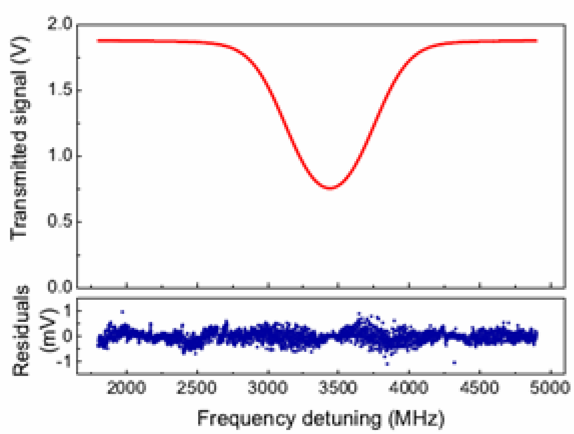
The Boltzmann constant from the shape of a $H_2{}^{18}O$ spectral line

A. Castrillo, L. Moretti, E. Fasci, M.D. De Vizia, G. Casa, and L. Gianfrani

Department of Mathematics and Physics, Seconda Università di Napoli, Viale Lincoln 5, 81100 Caserta, Italy, Tel.: 00390823274632, Fax: 00390823274714, E-mail: livio.gianfrani@unina2.it

As recently agreed at international level, the new definitions of kilogram, ampere, kelvin, and mole rely upon the assignment of fixed values to a set of fundamental constants, namely Planck constant, elementary charge, Boltzmann constant (k_B), and Avogadro number. These changes will be adopted only after a further refinement of the experimental values of these constants. The Doppler effect represents a unique tool for a direct access to k_B and gives the basis of a relatively new method of primary gas thermometry, known as Doppler-broadening thermometry (DBT), which converts temperature determinations into frequency measurements [1]. Here, we report on a new DBT experiment made in a ^{18}O-enriched water sample at the temperature of the triple point of water, using a pair of offset-frequency locked extended-cavity diode lasers at 1.39 µm, one of which being an optical frequency standard. This technique allowed us to build an absolute, highly accurate and reproducible frequency scale underneath absorption spectra [2]. A sophisticated and extremely refined spectral analysis procedure was developed for the retrieval of the Doppler width, also taking into account Dicke-narrowing and speed-dependent effects [3]. Hence, we provided a new determination of k_B with a combined uncertainty of 24 10^{-6} [4]. This is the best result obtained so far with an optical method. Our determination is in agreement with the recommended CODATA value.



[1] G. Casa, A. Castrillo, G. Galzerano, R. Wehr, A. Merlone, D. Di Serafino, P. Laporta, and L. Gianfrani: "Primary gas thermometry by means of laser absorption spectroscopy: Determination of the Boltzmann constant", *Phys. Rev. Lett.* **2008**, 100, 200801.

[2] A. Castrillo, E. Fasci, G. Galzerano, G. Casa, P. Laporta, and L. Gianfrani: "Offset-frequency locking of extended-cavity diode lasers for precision spectroscopy of water at 1.38 µm", *Opt. Express* **2010**, 18, 21851-21860.

[3] M. De Vizia, F. Rohart, A. Castrillo, E. Fasci, L. Moretti, and L. Gianfrani: "Investigation on speed-dependent effects in the near-IR spectrum of self-colliding $H_2{}^{18}O$ molecules", *Phys. Rev. A* **2011**, 83, 052506.

[4] L. Moretti, A. Castrillo, E. Fasci, M.D. De Vizia, G. Casa, G. Galzerano, A. Merlone, P. Laporta and L. Gianfrani: "Determination of the Boltzmann constant by means of precision measurements of $H_2{}^{18}O$ line shapes at 1.39 µm", *Phys. Rev. Lett.* **2013**, in press.