Lifetimes of bound excited states of Pt^-

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Synopsis Measurements of the radiative lifetimes of the two excited states of the platinum anion Pt^- are presented. Pt^- ions stored in the cryogenic ion storage ring DESIREE were photodetached at different photon wavelengths and the resulting yield of neutral Pt measured as a function of time was recorded. Analysis of the neutral decay curves show a 2.54 ± 0.10 s lifetime for the higher-lying $5d^{10}6s\ ^2S_{1/2}$ excited state and a lifetime in the range of 50–200 ms for the lower-lying $5d^96s^2\ ^2D_{3/2}$ excited state. This is the first study to report the lifetime of a bound anion excited state with an electron configuration different from that of the anion ground state.

Anions have long been fascinating systems to study. They are a testament to the subtle nature of electronic structure and dynamics on the atomic scale, with complex electron correlation effects responsible for their very existence. Properties such as bound state lifetimes are crucial in developing a theoretical understanding of these correlation effects. Measurements of these lifetimes provide critical benchmarks for theoretical methods treating these effects in anions and more general atomic systems.

We present studies of Pt^- conducted at the cryogenic electrostatic ion storage ring DESIREE [1, 2]. The storage temperature of 13 K results in pressures on the order of 10^{-14} mbar, significantly reducing ion losses due to collisions with residual gases. Photodetachment due to thermal blackbody radiation is also reduced, an important consideration for loosely-bound systems such as anions. DESIREE's capabilities for studying anion excited state lifetimes were recently demonstrated by lifetime measurements of the $3p^5\ ^2P_{1/2}$ excited state of the sulfur anion [3] and the $3d^94s^2\ ^2D_{3/2}$ excited state of the nickel anion [4].

In the present experiment [5], Pt^- anions were stored in DESIREE, with storage times of ~950 s. State-selective photodetchment was used on the stored Pt^- beam: 550 nm photons detached all three bound states of Pt^-, 750 nm photons detached the $5d^96s^2\ ^2D_{3/2}$ and $5d^{10}6s\ ^2S_{1/2}$ excited states, and 1360 nm photons detached only the $^2S_{1/2}$ state.

Analysis of decay curves due to photodetachment (Figure 1) yield a radiative lifetime of 2.54 ± 0.10 s for the $^2S_{1/2}$ excited state. Decay to the $5d^96s^2\ ^2D_{5/2}$ ground state of Pt^- proceeds via an electric quadrupole (E2) transition, the first of its kind to be observed in an anion. Measurement of the $^2D_{3/2}$ excited state, which decays via a magnetic dipole (M1) transition to the ground state, is complicated by its faster decay compared to the higher-lying $^2S_{1/2}$ state. As a result, only a lifetime in the range of 50–200 ms could be estimated for the $^2D_{3/2}$ excited state.

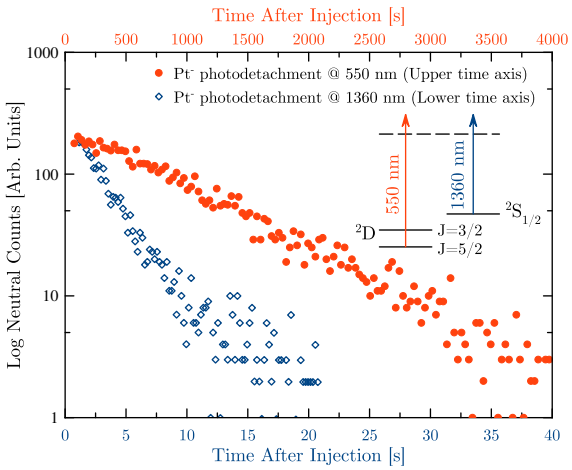

Figure 1. Neutral counts for Pt^- photodetachment at 550 nm and 1360 nm photon wavelengths. The decay curve measured at 550 nm yields the storage time of Pt^- ions in the ring (~950 s).

References

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