Atomic and Molecular Spectroscopy and Self-Absorption Measurements

C.G. Parigger

University of Tennessee, University of Tennessee Space Institute,
Center for Laser Applications, Tullahoma, TN 37388

This work discusses laboratory measurements of atomic and diatomic molecular species in laser-plasma [1]. Noticeable self-absorption of the Balmer series hydrogen alpha line occurs for electron densities of the order of one tenth of standard ambient temperature and pressure density [2]. Self-absorption measurements include the use of a doubling mirror [3, 4]. Line-of-sight emission spectra of selected diatomic molecules in air or specific gaseous mixtures at or near atmospheric pressure reveal minimal plasma re-absorption.

Abel inverted data confirm plasma expansion dynamics that unravel regions of atomic and molecular species of different electron density and temperature. Time-resolved spectroscopy determines self-absorption and self-reversal of hydrogen alpha lines in ultra-high pure hydrogen gas and in standard laboratory air that usually contains water vapor.

A Nd:YAG laser device generates the laser plasma with pulse widths in the range of 6 ns to 14 ns, pulse energies in the range of 100 mJ to 800 mJ, and for peak irradiance of the order 1 to 10 TW/cm^2. Atomic line profiles yield electron density and temperature from fitting of wavelength- and sensitivity- corrected spectral radiance data. Analysis of measured diatomic laser-plasma emission data yields excitation temperature of primarily molecular recombination spectra [5]. Applications include diagnosis of astrophysics white dwarfs [6, 7] and exoplanet spectra [8].

References

[1] C.G. Parigger, Spectrochim. Acta Part B: At. Spectrosc. **79-80**, 4 (2013).
[2] C.G. Parigger, L.D. Swafford, D.M. Surmick, M.J. Witte, A.C. Woods, G. Gautam, J. Phys.: Conf. Ser. **548**, 012043 (2014).
[3] H.-Y. Moon, K.K. Herrera, N. Omenetto, B.W. Smith, J.D. Winefordner, Spectrochim. Acta Part B: At. Spectrosc. **64**, 702 (2009).
[4] G. Gautam, C.G. Parigger, D.M. Surmick, A.M. EL Sherbini, J. Quant. Spectrosc. Radiat. Transfer **170**, 189 (2016).
[5] C.G. Parigger, A.C. Woods, D.M. Surmick, G. Gautam, M.J. Witte, J.O. Hornkohl, Spectrochim. Acta Part B: At. Spectrosc. **107**, 132 (2009).
[6] R.E. Falcon, G.A. Rochau , J.E. Bailey, J.E., T.A. Gomez, M.H. Montgomery, D.E. Winget, T. Nagayama, Astrophys. J. **806**, 214 (2015).
[7] C.G. Parigger, K.A. Drake, C.M. Helstern, G. Gautam, Atoms **6**, 30036 (2018).
[8] J. Tennyson, S.N. Yurchenko, Atoms **6**, 20026 (2018)