H_2 A CENTURY AFTER LYMAN

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Exactly a century ago Lyman reported on the first spectroscopic identifictaion of the hydrogen molecule [a]. Over the years past many spectroscopists have searched for spectral signatures of the smallest neutral molecule, which has become the fundamental test system for quantum chemical *ab initio* calculations. Experimental work on H_2 and its isotopomers is more difficult than in other systems because electronic absorption occurs only at wavelengths $\lambda < 100$ nm; the vibrational spectrum is extremely weak due to the inversion symmetry; due to the low nuclear mass spectra are not organized in bands as bands but rather occur as randomly organized lines; isotopic substitution is not helpful because it gives rise to another set of randomly appearing lines. In the past decade we have employed laser based techniques to unravel new spectral structures in hydrogen and measure at high resolution. Specific breakthroughs are the use of a narrowband tunable laser in the extreme ultraviolet domain and of multiple-resonance techniques involving XUV photons. These studies have led to: the observation of high-lying double-well structures of *gerade* symmetry [b]; the observation of a double-well structures of *ungerade* symmetry [c]; the observation of strong *u-g* symmetry breaking [d]; the observation of heavy Rydberg states of the H^+H^- system [e]. From a comparison of extremely accurate calibration of Lyman and Werner transitions, and by comparing the laboratory results with absorptions in spectra of quasars that have occured 12 Billion years ago, a rather strict constraint can be set om a possible variation of the proton-to-electron mass ratio [f].

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[a] T. Lyman, Astroph. J. 19, 263 (1904).
[b] E. Reinhold, W. Hogervorst, and W. Ubachs, Phys. Rev. Lett. 78, 2543 (1997).
[c] A. de Lange, E. Reinhold, and W. Ubachs, Phys. Rev. Lett. 86, 2988 (2001).
[d] A. de Lange, E. Reinhold, and W. Ubachs, Int. Rev. Phys. Chem. 21, 257 (2002).
[e] E. Reinhold and W. Ubachs, Phys. Rev. Lett. 88, 013001 (2002)
[f] W. Ubachs and E. Reinhold, Phys. Rev. Lett. accepted (2004).