§1. Evaluation of Atomic Data for Lithium Ions

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Injection of tracer encapsulated solid pellets has been proposed to diagnose particle transport in plasma of the LHD and the CHS. Lithium is considered as a tracer and the pellet consists of polystyrene shell and LiH core. When the pellet is injected into a plasma, it is ablated near the central region of plasma and Lithium is ionized in a short period. Simultaneous injection of a hydrogen neutral beam (NBI) causes the charge transfer process mainly between Li^{3+} ion and H atom, producing Li^{2+} ion. Measurement of emission lines from lithium ions can be used to diagnose particle transport as well as plasma parameters. We need reliable atomic data for diagnostics and plasma modeling. This working group aims to search atomic data relevant for this research and to evaluate data.

The spectral lines used for the measurement are Li I λ 670.8nm (2p ^{2}P $\rightarrow$ 2s ^{2}S), Li II λ 548.5nm (2p ^{3}P $\rightarrow$ 2s ^{3}S), and Li III λ 449.9nm (5g ^{2}G $\rightarrow$ 4f ^{2}F). The Li III line is the transition from high n (principal quantum number) level and atomic data for such high n levels are required. Some experiments in CHS and LHD had been done with the pellets and these spectral lines were measured. To model these spectral lines, state selective rate coefficients of all atomic processes are necessary.

We had carried out almost complete search for charge transfer cross section data of Li ions with neutral hydrogen in 1999 and continuously in 2000 we searched for some lacked data, such as cross sections for higher n states or for lower energy. The ADAS data package has the cross section data of Li^{3+} up to $n = 6$ states, but none is found for other higher states for wide energy range.

For modeling spectral lines and for more convenient use of atomic data generally, analytic form which represents recommended data is more preferable. We have tried to fit the cross sections with polynomial function of $(\log E)^n$ where E is the incident energy of neutral hydrogen. Figure 1 shows examples of the cross section data with a fitted polynomical function $\sum_n C_n(\log E)^n$ with $-13 \leq n \leq 13$ and C_n is a fitting parameter. In order to get a good fit, we need such a higher order polynomial function. Even so, the behavior of the fitting function at the low energy region looks strange. Since the fitting function is valid only for energy region where atomic data exit, the function at lower energy $E \lesssim 10^3$eV without any atomic data behaves strangely sometimes and are not reliable. Indeed, some ions which have theoretically calculated cross sections at lower energy region shows resonant osicllating feature in the cross sections. Simple extrapolation of fitting functions could lead wrong cross sections for such low energy region. Even if experiments in LHD and CHS plasmas do not need charge transfer cross sections at such low energy, it is better to have ones to get better fitting functions.

At the same taime, we need a method of fitting with non-linear functions with smaller number of fitting parameters, which would behave better for wide energy range.

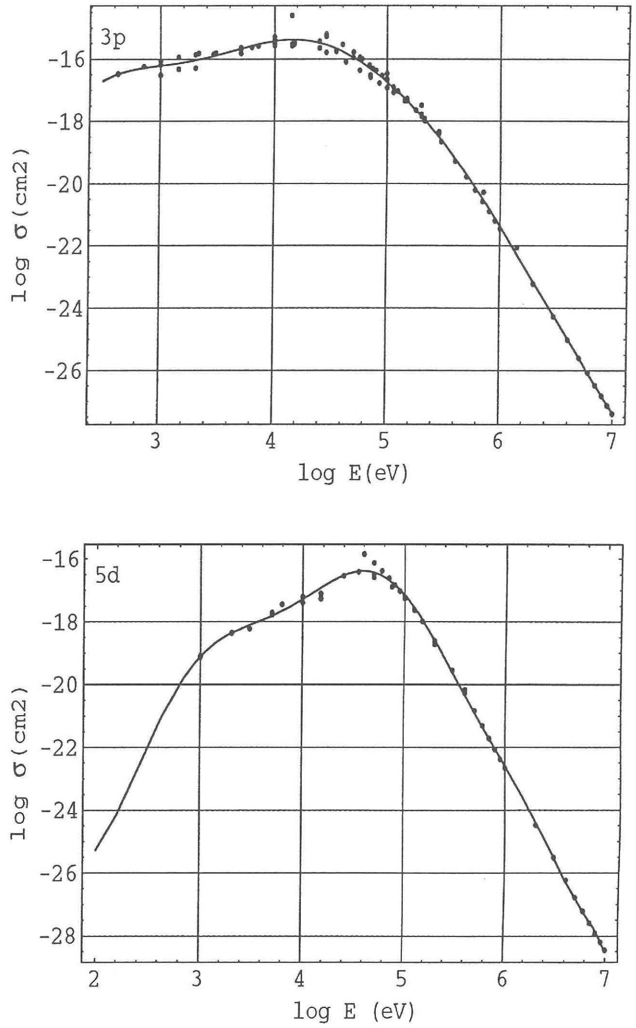

Fig. 1: Charge transfer cross sections for $Li^{3+} + H(1s) \rightarrow Li^{2+}(nl)$ as a function of incident energy of H. Dots are atomic data and solid line is fitted function. The upper panel is for $Li^{2+}(3p)$ and lower panel is for $Li^{2+}(5d)$.