

Appendix E

Ionization and Excitation Reaction Rates for Xenon in Maxwellian Plasmas

Ionization and excitation reaction rate coefficients $\langle \sigma v \rangle$ for xenon calculated from the data in Appendix D averaged over a Maxwellian electron distribution are given in Table E-1. Over the ranges indicated, the data can be well fit to the cross section averaged over a Maxwellian distribution times the electron thermal velocity [1], where T_{eV} is in eV. The fits to the calculated values are

Ionization ($T_{eV} < 5$ eV):

$$\langle \sigma_i v_e \rangle \approx \langle \sigma_i \rangle \bar{v}_e = 10^{-20} \left[\left(3.97 + 0.643 T_{eV} - 0.0368 T_{eV}^2 \right) e^{-12.127/T_{eV}} \right] \left(\frac{8eT_{eV}}{\pi m} \right)^{1/2}$$

Ionization ($T_{eV} > 5$ eV):

$$\langle \sigma_i v_e \rangle \approx \langle \sigma_i \rangle \bar{v}_e = 10^{-20} \left[- \left(1.031 \times 10^{-4} \right) T_{eV}^2 + 6.386 e^{-12.127/T_{eV}} \right] \left(\frac{8eT_{eV}}{\pi m} \right)^{1/2}$$

Excitation:

$$\langle \sigma^* v_e \rangle \approx \langle \sigma^* \rangle \bar{v}_e = 1.9310^{-19} \frac{e^{-11.6/T_e}}{\sqrt{T_{eV}}} \left(\frac{8eT_{eV}}{\pi m} \right)^{1/2}$$

Table E-1. Ionization and excitation reaction rates for xenon.

Electron Energy (eV)	Ionization (m ³ /s)	Excitation (m ³ /s)
0.5	4.51×10^{-25}	1.99×10^{-22}
0.6	3.02×10^{-23}	4.01×10^{-21}
0.7	6.20×10^{-22}	3.61×10^{-20}
0.8	6.04×10^{-21}	1.95×10^{-19}
0.9	3.58×10^{-20}	7.44×10^{-19}
1.0	1.50×10^{-19}	2.21×10^{-18}
1.5	1.16×10^{-17}	6.64×10^{-17}
2.0	1.08×10^{-16}	4.02×10^{-16}
2.5	4.24×10^{-16}	1.23×10^{-15}
3.0	1.08×10^{-15}	2.66×10^{-15}
3.5	2.13×10^{-15}	4.66×10^{-15}
4.0	3.59×10^{-15}	7.12×10^{-15}
4.5	5.43×10^{-15}	9.93×10^{-15}
5.0	7.61×10^{-15}	1.30×10^{-14}
5.5	1.01×10^{-14}	1.61×10^{-14}
6.0	1.28×10^{-14}	1.94×10^{-14}
6.5	1.57×10^{-14}	2.26×10^{-14}
7.0	1.88×10^{-14}	2.57×10^{-14}
7.5	2.20×10^{-14}	2.87×10^{-14}
8.0	2.53×10^{-14}	3.14×10^{-14}
8.5	2.86×10^{-14}	3.34×10^{-14}
9.0	3.20×10^{-14}	3.41×10^{-14}
9.5	3.55×10^{-14}	3.21×10^{-14}
10.0	3.90×10^{-14}	2.48×10^{-14}

A comparison of the ionization and excitation reaction rate coefficients with the curve fits is given in Fig. E-1. The fits provide excellent agreement with the exact calculations over this temperature range. The fitted ionization reaction rate for >5 eV also fits well up to about 30 eV, which is useful for Hall thruster calculations.

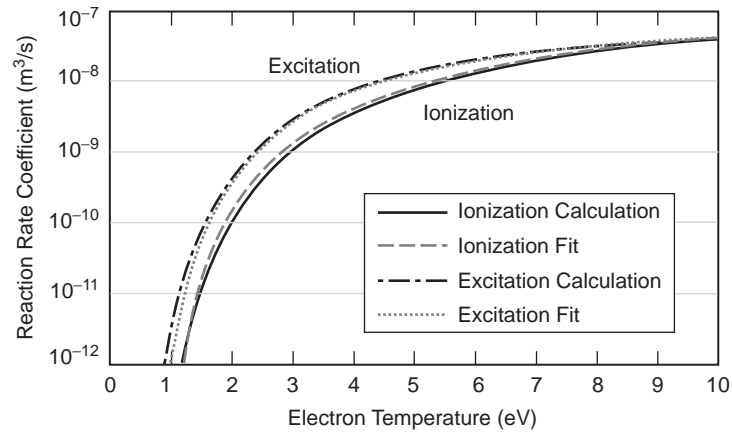


Fig. E-1. Ionization and excitation reaction rate coefficients from the calculation results (black) and fitting equations (gray), showing good agreement.

Reference

- [1] I. G. Mikellides, I. Katz, and M. Mandell, "A 1-D Model of the Hall-Effect Thruster with an Exhaust Region," AIAA-2001-3505, 37th Joint Propulsion Conference, Salt Lake City, Nevada, July 8–11, 2001.