of the interferometer. It is known that a Raman process in an atomic ensemble involves a strong pump field interacting with the atomic medium and produces a Stokes light field together with a correlated atomic spin excitation wave (also known as atomic pseudo-spin wave). So, this new interferometer has atom in one path and light in another path to form a hybrid atom-light interferometer. It is observed that the high-contrast interference fringe is sensitive to the optical phase via a path change as well as the atomic phase via a magnetic field change. This new atom-light hybrid interferometer should find wide applications in precision measurement, quantum control with atom and photon.