All atomic generation and manipulation of squeezed light with Rb atoms

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Optical measurements with coherent states of light are fundamentally limited by quantum fluctuations. The Heisenberg uncertainty principle sets the standard quantum limit (SQL) for the product of the amplitude and phase light quadrature fluctuations. However, it is possible to decrease (squeeze) the quantum noise of one of the quadratures below the SQL and generate so called “squeezed” light with a noise level below shot noise. Due to their unique properties, squeezed states of light find applications in precision metrology and as carriers of quantum information. The former requires noise suppression to be present at frequencies as low as 10 Hz and the ability to modify the squeezing spectrum. The latter requires matching the squeezed light wavelength to the atomic transition of the atom used for quantum storage, for example a 795 nm Rb D1 line.

Our squeezer is based on the polarization self-rotation (PSR) effect in an atomic medium, when the light polarization axis rotates due to the nonlinear interaction of the orthogonal circular polarizations constituting the light polarization basis. The same nonlinear interaction leads to the squeezing of the vacuum mode orthogonal to the linearly polarized laser pump field.

Here we report our results for squeezing generation via the PSR effect in hot Rb atoms and the subsequent manipulation of the quantum noise spectrum by passing the light through another cell with Rb atoms under conditions of electromagnetically induced transparency (EIT).

The benefits of this method for squeezing generation are the simplicity of the experimental apparatus, low demand of the laser pump power (several mW is enough), and most importantly, the generation of squeezing at atomic transition wavelengths suitable for quantum memory and storage. This method could be extended to other atomic transitions, and could bring squeezing to much shorter wavelengths which are unobtainable with conventional non-linear crystal squeezers due to the increased absorption in crystals at these wavelengths.