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Photoinduced Effects in Mechanical Loss and Elasticity of GaAs for Ultra-Stable Laser Interferometers

Crystalline AlGaAs/GaAs coatings are a promising low-noise material candidate for high-precision optical metrology due to their low mechanical loss. However, recent studies have revealed excess Brownian thermal noise in optical cavities, which appears to be linked to photoinduced effects. Additionally, there are indications that illumination influences the mechanical loss in GaAs, leading to changes in Brownian thermal noise.

To investigate these effects, we studied the mechanical loss characteristics of GaAs at 80 K, 200 K, and 295 K under controlled illumination with wavelengths around the GaAs bandgap. Our results show that low-frequency mechanical resonance modes exhibit decreasing losses with increasing photon energy, whereas higher-frequency modes display the opposite trend. As temperature decreases, the behavior of mechanical loss changes.

Beyond mechanical loss, elasticity is also affected, showing a pronounced wavelength-dependent peak. Relaxation effects occur when switching illumination on and off, with timescales ranging from seconds to minutes. Interestingly, at room temperature, infrared light (1550 nm) influences the resonance frequency to a similar extent as blue light (461 nm), despite GaAs being transparent to infrared light and fully absorbing blue light. However, this trend reverses at lower temperatures.

These findings suggest that photoinduced changes in mechanical loss and elasticity may contribute to variations in birefringence observed in AlGaAs/GaAs coatings and could be relevant for understanding excess thermal noise in mirror coatings. While this study does not fully explain all observed effects in GaAs, it represents a step toward a more comprehensive understanding of photoinduced mechanical changes in the material.

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