RELATIVE CROSS SECTIONS FOR THE ELECTRON IMPACT SINGLE DETACHMENT ON Li^-

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Introduction

The Electron Impact Single Detachment, EISD, process on Li^- targets was studied using CRYRING. The Li^- anion was quite extensively documented, both experimentally and theoretically, and special emphasis was put on the strongly correlated doubly excited states in Li^- (Ljungblad *et al.* [1], Haeffler *et al.* [2], Starace and co-workers [3-4], Lindroth [5]).

One application of lithium of noticeable interest concerns its possible use in fusion reactors. The main advantage of lithium in a reactor is to ensure tritium breeding, and technologically, it works up as a coolant. The DEMO types of reactors presently under development are also based on the use of high-temperature liquid lithium [6] and therefore all the gas phase atomic rates as well as the data about surface interactions not yet documented, are badly needed. In that respect, it is important to know the energy dependent cross-sections for the various collisional processes, and this might include anions.

Experimental configuration and results

The target ions were produced in a caesium sputter ion source, with LiH as the cathode material. Three electronic states of Li^- are bound states, the $1s^22s^2\ ^1S$ ground state, $1s2s2p^2\ ^5P$ and $1s2p^3\ ^5S$ states, with binding energies of 0.618 [7], 0.505 and 0.291 eV [8-9], respectively. If ever produced, the ^5S state would have decayed rapidly within the time scale of our experiment, since it decays to the ^5P in about 3 ns [9]. The radiative transition ^5P-^1S is spin forbidden and the only remaining (destructive) stabilisation of the ^5P system is the autoionisation, with (much) longer mean lifetime (not documented in the literature, but likely in the millisecond range at the most). Therefore, we are confident that our target beam was consisted exclusively of the ^1S ground state. The data analysis procedure was the usual one, but since the current of the target ions circulating in the ring was below the sensitivity of the current transformer, we could only quote relative cross sections, even if a precise estimation of the absolute magnitude can be provided.

Our cross-section curve displays the expected trend for an electron impact detachment process: its rises from zero, at threshold, to a maximum value and then decreases monotonically according to the Bethe-Born formalism. We only display here the near threshold cross-section curve, using an accurate scaling law that could be derived from various storage ring data about the EISD mechanism. Together with our experimental data is a fit (in full line) using a classical model by Andersen *et al.* [10], in which it is assumed that the incoming electron experiences a purely repulsive Coulomb potential. The near threshold cross-section versus collision energy is expressed as:

$$\sigma = p\pi R^2\left(1-\frac{E_{th}}{E}\right)$$

where the factor p depicts the probability for the detachment process to occur within the reaction radius *R*. This latter parameter R is related to the threshold E_{th} and to the spatial extension of the valence electrons a, by:

$$R=\frac{1}{E_{th}}=\left(\frac{E_B}{a}\right)^{-1/2}.$$

The R and a parameters on one hand, the threshold E_{th} and binding E_B energies on another hand, are expressed in atomic units, respectively. From the fit, we obtained a probability p=0.086 and a reaction radius R=19.4 a_0. Consequently, the apparent threshold and spatial extension are $E_{th}=0.0515\,\text{Hartree}=1.4\,\text{eV}$ and 8.6 a_0, respectively. The value for the spatial extension is about twice larger than the classical radius of the $Li^-(^1S)$ anion, thus 4.9 a_0 [11]. We are confident with the parameters extracted from the classical model, especially since these are in the same order as those obtained for D^-, similar to Li^- from many aspects, and obtained by Andersen *et al.* [10].

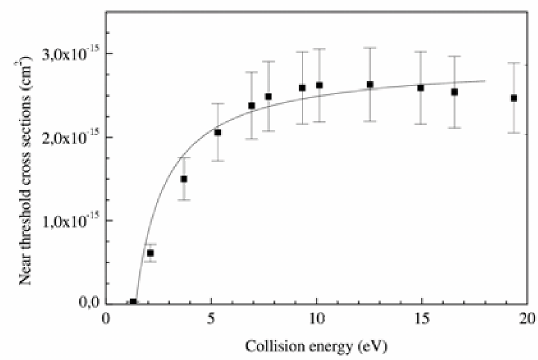

Fig. 1. Near threshold cross sections for Li^- + e

Conclusions

In this report, we have presented our results concerning the Electron Impact Single Detachment on Li^-. We found the detachment threshold at about 1.4 eV, more than twice the electron affinity of Li, thus 0.618 eV. This is a common feature to all of the atomic anions studied so far, as it has to do with the Coulomb repulsion between the electron and the negative ion target. The cross section increases monotonically up to a certain value, that we believe to be in the range 2.75-3x10^{-15} cm^2, and then decreases according to the Bethe-Born formalism.

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References

[1] U. Ljungblad, D. Hanstorp, U. Berzinsh and D.J. Pegg, Phys. Rev. Lett., **77**(18) (1996) 3751.

[2] G. Haeffler, I. Kiyan, U. Berzinsh, D. Hanstorp, N. Brandefelt, E. Lindroth and D.J. Pegg, Phys. Rev. A **63** (2001) 053409.

[3] C.N. Liu and A.F. Starace, Phys. Rev. A **58**(6) (1998) 4997.

[4] C. Pan, A.F. Starace and C.H. Greene, Phys. Rev. A **53**(2) (1996) 840.

[5] E. Lindroth, Phys. Rev. A **52**(4) (1995) 2737.

[6] L.G. Golubchikov, V.A. Evtikhin, I.E. Lyublinski, V.I. Pistunovich, I.N. Potapov and A.N. Chumanov, J. Nucl. Materials **233-237A** (1996) 667.

[7] G. Haeffler, D. Hanstorp, I. Kiyan, E.E. Klinkmüller, U. Ljungblad and D.J. Pegg, Phys. Rev. A **53**(6) (1996) 4127.

[8] T.A. Patterson, H. Hotop, A. Kasdan, D.W. Norcross and W.C. Lineberger, Phys. Rev. Lett. **32** (1974) 189.

[9] C.F. Bunge, Phys. Rev. Lett. **44** (1980) 1450.

[10] L.H. Andersen, D. Mathur, H.T. Schmidt and L. Vejby-Christensen, Phys. Rev. Lett. **74** (1995) 892.

[11] V.V.S.S. Sai Sunder and K.D. Sen, Chem. Phys. Lett. **162**(3) (1989) 185.