Broadband Characterization of an Ultrastable Optical Cavity with Crystalline Mirrors Using an Optical Frequency Comb

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***Summary*—We present the characterization of an ultrastable optical cavity based on crystalline mirrors. The measurement was performed in the near-IR spectral range around 1550 nm using an optical frequency comb and Fourier-transform spectrometer. From a single measurement we retrieve the cavity finesse, dispersion, and birefringence over a 100 cm^{-1} range. In consecutive measurements the temperature dependence of these properties was also obtained.**

Keywords—crystalline mirrors, optical frequency comb, mirror dispersion

I. Introduction

Mirrors with crystalline layers allow for a significant reduction in the thermal noise contribution [1,2] to the overall stability of ultrastable optical cavities compared to mirrors using amorphous dielectric coatings. This improved stability is especially important in optical clocks, where the cavity limits the clock performance for short time scales. High-finesse cavities are also used i.e., in precision spectroscopy, where cavity ring-down spectroscopy (CRDS) [3] has become one of the most widely used, accurate, and sensitive spectroscopic techniques. Recently, new developments of cavity mode-width (CMWS) and mode-dispersion (CMDS) spectroscopy have been presented [4,5], which, together with optical frequency combs and atomic clocks, can be used to replace intensity measurements with more precise frequency measurements. The various applications of crystalline coated mirrors necessitate a better understanding of their optical properties, such as dispersion for broadband spectroscopy applications and birefringence for ultrastable cavities [6].

II. Results\Conclusions

Here, we use a newly developed method of determining the dispersion, birefringence, and finesse of an optical cavity over a wide wavelength range with an optical frequency comb [7-10]. This method was employed to characterize an ultrastable cavity comprising a 30 cm-long ULE glass spacer with crystalline mirrors deposited on fused silica substrates [11]. We present the temperature and polarization dependence of dispersion over the wavelength range of 1535-1565 nm.

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