The Phonon-Limited-Linewidth of Brillouin Lasers at Cryogenic Temperatures - Supplemental Material

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BRILLOUIN LASER LINEWIDTH UNDER CASCADED OPERATION

The linewidth formula Eq. (1) in the main text has been observed to hold under cascaded operation [1]. Strong coherent interaction of the Stokes waves that might impact the linewidth formula could be possible if cavity dispersion and Brillouin mode pulling [1] created Stokes waves having equal frequency spacing. This arrangement was not observed here.

BRILLOUIN GAIN BANDWIDTH AND $\mathbf{n}_T$ MEASUREMENT

The Brillouin gain bandwidth ($\Delta\nu_B$) is also extracted from a quadratic fit of the curves in Fig. 2(b) [1]. We measure 20 MHz at 300 K, 25 MHz at 77 K, and 35 MHz at 8 K. These linewidths reflect the damping rate of the Brillouin process and have been the focus of theory and experiment in silica optical fiber [2, 3]. The measured temperature dependence is not consistent with theory and is believed to result from different optical and acoustical mode families participating in the Brillouin process at different temperatures. To partially test this hypothesis, Brillouin linewidths were measured at room temperature by inducing Brillouin laser action on a range of different cavity modes. Linewidths in the range 15 MHz - 45 MHz were measured suggesting that damping of the Brillouin process is strongly affected by the spatial structure of the mode. This could, for example, result from differences in the surface interactions of the various spatial acoustical modes with the wedge resonator dielectric-air interface. It is important to note that this behavior in no way affects the measurement of n_T since it is the measured value of g and not the theoretical value of g that matters.

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