§15. Measurement of the Ionization Cross Sections of Rare Gas Atoms

Nishimura, H. (Niigata Univ. Sci.)
Sakae, T. (Kyushu Univ. Eng.)
Tawara, H.

For the protection of the inner surface of the vacuum vessel for the magnetically confined high plasma a method called the "radiative plasma cooling" is under considered. For designs of such apparatus, various reliable cross section data involving heavy rare gas atoms are needed. Although a lot of experimental results have been reported so far, those are still not sufficient. As a first step of our systematic studies of the cross sections for rare gas atoms, we have measured the total ionization cross sections Q_i for electrons in the energy range from threshold to 3 keV. The apparatus used in this study is the same as that described in a previous report[1]. The measured Q_i for He, Ar, Kr and Xe are shown in Fig.1 together with those of Rapp[2], and those of Schram[3]. Slight discrepancies have been seen among the present results and those of published data. This may be due to the absolute pressure determination in the collision cell. At sufficiently high electron energies Q_i is given by Bethe's asymptotic formura

$$Q_i = \frac{4\pi a_0^2 R}{E} M_I^2 \ln \frac{4c_i E}{R}, \qquad (1)$$

where the notations in eq(1) are as usual. Fitting eq (1) to the measured Q_i at energies above 600 eV, the values M_I^2 can be determined. These are listed in Table I. The discrepancy of the present results from the available data is small

Table I: M_I^2

He	Ar	Kr	Xe
0.59	5.8	9.1	16

for He but increase with high z atoms. As previously reported[4], the dependence of Q_i on the total number of electrons z and on the dipole polarizability α have been examined. These values Q_i/z and Q_i/α are shown in Fig.2.

The present results suggest that Q_i relate closely to the sum rules of various moments of oscillator strengths S(0), S(-1) and S(-2) which were discussed in detail by Inokuti[5].

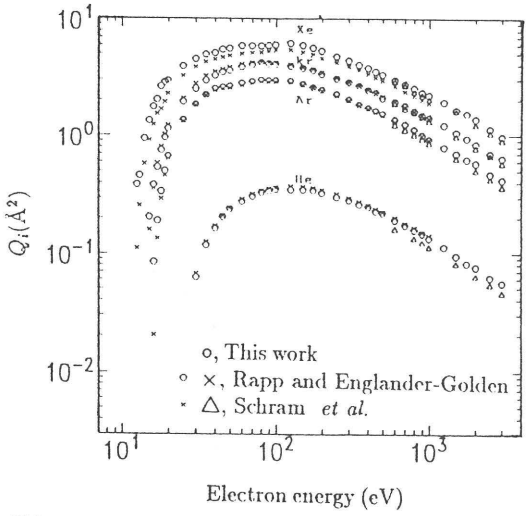

Fig.1. Total electron impact ionization cross sections Q_i v.s. electron energy.

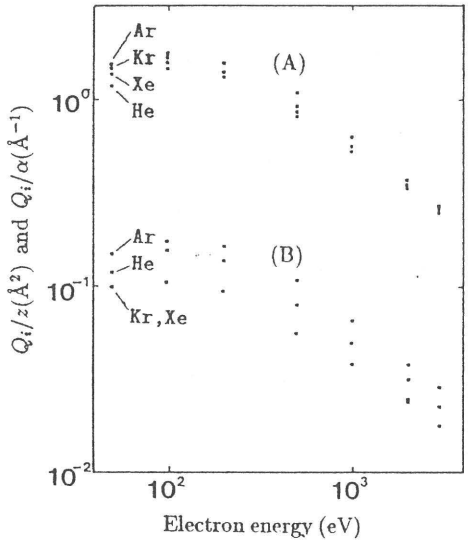

Fig.2. (A):Q_i/α and (B):Q_i/z v.s. electron energy.

References

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