Since the main motivation of the demonstrated temperature stabilization technique is to provide a stable laser locking reference, it is interesting to evaluate the projected fractional frequency stability of such a reference. This can be done by multiplying the measured temperature stability by the coefficient Eq. (4). This result is also shown in Fig. 4. According to this, we should be able to stabilize our laser to one part per 7×10^{-12} per 1 s integration time, and down to one part per 6×10^{-14} per 10,000 s integration time even with the present proof-of-principle system.

It should be pointed out that in addition to its temperature dependence, the dual-mode frequency detuning Δf may have other dependencies, e.g. on the atmospheric pressure, TE/TM power ratio, etc. It also could be time-dependent due to crystal aging. Successfully using Δf for temperature stabilization however shows that its temperature dependence is dominant, and serves as a validation of our technique of ultra-sensitive temperature measurements. A further verification of the achieved temperature stability will be available from measuring the relative frequency stability of two independently stabilized lasers, which will be the subject of our future work.

4. Conclusions

We have demonstrated a WGM based temperature sensor with nano-Kelvin sensitivity operating at room temperature. We have used it to stabilize a WGM resonator at the level of a few nano-Kelvin, which will allow us to use this resonator as an ultra-stable laser lock reference. The demonstrated technique can be used in a variety of other applications requiring high temperature stability, as well as ultra-sensitive measurements of temperature variations. As a few examples of such applications we would like to suggest the thermal stabilization of quartz oscillator, mid- or far-IR sensitive bolometers, precise calorimetric measurements in chemistry, and study of optical and mechanical aging effects in various crystalline resonators.

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