

# PTPC2019

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## On the ionization and dissociation energies of molecular hydrogen and metastable helium ( $\text{He}_2$ )

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Few-electron molecules represent attractive systems for precision spectroscopy because their properties can be calculated with extraordinary accuracy by ab initio quantum-chemical methods. [1,2] Comparing experimental and theoretical results thus offers the opportunity to assess the limitations of ab initio calculations, ultimately and ideally at the level where their accuracy is limited by either the uncertainties of the fundamental constants or so far unrecognized physical effects. We present the results of precision measurements in cold samples of hydrogen ( $\text{H}_2$ ) and metastable  $\text{He}_2$  molecules. The cold-molecule samples are prepared in supersonic beams using pulsed cryogenic valves and, in the case of metastable  $\text{He}_2$ , a multistage Zeeman decelerator.

In the case of the metastable a  $^3\Sigma_u^+$  state of  $\text{He}_2$ , we exploit multistage Zeeman deceleration to prepare slow beams of cold and fully magnetized molecules in selected spin-rotational components. [3] We use the long transit times of these molecules through microwave and laser fields to carry out highly precise measurements of (i) fine-structure intervals in the metastable a state, (ii) the frequencies of transitions to high Rydberg states of  $\text{He}_2$ , and (iii) the spin-rovibrational energy level structure of the  $X^+ \ ^2\Sigma_u^+$  ground state  $\text{He}_2^+$  by Rydberg-series extrapolation. [4]

In the case of  $\text{H}_2$ , we measure transitions from selected rovibrational levels of the  $\text{GK} \ ^1\Sigma_g^+$  state to high Rydberg states belonging to p and f series converging on different rovibrational levels of  $X^+ \ ^2\Sigma_g^+$  ground state of  $\text{H}_2^+$ . The transition frequencies are determined with a relative precision ( $\Delta\nu/\nu$ ) of  $2 \cdot 10^{-10}$ . [5] Extrapolation of these series by multichannel quantum defect theory enables us to determine the spin-rovibrational intervals of  $\text{H}_2^+$  and the dissociation energy of  $\text{H}_2^+$  at unprecedented accuracy. [6] The relevance of these results in the context of measurements of fundamental constants and elementary-particle properties will be discussed.

### References

- 1\ V. I. Korobov, L. Hilico and J.-P. Karr, Phys. Rev. Lett., 118 (2017) 233001.
- 2\ M. Puchalski, J. Komasa and K. Pachucki, Phys. Rev. A, 95 (2017) 052506
- 3\ P. Jansen, L. Semeria, L. Esteban Hofer, S. Scheidegger, J. A. Agner, H. Schmutz and F. Merkt, Phys. Rev. Lett., 115 (2015) 133202.
- 4\ P. Jansen, L. Semeria and F. Merkt, Phys. Rev. Lett., 120 (2018) 043001.
- 5\ M. Beyer, N. Hölsch, J. A. Agner, J. Deiglmayr, H. Schmutz and F. Merkt, Phys. Rev. A, 97 (2018) 012501; 039903(E).
- 6\ C.-F. Cheng et al., Phys. Rev. Lett. 121, (2018) 013001

### Summary

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