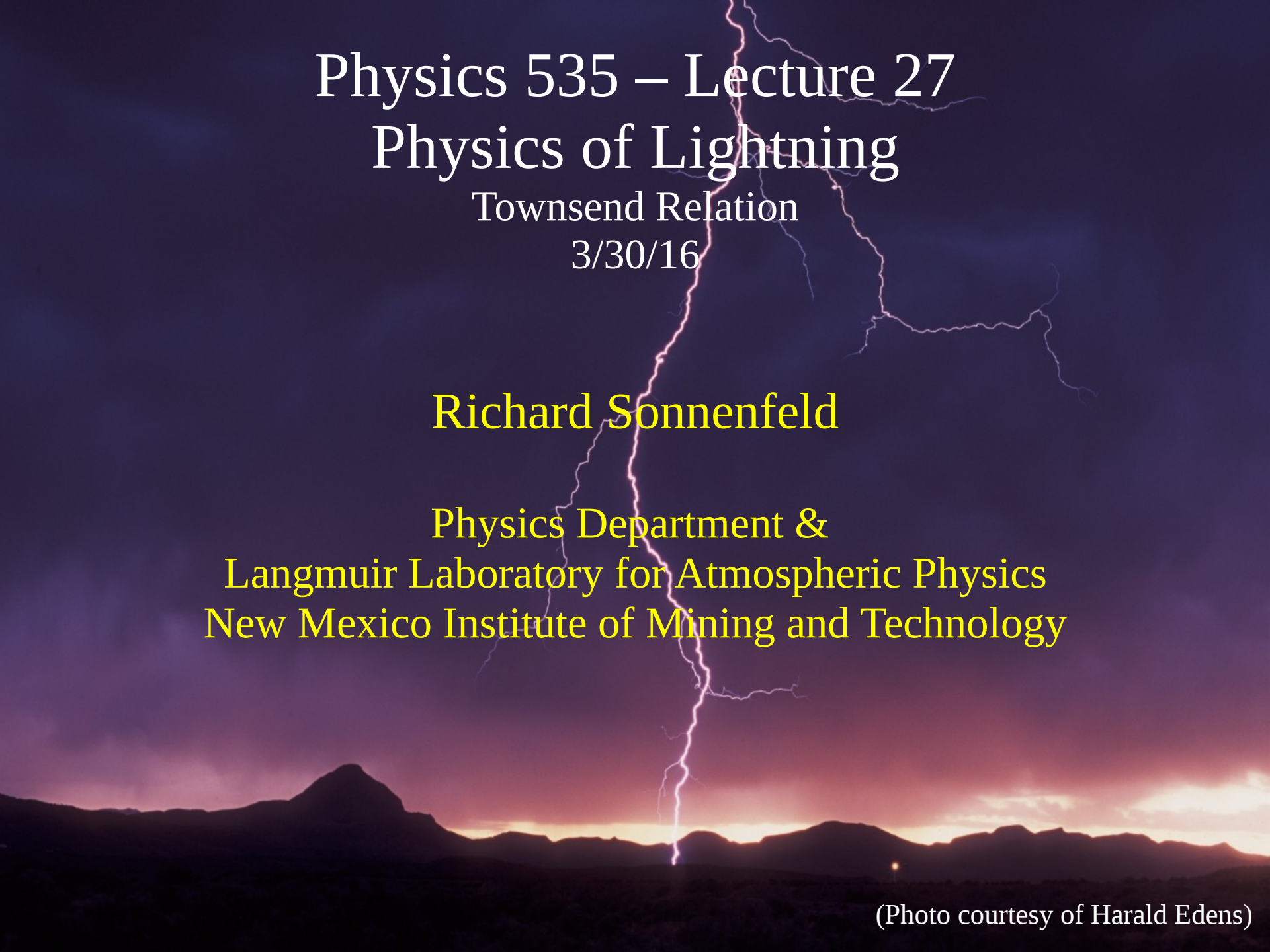
Physics 535 – Lecture 27
Physics of Lightning

Townsend Relation

3/30/16

Richard Sonnenfeld

Physics Department &
Langmuir Laboratory for Atmospheric Physics
New Mexico Institute of Mining and Technology



(Photo courtesy of Harald Edens)

Bazelyan 2.2

We can convert ionization rate to ionization length.

The field must provide the ionization energy.

Energy losses are both elastic (electrons transfer energy to gas molecules) and inelastic (ionization and excitation of gas molecules).

There is a peak in inelastic losses. If electrons gain energy faster than this, they can be accelerated to arbitrary energies (e.g. 1 keV). This is called “Runaway Breakdown”

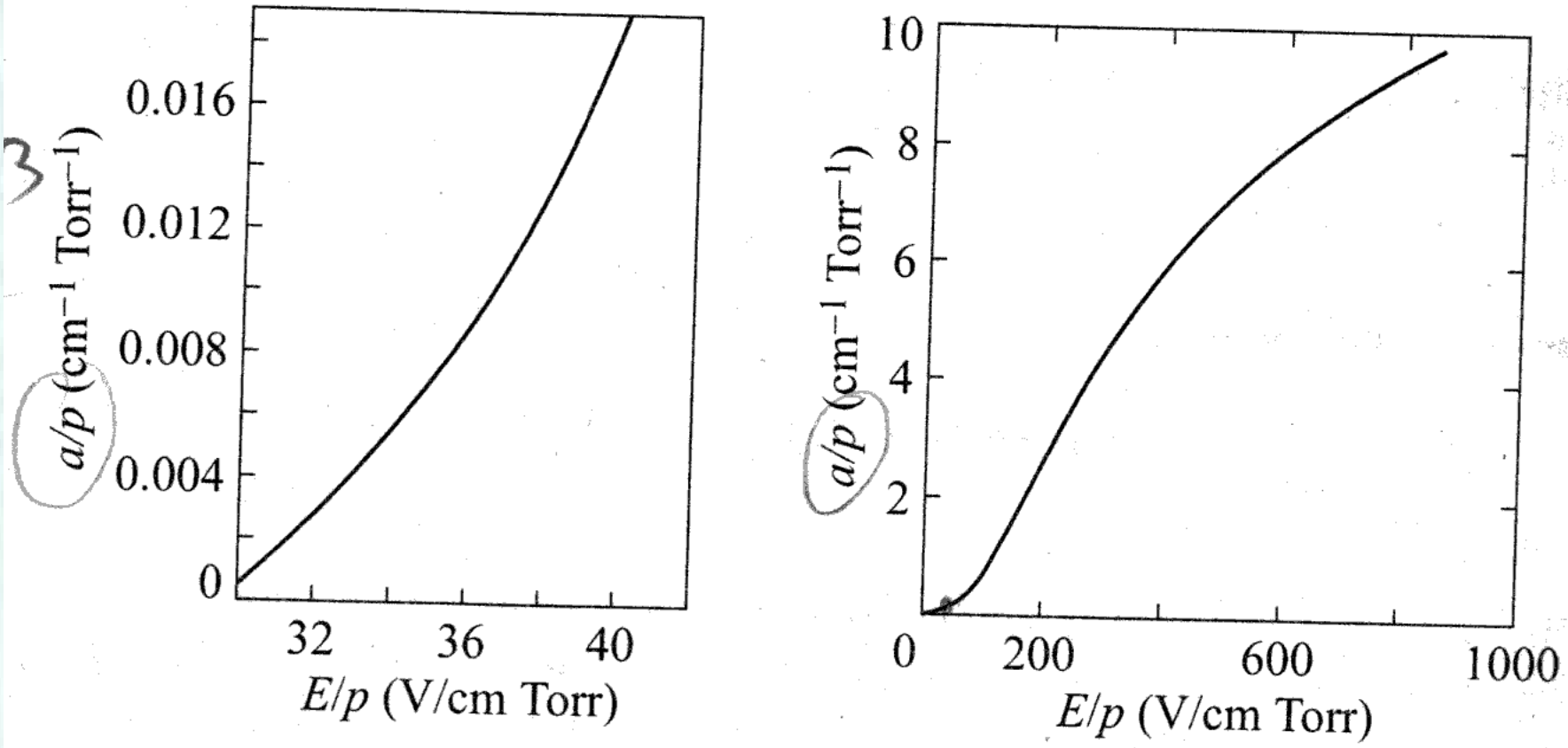


FIGURE 2.2
The Townsend ionization coefficient for air (from data of [2.4, 2.5]).

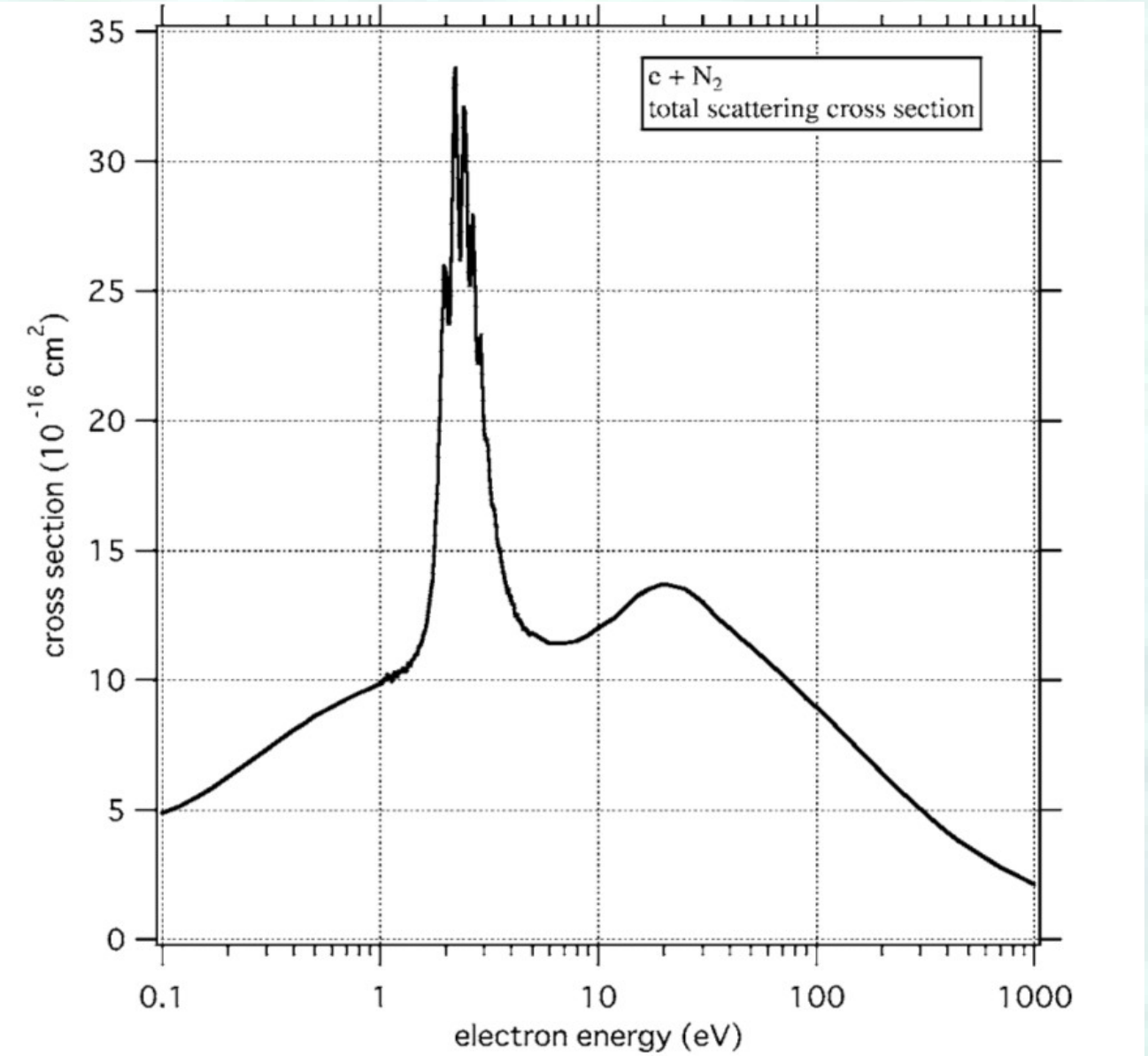


FIG. 1. Recommended values of the total scattering cross section, Q_T, of N_2.

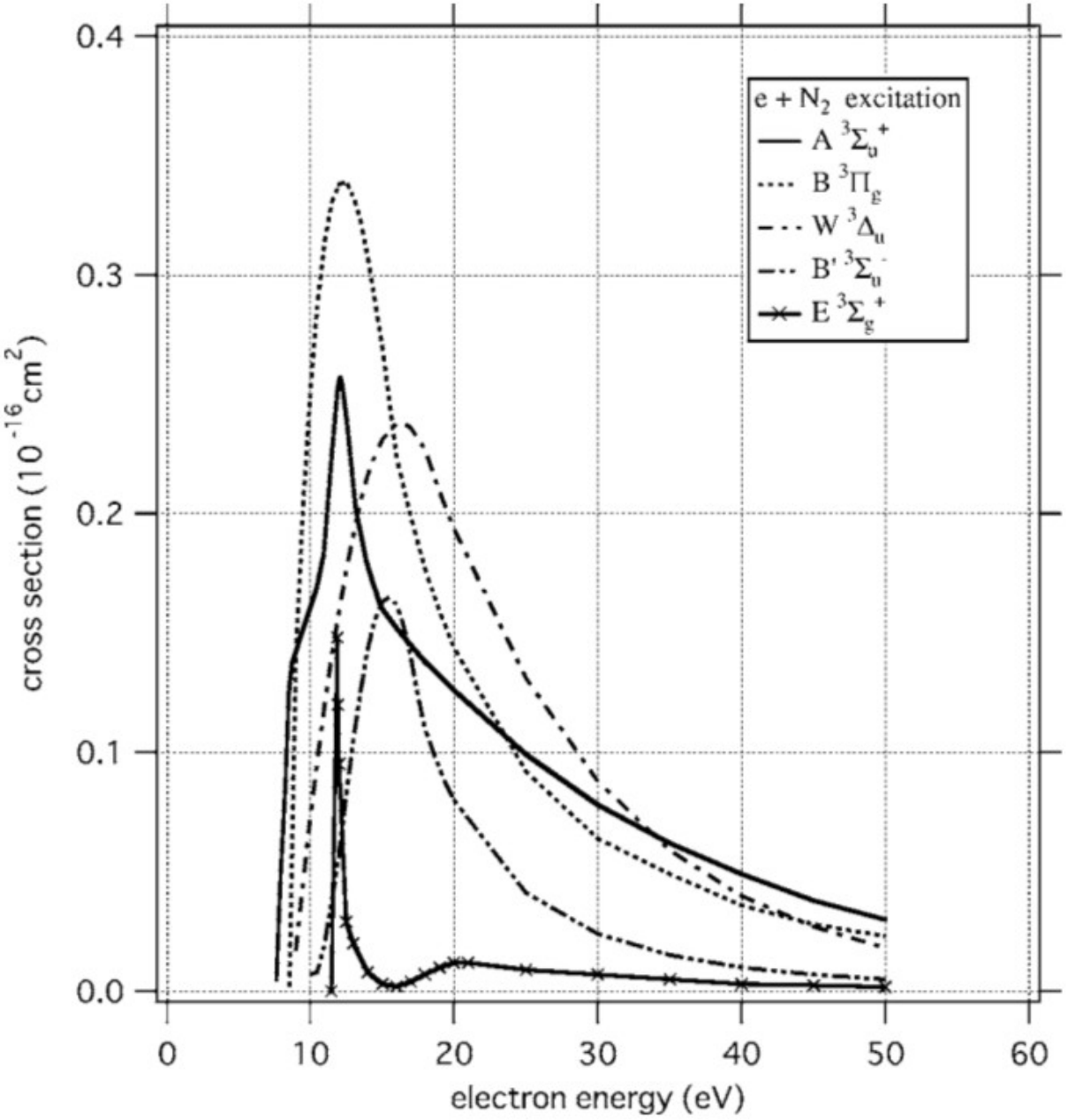


FIG. 8. Recommended values of the cross sections for the excitation of electronic states of N_2: $A\,^3\Sigma_u^+$, $B\,^3\Pi_g$, $W\,^3\Delta_u$, $B'\,^3\Sigma_u^-$, and $E\,^3\Sigma_g^+$.

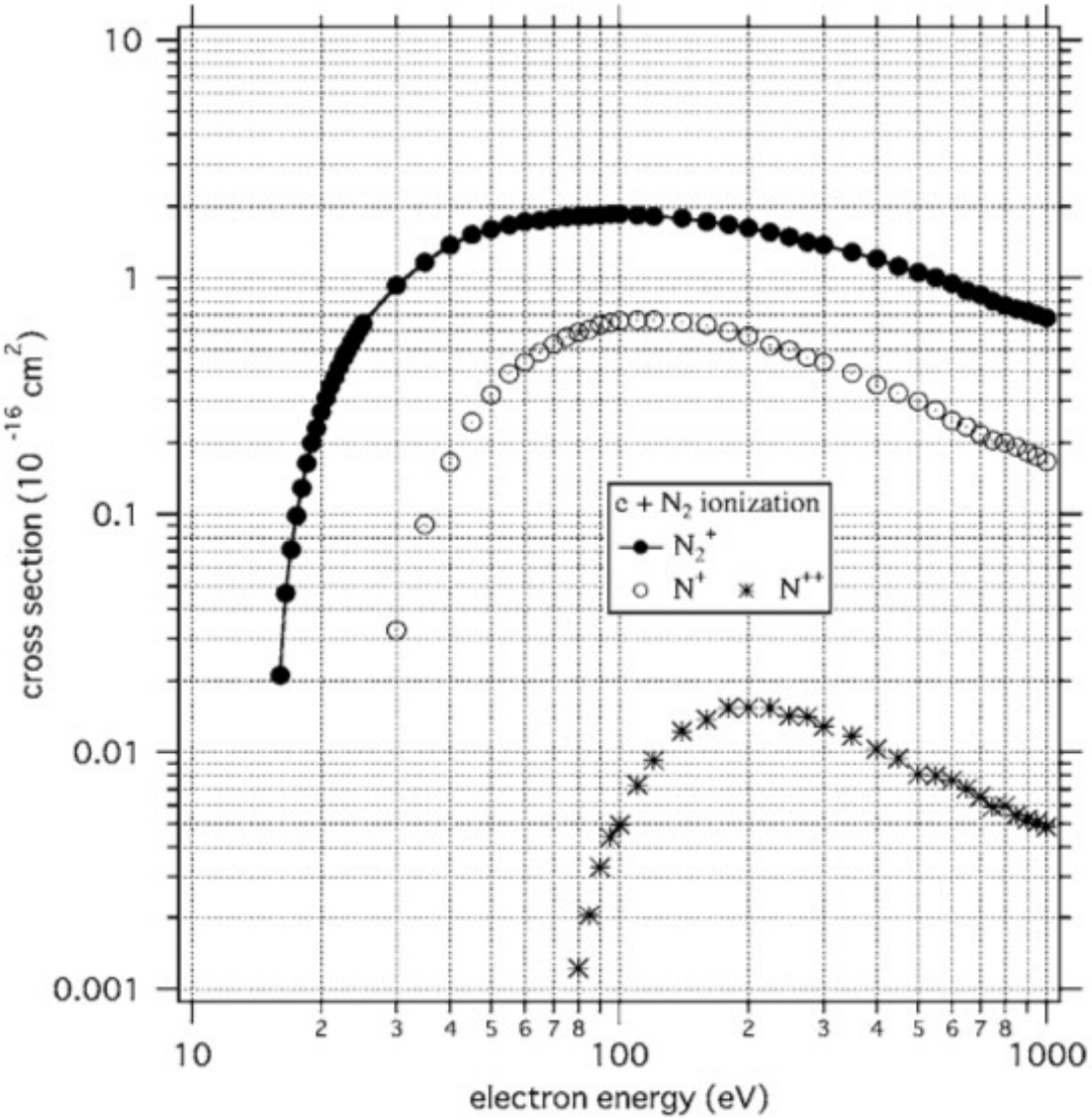


FIG. 23. Recommended values of ionization cross section of N_2 for the productions of N_2^+, N^+, and N^{++}.

$$v_e = \frac{q}{m_e \nu} \qquad \nu = \bar{v}\,\sigma\,N$$

$$\bar{v} = \sqrt{3\,\frac{k_B\,T}{m_e}}$$