SPECTROSCOPIC CHARACTERIZATION OF THE $A^1\Pi, v = 6 \leftrightarrow b^3\Sigma^+, v = 5$ INTERACTION OF ALUMINUM MONOFLUORIDE IN VIEW OF LASER COOLING AND TRAPPING EXPERIMENTS

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Aluminum monofluoride (AlF) is an excellent candidate for laser cooling.[a] All Q-lines of the strong $A^1\Pi \leftarrow X^1\Sigma^+$ transition are rotationally closed and thereby suitable for the main cooling cycle, while the spin-forbidden $a^3\Pi \leftarrow X^1\Sigma^+$ transition can be used to achieve final temperatures in the μK range. In view of cooling and trapping experiments, it is essential to have a detailed insight into the energy structure of the directly and indirectly involved states.

The $A^1\Pi, v = 6, J = 1$ and the $b^3\Sigma^+, v = 5, N = 2$ levels are very nearly iso-energetic and strongly interact.[b] Consequently, these levels have a mixed singlet and triplet character. The triplet character of the $A^1\Pi$ state causes a loss from the main laser cooling cycle that has been studied previously.[c] Furthermore, these states with their mixed character are particularly suited as doorway states between the singlet and the triplet manifold for ultracold experiments on AlF.

We completed an extensive rotationally resolved spectroscopic investigation of energy levels in this perturbed range using optical-optical double resonance ionization, followed by mass-selective ion detection. Subsequently, we performed hyperfine resolved excitation with a cw laser, using laser induced fluorescence for detection. Both measurement schemes were employed on a supersonic, pulsed molecular beam. The lifetimes of the perturbed levels cover two orders of magnitudes (about $2 - 200$ ns), which requires different experimental techniques to determine their exact values. Lifetimes of selected levels have been measured using e.g. time delayed ionization and Lamb-dip experiments. The fine- and hyperfine structure parameters as well as the spin-orbit interaction parameter are determined from the experimental data.

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[a] Truppe et al., Physical Review A 100, 052513 (2019)
[b] Barrow et al., Physica Scripta 10, 86 (1974)
[c] Doppelbauer et al., Molecular Physics 119(1-2), e1810351 (2020)