Improved Gaunt Factors for Van Regemorter Formula.

Fisher, V., Bernshtam, V., Golten, H., Maron, Y. (Dept. of Particle Physics, Weizmann Institute of Sciences, Rehovot 76100 Israel)
Tawara, H.

At present, any excitation cross section of atom or ion may be calculated quite accurately using one of computer codes designed for this purpose. Some cross sections (calculated or experimentally determined) may be found in atomic data bases and publications. But in many cases it is desirable to have convenient formula for immediate estimate of a few cross sections or for computer simulations which require for many thousands of collisional transitions. Widely used Van Regemorter formula

$$\sigma_{qq'}(x) = \frac{8\pi^2 a_0^2}{\sqrt{3}} \frac{I_{qq'} f_{qq'}}{E_{qq'} x} G(x)$$

is applicable to optically allowed (electric dipole) transitions. Here $\sigma_{qq'}(x)$ is the cross section for transition from quantum state $q$ into quantum state $q'$ (inverse transition $q' \Rightarrow q$ has to be optically allowed for spontaneous emission), $x = e / E_{qq'}$, $e$ is the incident electron energy, $E_{qq'}$ is the transition energy, $I_{qq'}$ is the Rydberg unit, $f_{qq'}$ is the oscillator strength for absorption, and $G(x)$ is the Gaunt factor.

Simple expression $G(x) = (3/2\pi \ln x)$ provides Bethe asymptotic of the cross sections, but for some species the cross sections calculated using this expression may be inaccurate up to an order of magnitude. To provide more precise calculations, Gaunt factors have to be different for different classes of optically allowed transitions. Here we report on Gaunt factors for atoms and demonstrate an accuracy of proposed expressions.

To infer these expressions, we used all available experimental data on optically allowed excitation of atoms by electron impact (single-electron transitions in the outer $\ell = 0$ - subshell, $\Delta S = 0$, $\Delta \ell = \pm 1$).

For transitions with no change of principal quantum number ($\Delta n = 0$) we suggest an expression

$$G(x) = (0.41 - 0.3/x) \ln x.$$

For transitions with $\Delta n > 0$ we suggest

$$G(x) = \frac{3/2}{2\pi} - 0.205/x \ln x.$$

One can see that these expressions provide rather good fit to the values $G(x)$ obtained from experimental data (total 1020 experimental points for 23 cross sections discussed in 55 publications, taking no more than 30 points from one publication for one cross section):