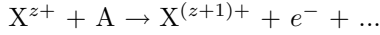


# Stripping of Fast Heavy Low-Charged Ions in Gases

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Electron loss and capture processes arising in collisions of heavy low-charged ions with atoms and ions are the main charge-changing reactions in heavy-ion driven inertial fusion (HIDIF) [1]. However, at present time, virtually no experimental and theoretical data are available for removal processes involving fast heavy low-charged ions.

In this work, the projectile-ionization (stripping) cross sections and beam lifetimes in reactions



have been calculated for ions  $X = \text{Xe}, \text{Pb}, \text{Bi}, \text{U}$  ( $z < 10$ ) colliding with neutral atoms  $A = \text{H}, \text{He}, \text{Be}, \text{C}, \text{F}, \text{N}, \text{Ar}, \text{Xe}$  in the  $E = 1 - 100 \text{ MeV/u}$  energy range. Calculations have been performed for *single*-electron stripping in the first-order perturbation theory using the LOSS computer code. The atomic structure of the target was taken into account in the form of its atomic form-factor  $F(q)$  depending on the momentum transfer  $q$ .

For the case of ionization of Pb-like ions ( $\text{Xe}^{0+}, \text{Bi}^{1+}, \dots, \text{U}^{10+}$ ) and the energy range considered, a scaling law for stripping cross sections was obtained in the form:

$$\tilde{\sigma} = \sigma \cdot (I_P/Z_T)^{1.4}, \quad \tilde{E} = E/I_P, \quad (1)$$

where  $I_P$  is the *first* ionization potential of the projectile in eV,  $E$  is the beam energy in eV/u, and  $Z_T$  denotes the target nuclear charge. The scaled cross sections for Pb-like ions are displayed in Fig. 1 in comparison with available experimental data and other calculations (see [2] in detail);  $1 \text{ Ry} = 13.606 \text{ eV}$ .

Ion-beam lifetimes  $\tau$  have been calculated with account for electron capture processes using the CAPTURE computer code. The values of  $\tau$  are shown in Fig. 2. A small minimum for  $\text{U}^{28+}$  ions around 2 MeV/u is related to the influence of electron capture which for these ions prevails at energies  $E < 10 \text{ MeV/u}$ .

A comparison of the present calculations with experimental data [3]–[5], classical-trajectory Monte-Carlo (CTMC) calculations [6] and  $Z_T^2 + Z_P$  scaling [7] shows the following peculiarities for the stripping processes of heavy low-charged ions in neutral targets:

1) the contribution from ionization of the projectile inner-shell electrons is very significant, and, in calculations, one has to account for 6–8 inner subshells,

2) at high energies, the stripping cross sections fall off approximately as  $\sigma \sim E^{-1}$ ,

3) multiple-ionization processes seem to play a very important role and, according to [6], their contribution can reach up to 50 % to the total stripping cross section.

## References

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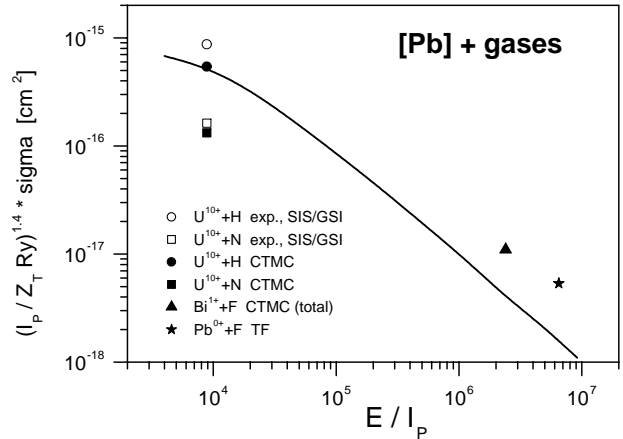


Figure 1: Scaled ionization cross sections of Pb-like ions colliding with neutral atoms, eq. (1). Solid curve – present result, symbols – experimental and theoretical data (see [2] in detail).

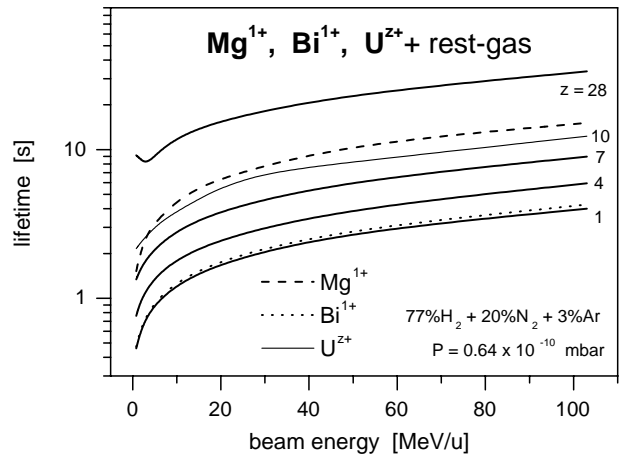


Figure 2: Beam lifetimes of ions colliding with a residual gas mixture and a gas pressure indicated in the figure – present result.

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