VELOCITY DEPENDENCE OF THE PENNING AND ASSOCIATIVE IONIZATION CROSS SECTIONS OF Ar ATOMS BY He (2^3S) AND He (2^1S) ATOMS

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The velocity dependence of both the Penning and associative ionization cross section σ_{PI} and σ_{AI} of Ar atoms by He (2^3S) and He (2^1S) metastable atoms, and of their sum $\sigma_T = \sigma_{PI} + \sigma_{AI}$, is measured in the velocity range 1200-4500 m/sec (30-400 meV) in a crossed-beam experiment by a time-of-flight technique. Characteristic cross-section ratios σ_{AI}/σ_T and σ_T(Singlet)/σ_T(Triplet) are reported along with the relative magnitude of the cross sections σ_{AI}, σ_{PI}, σ_T. The measurements clearly show a difference in the reaction mechanisms involving He (2^3S) and He (2^1S). This difference appears not only in the ratio σ_{AI}/σ_T, whose magnitude reaches 19% and 38% for He (2^3S) and He (2^1S) respectively at the velocity v = 1200 m/sec (30 meV), and in the ratio σ_T(Singlet)/σ_T(Triplet), which increases from 0.5 to 3.8 for velocity decreasing from 4500 m/sec to 1200 m/sec, but also in the different shapes of the σ_{AI} and σ_{PI} cross sections for He (2^3S) and He (2^1S) (Figs 1 and 2).

A theoretical interpretation for He (2^3S) + Ar, based on the model of Nakamura /1/, gives a total cross section $\sigma_T(v)$ and partial cross sections $\sigma_{AI}(v)$ and $\sigma_{PI}(v)$ in good agreement with our experimental results, with a probability of autoionization of $He^* + Ar$, $\Gamma(R) = Ae^{-R/B}$ where A = 4000 a.u. and B = 0.360 a.u. (Fig. 1).

The $He+Ar^+$ potential curve which is thus derived exhibits (Fig. 3) a well depth of 16.5 meV and has a minimum located at about 5.8 a.u. /2/ These values are in good agreement with the well depth (18.3 meV - 5.7 a.u.) estimated by using the $Ar + He^+$ potential curve obtained from differential scattering measurements /3/ and scaling to the different polarisabilities of He and Ar. The well depth and its position are also in good agreement to the values (16.7 meV-5.7 a.u.) estimated by adding the charge induced dipole term $-\alpha_{He}/2\,R^4$ to the He+Ar potential curve derived by differential scattering /4/.

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/5/ C.H. Chen, H. Haberland and Y.T. Lee, J. Chem. Phys. 61, 3095 (1974).

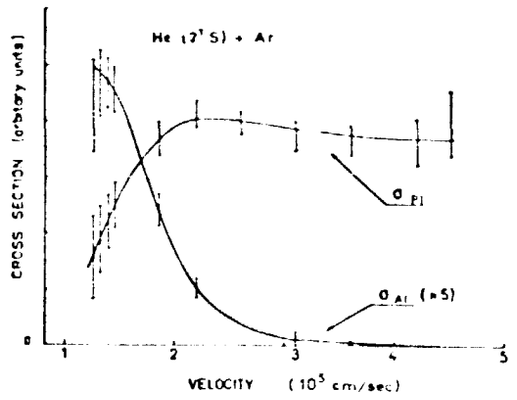

Fig. 1 : Associative and Penning ionization cross sections for He (2^1S) + Ar interaction.

—— Present experimental work (a smooth curve has been drawn through about 200 points; typical error bars are shown).

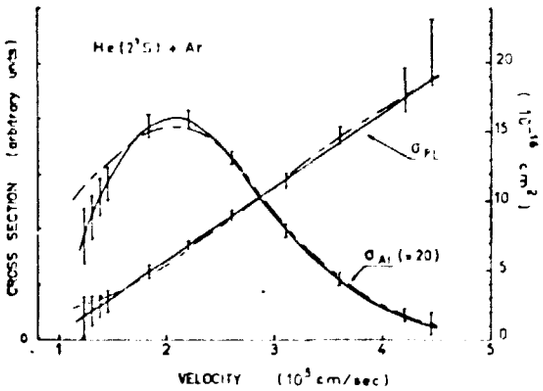

Fig. 2 : Associative and Penning ionization cross sections for He (2^3S) + Ar interaction.

—— Present experimental work (as in Fig. 1).

– – Present theoretical work.

The experimental results are relative. However an absolute scale, shown on the right side of the figure, has been obtained by theoretical calculations.

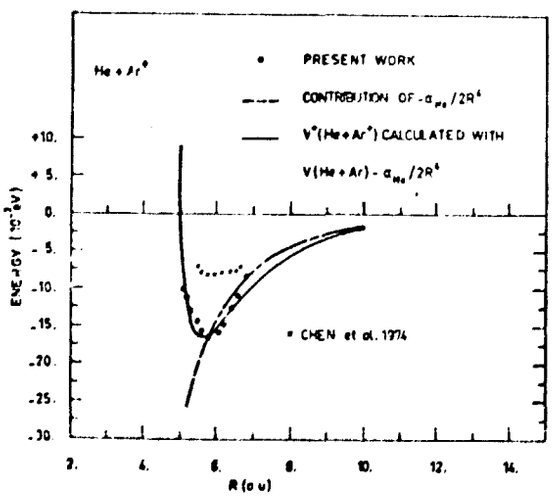

Fig. 3 : V^+ (He + Ar^+) potential curve.

• • Present work.

Comparison with :

—— V^+ (He + Ar^+) calculated with V (He + Ar) - αHe /2R^4

× × V^+ (He + Ar^+) given by Chen et al. 1974 /5/.