An In-Vacuum Optical Parametric Oscillator Squeezer for Gravitational Wave Detectors

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We present the first optical parametric oscillator (OPO) squeezer operating under vacuum. The aim of this experiment is to demonstrate a prototype squeezed light source at audio Fourier frequencies for injection into the advanced laser interferometer gravitational wave detectors (LIGO). This is to enable metrology below the quantum noise limit set by shot noise and radiation pressure noise in an optical interferometer. LIGO is the most sensitive metrology experiment in the world, consisting of two Michelson interferometers with optical cavity arms each at 4 km in length. A squeezer for operation with LIGO needs to produce ~10 dB of squeezing below the shot noise level in the audio frequency band, have low cavity length noise, and be housed in the vacuum envelope with the interferometer. Injection of such a squeezed light source permits both enhancement of the strain sensitivity of the instrument and a lower required intracavity circulating intensity in the interferometer. The OPO cavity is in a medium finesse bowtie ring configuration, producing vacuum squeezing at 1064 nm using PPKTP as the nonlinear crystal. The cavity is quasi-monolithic and the spacer is glass based for length stability. Cavity mirrors are glued to glass tombstones, which are optically contacted to the glass breadboard base. To maintain dual resonance at the 532 nm pump and 1064 nm fundamental wavelengths, the crystal is kept at 33 degrees Celsius, in a translatable vacuum-compatible oven. Operating the experiment under vacuum presents several technical challenges, such as different thermal characteristics in the crystal oven, and a difference in the intracavity dispersion. We will present our latest squeezing results from the collaborative experiment between the Australian National University and the Massachusetts Institute of Technology.