A UNIVERSAL FUNCTION FOR IONIZATION OF ATOMS BY STRUCTURELESS CHARGED PARTICLES OF ARBITRARY MASS AND CHARGE

O. BELY and P. FAUCHER
Observatoire de Nice, Nice, France

The collisional ionization of atomic systems by structureless charged particles of arbitrary mass and charge is considered. For the theoretical study, the classical impulse approximation is used. In this case, analytical expressions Q for the ionization cross-sections are given by Garcia *et al.* (1968). From these expressions, a reduced cross-section Q^R is obtained as a function of a scaled energy X. It is found that, for a particle of mass M, charge Z, and energy E, incident on a target having ξ equivalent electrons with a binding energy I, Q^R is given by:

$$Q^R = \left(\frac{I}{I_H}\right)^2 \xi^{-1} Z^{-2} \left\{1 + \frac{m_e}{M[1 + (\log_{10} X)^2]}\right\} Q, \tag{1}$$

where

$$X = 1 + \frac{m_e}{M}\left[\frac{E}{I} - 1\right] \tag{2}$$

I_H is the hydrogen ionization potential and m_e is the electron mass.

The curves of the reduced cross-sections Q^R as a function of $\log_{10} X$, for values of M lying between 1 and ∞, can be represented by a unique curve within better than 20%, in the low and medium energy range ($X \leqslant 100$).

The experimental reduced cross-sections available for electron impact and for proton impact, can be represented by a unique curve within a factor of 2. This curve agrees with the theoretical one to within a factor of 2 in the considered energy range, and can be fitted by the following analytical expression:

$$Q^R = \left[2.284 \frac{\ln X}{X} + 2.023 \frac{X - 1}{X^2} - 1.699 \frac{X - 1}{X^3}\right] 10^{-16}\,\mathrm{cm}^2 \tag{3}$$

At high impact energy, i.e. for $X \geqslant 100$, classical mechanics limits the validity of the universal reduced cross-section and, at low energy, the classical impulse approximation is valid only if the collision-time is much smaller than the orbital time of the atomic electron. For attractive potentials, this is always true, but in the repulsive case, this condition depends on M. Thus, for ionization of positively (negatively) charged targets by protons (electrons) X must satisfy $X \geqslant 1.05$ ($X \geqslant 100$). This means that the proposed method is unsuitable for the ionization of negative ions by electrons.

Space Science Reviews **13** (1972) 588. *All Rights Reserved*