Negative ion resonances (NIRs) have been extensively studied, in large part because the properties of these systems are dominated by electron correlation effects. Studies of NIRs in static electric fields can yield useful information on the dynamic stability of ions and reveal the presence of non-optically accessible resonance states. The effects of electric fields on NIRs have previously been investigated experimentally only for the simplest negative ion, $^-$.[1,2] In the present work, we report the first measurements of electric field effects on non-hydrogenic NIRs. Photodetachment spectra were measured in fields up to several kV/cm in the vicinity of the $s^2p^2\,^4P_e$ shape resonance of He and the $^1P_o$ Feshbach resonances of Rb (5p6s) and Cs (6p7s+6p5d).

In the experiment, a 1-4 keV mass-selected ion beam is perpendicularly intersected with a pulsed tunable OPPO/laser beam in a uniform electric field.[3] Relative total photodetachment cross sections are measured by detecting the fast neutral atoms produced by detachment.

The photodetachment spectrum of Rb with and without an applied electric field is shown in Fig. 1. The electric field removes the zero in the cross section caused by the Feshbach resonance. Interpretation of the spectra is complicated by electric-field induced tunneling to the neutral excited state just above the resonance (5p $^3P_{1/2}$). The partial cross section to the excited state is subtracted from the total cross section by using the previously measured ground state-excited state branching ratios [4] modified by tunneling [3]. The width of the remaining resonance dip increases by a factor of ~3 from zero field up to 1500 V/cm (Fig. 2). This broadening may be caused by a reduction of the effective lifetime of the resonance due to tunneling or Stark mixing with shorter-lived autodetaching states.

In contrast, the photodetachment spectra near the Feshbach resonance of Cs and the shape resonance of He showed no changes due to applied electric fields up to 2.0 kV/cm and 8.0 kV/cm, respectively. Thus, these NIRs remain stable at field strengths that lead to significant changes for Rb. The results for the different ions will be compared and discussed.

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References