PRIMARY THERMOMETRY FROM A CO_2 OVERTONE LINE VIA COMB-ASSISTED CAVITY-RING-DOWN SPECTROSCOPY

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We provide the most accurate absolute temperature measurement ever performed on an atomic or molecular sample with a Doppler-Broadening-Thermometry approach. Specifically, the absorption profile of the $P_e(12)$ line of the (30012) - (00001) band of a CO_2 sample at thermodynamic equilibrium is accurately measured at 1.578 μm by a comb-assisted cavity-ring-down spectrometer that combines an extremely dense frequency axis (3000 points over 4.2 GHz) with an acquisition time as low as a few seconds. The Doppler width is extracted from a refined multi-spectrum fitting procedure accounting for the speed dependence of the relaxation rates, which were found to play a role even at the very low pressures explored, from 1 to 7 Pa. The thermodynamic gas temperature is retrieved with relative uncertainties of $8{\cdot}10^{-6}$ (type A) and 11 $\cdot 10^{-6}$ (type B), which rank the system at the first place among optical methods. Thanks to a measurement time of only 5 h, the technique represents a promising pathway towards the optical determination of the thermodynamic temperature with a global uncertainty at the 10^{-6} level [a]. An additional element of interest derives from the forthcoming redefinition of the unit Kelvin [b], in 2018, which calls for primary thermometers that are capable to operate over a large part of the temperature scale with very high accuracy.

[a] Gotti R., Moretti L., Gatti D., Galzerano G., Castrillo A., Laporta P., Gianfrani L., and Marangoni M., Phys. Rev. A 97, 12512 (2018)

[b] J. Fischer, Phil. Trans. R. Soc. A 374, 20150038 (2016)