SPIN-SPIN AND SPIN-ROTATION FINE STRUCTURE OF THE METASTABLE $a\,^3\Sigma_u^+$ STATES OF MOLECULAR HELIUM

PAUL JANSEN, LUCA SEMERIA, FREDERIC MERKT, *Laboratorium für Physikalische Chemie, ETH Zurich, Zurich, Switzerland.*

In a recent series of experiments[a,b], we have determined term values of all rotational levels of the $X^+\,^2\Sigma_u^+$ $(\nu^+ = 0)$ ground vibronic state of $^4He_2^+$ with rotational quantum number $N^+ \leq 19$ at an accuracy of 25 MHz using MQDT-assisted Rydberg-series extrapolation of metastable helium molecules in the $a\,^3\Sigma_u^+$ state. The precison of these experiments was limited by the 150 MHz linewidth of the pulsed laser system employed. In order to improve our resolution and possibly observe the spin-rotation splitting in the He_2^+ ion, we have replaced the pulsed laser by a CW laser system with a bandwidth of 1.5 MHz. This system was used to measure the spin-spin and spin-rotation fine structure of metastable He_2 in the $a\,^3\Sigma_u^+$ $(\nu'' = 0)$ state. Metastable helium molecules were produced by striking a discharge in an expansion of neat helium gas. By cooling the source to a temperature of 10 K, the velocity of the molecular beam was reduced to 500 m/s and an experimental Doppler-limited linewidth of 25 MHz was observed. Fine-structure splittings for all rotational levels with $N'' \leq 27$ have been measured at an accuracy of 5 MHz and, when possible, have been compared to the values reported in earlier investigations.[c,d,e,f] This comparison revealed a discrepancy that increased with increasing values of N''. To verify our results, we have recently constructed a variaton of a classical molecular-beam magnetic-resonance setup that uses a multistage Zeeman decelerator and a RF stripline for de- and repopulation of the F_2 spin-rotational components with $J'' = N''$, respectively.

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