Detection of 10 dB vacuum noise squeezing at 1064 nm by balanced homodyne detectors with a common mode rejection ratio more than 80 dB

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Abstract: We report our implementation of a squeezer, by generating squeezed vacuum state at 1064 nm through a bow-tie optical parametric oscillator cavity operated below the threshold. With the help of our home-made balanced homodyne detector (BHD), characterized with a Common Mode Rejection Ratio (CMRR) more than 80 dB, a noise reduction up to 10 dB is observed. © 2019 The Author(s)

OCIS codes: 270.6570, 270.5570.

1. Introduction

Even though Heisenberg uncertainty relation sets a fundamental limit on the quantum fluctuations, the noise of light at certain phases can be *squeezed* to fall below that of the vacuum state [1]. Now as true applications, this non-classical state has also been used to enhance quantum metrology [2,3] and future gravitational wave detection [4, 5]. In particular, with the process of degenerate parametric down-conversion in a nonlinear crystal placed inside an optical cavity, optical parametric oscillator (OPO) and optical parametric amplification (OPA) have provided efficient routines to produce high degree of squeezing. Recently, assisted by a doubly resonant, nonmonolithic OPA cavity, up to 15 dB squeezing was observed as the state-of-the-art technology [6]. Alternatively, with the recent experimental advance of high optical depth (OD) in atomic ensembles, direct generation of squeezed light under the coherent population trapping (CPT) condition was studied [7]. Combined with light storage and retrieval, generation, detection, and gate operation of squeezed light pave the way for applications of quantum optics and quantum information manipulation utilizing continuous variables.

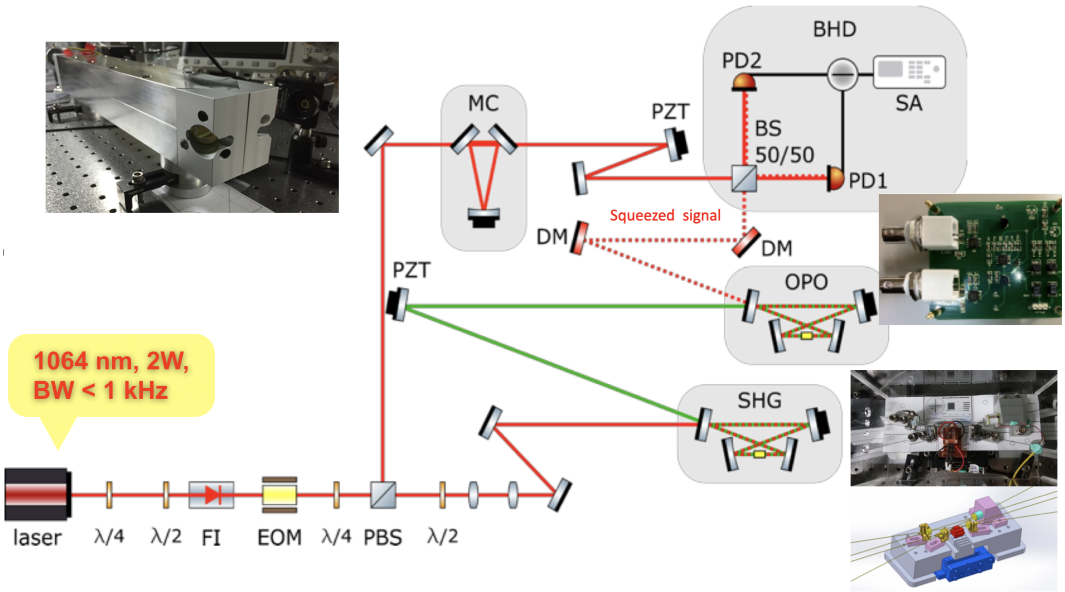

Fig. 1. The schematic of our experimental setup for the squeezer.

2. Experimental Setup and Measurement Results

Here, we implemented a squeezer, by generating squeezed vacuum state at 1064 nm through a bow-tie OPO cavity operated below the threshold. The experimental setup of detecting squeezed light, as shown in Fig. 1. Our experimental setup includes: a Nd:YAG laser at 1064 nm is used as the laser source, which is split into two paths with one serving as the local oscillator field; while the other one used to for second harmonic generation (SHG). The 532 nm light is injected into a bow-tie cavity with a periodically poled KTiOPO4 (PPKTP) inside, as an optical parametric oscillator (OPO). Other components used includes a mode cleaner (MC) used as filters for improving the beam quality of laser beams, electro-optical modulator (EOM), polarization beam splitter (PBS), piezo electric transducer (PZT), dichroic beam splitter (DM); and balanced homodyne detector (BHD) with two identical photodiodes (PDs).

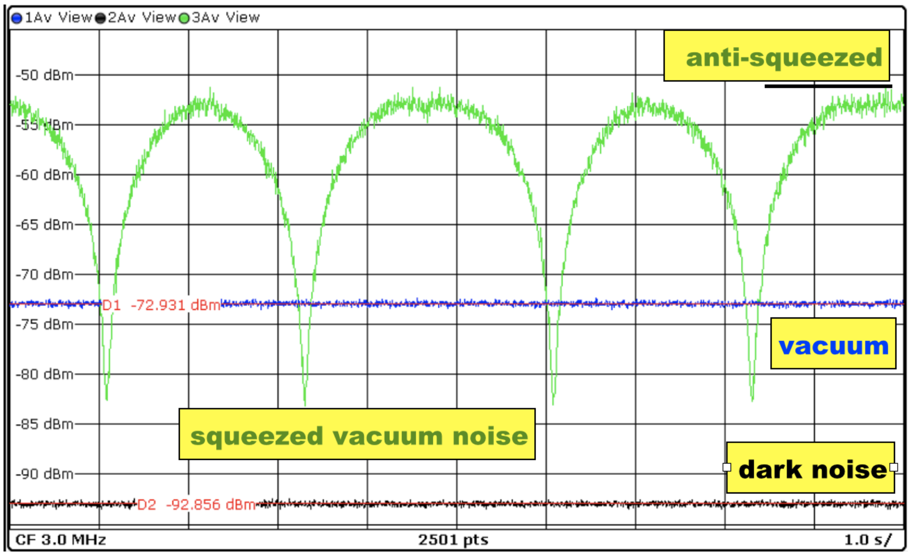

Fig. 2. By fixing the frequency at 3 MHz, the noise fluctuation is recorded in green color by changing the phase of the local oscillator (LO). Here, the vacuum noise is depicted in blue color; while the electronic noise is recorded in black color.

Figures 2 shows the measurement of squeezed states as a function of the phase in the local oscillator (LO). Clearly, up to 10 dB noise reduction is achieved at 3 MHz through a BHD scheme. The performance of a BHD can be evaluated by it capacity to cancel noise (thermal noise or classical noise) with the injection from two detectors, i.e., Common Mode Rejection Ratio (CMRR). Our home-made BHD is characterized with a CMRR larger than 80 dB.

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