DETERMINATION OF THE BOLTZMANN CONSTANT BY MEANS OF DOPPLER-BROADENING THERMOMETRY ON WATER AT 1.39 μm.

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Based upon precision laser spectroscopy in the linear regime of interaction, Doppler broadening thermometry (DBT) consists in retrieving the Doppler width from the highly-accurate observation of the absorption profile corresponding to a given atomic or molecular line in a gas sample at the thermodynamic equilibrium. We report on a DBT experiment based on a pair of offset-frequency locked extended-cavity diode lasers at 1.39 μm, to probe the $4_{4,1}\rightarrow 4_{4,0}$ line of the $H_2^{18}O$ $\nu_1 + \nu_3$ band. This method allows us to perform highly-accurate and reproducible frequency scans of the probe laser around a given center frequency. A sophisticated and extremely refined spectral analysis procedure was developed for the highly-accurate retrieval of the Doppler width, taking into account the Dicke narrowing effect, the speed-dependence of relaxation rates, and the partial correlation between velocity-changing and rotational-state-changing collisions. In particular, the partially correlated speed-dependent Nelkin-Ghatak model was employed to perform the spectral analysis of 718 spectra acquired in the pressure range between 200 and 500 Pa, at the temperature of the triple point of water, using a 97%-enriched ^{18}O water sample. Doppler width retrievals allowed for a spectroscopic determination of the Boltzmann constant with a combined (type A and type B) uncertainty of 1.9×10^{-5}, which is the best result obtained so far by means of an optical method. Our determination is in full agreement with the recommended CODATA value.