# From metrology of spectral line shapes to fundamental physics

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Search for accurate spectroscopic techniques led us to one-dimensional cavity mode dispersion spectroscopy (1D-CMDS) [1], a spectroscopy technique purely based on frequency measurement. Because the spectrum obtained with this method comes from accurate cavity mode frequency measurement, 1D-CMDS has great potential for minimization of systematic errors in the line shape studies of very week transitions [2]. Nowadays, the ab initio approaches as well as analytical models, allowing to take into account basic effects forming the shape of molecular transitions, make possible the correct interpretation of high accuracy data and testing interatomic potentials [3,4]. All these opens new possibilities for Doppler limited spectroscopy. Especially, molecular hydrogen and its isotopologues are an attractive playground for testing quantum electrodynamics in molecules [5] and search for new physics [6]. The accuracy of measurements can be improved by use of optical atomic clocks [7] as the most stable frequency reference. Going farther, spectroscopy of ultra cold molecules having narrow photoassociation resonances near intercombination transition provides valuable information and new level of control. Narrow optical Feshbach resonances [8] allow efficient control of properties of ultra cold matter [9]. On the other hand analysis of two-colour mass-scaled photoassociation spectroscopy for set of isotopologues of $Yb_2$ can set bounds for non-Newtonian gravity in the nanometer range [10]. Finally use of optical atomic clocks can help in laboratory search for dark matter [11,12,13,14] and understanding physics beyond Standard Model.

## References

[1] A. Cygan, P. Wcisło, S. Wójtewicz, P. Masłowski, J. Hodges, R. Ciuryło, D. Lisak,, *Opt. Express* 2015, **23**, 14472-14486.

[2] A. Cygan, S. Wójtewicz, G. Kowzan, M. Zaborowski, P. Wcisło, J. Nawrocki, P. Krehlik, L. Śliwczyński, M. Lipiński, P. Masłowski, R. Ciuryło, D. Lisak, *J. Chem. Phys.* 2016, **144**, 214202-11.

[3] P. Wcisło, H. Tran, S. Kassi, A. Campargue, F. Thibault, R. Ciuryło, *J. Chem. Phys.* 2014, **141**, 074301-14.

[4] P. Wcisło, F. Thibault, H. Cybulski, R. Ciuryło, *Phys. Rev. A* 2015, **91**, 052505-6.

[5] S. Kassi, A. Campargue, K. Pachucki, J. Komasa, *J. Phys. Chem.* 2012, **136**, 184309-10.

[6] E. J. Salumbides, J. C. J. Koelemeij, J. Komasa, K. Pachucki, K. S. E. Eikema, W. Ubachs, *Phys. Rev. D* 2013, **87**, 112008-8.

[7] A. D. Ludlow, M. M. Boyd, J. Ye, E. Peik, P. O. Schmidt, *Rev. Mod. Phys.* 2015, **87**, 637-701.

[8] R. Ciuryło, E. Tiesinga, P. S. Julienne, *Phys. Rev. A* 2005, **70**, 062710-14.

[9] M. Yan, B. J. DeSalvo, B. Ramachandhran, H. Pu, and T. C. Killian, *Phys. Rev. Lett.* 2013, **110**, 123201-5.

[10] M. Borkowski, A. A. Buchachenko, R. Ciuryło, P. S. Julienne, H. Yamada, K. Yuu, K. Takahashi, Y. Takasu, Y.

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[11] A. Derevianko, M. Pospelov, *Nat. Phys.* 2014, **10**, 933–936.
[12] Y. V. Stadnik, V. V. Flambaum, *Phys. Rev. A* 2016, **93**, 063630-8.
[13] P. Morzyński, M. Bober, D. Bartoszek-Bober, J. Nawrocki, P. Krehlik, L. Śliwczyński, M. Lipiński, P. Masłowski, A. Cygan, P. Dunst, M. Garus, D. Lisak, J. Zachorowski, W.Gawlik, C. Radzewicz, R. Ciuryło, M. Zawada,, *Sci. Rep.* 2015, **5**, 17495-9.
[14] P. Wcisło, P. Morzyński, M. Bober, A. Cygan, D. Lisak, R. Ciuryło, M. Zawada, 2016, arXiv: 1605.05763