Physics 535 – Lecture 28
Physics of Lightning
Recombination and Dissociation
4/1/16

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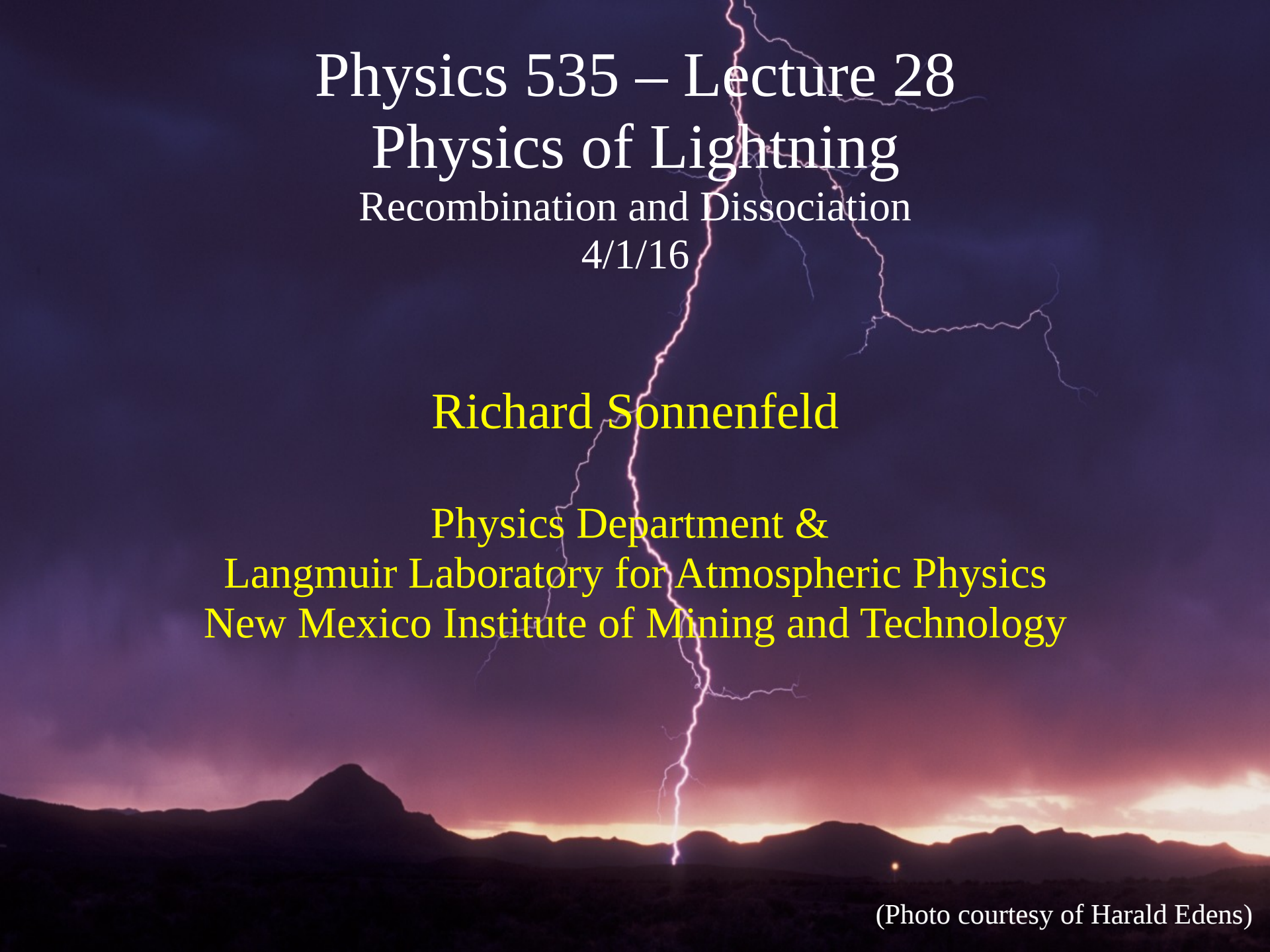


(Photo courtesy of Harald Edens)

Bazelyan 2.3

In section 2.2 we were concerned with “elastic” processes, in which electrons just transferred their momenta to molecules. Since the energies were very low (around 1 eV) the molecules might be rotationally or vibrationally excited, but they could not be ionized.

In section 2.3 we proceed to ionization, but that means we have electron temperatures up to 100,000 Kelvin.

The section concerns itself with the dynamics of ionization and relaxation.

Figure 2.4 amazingly well predicts the classical breakdown field for air at 1 atmosphere at 3 MV/m.

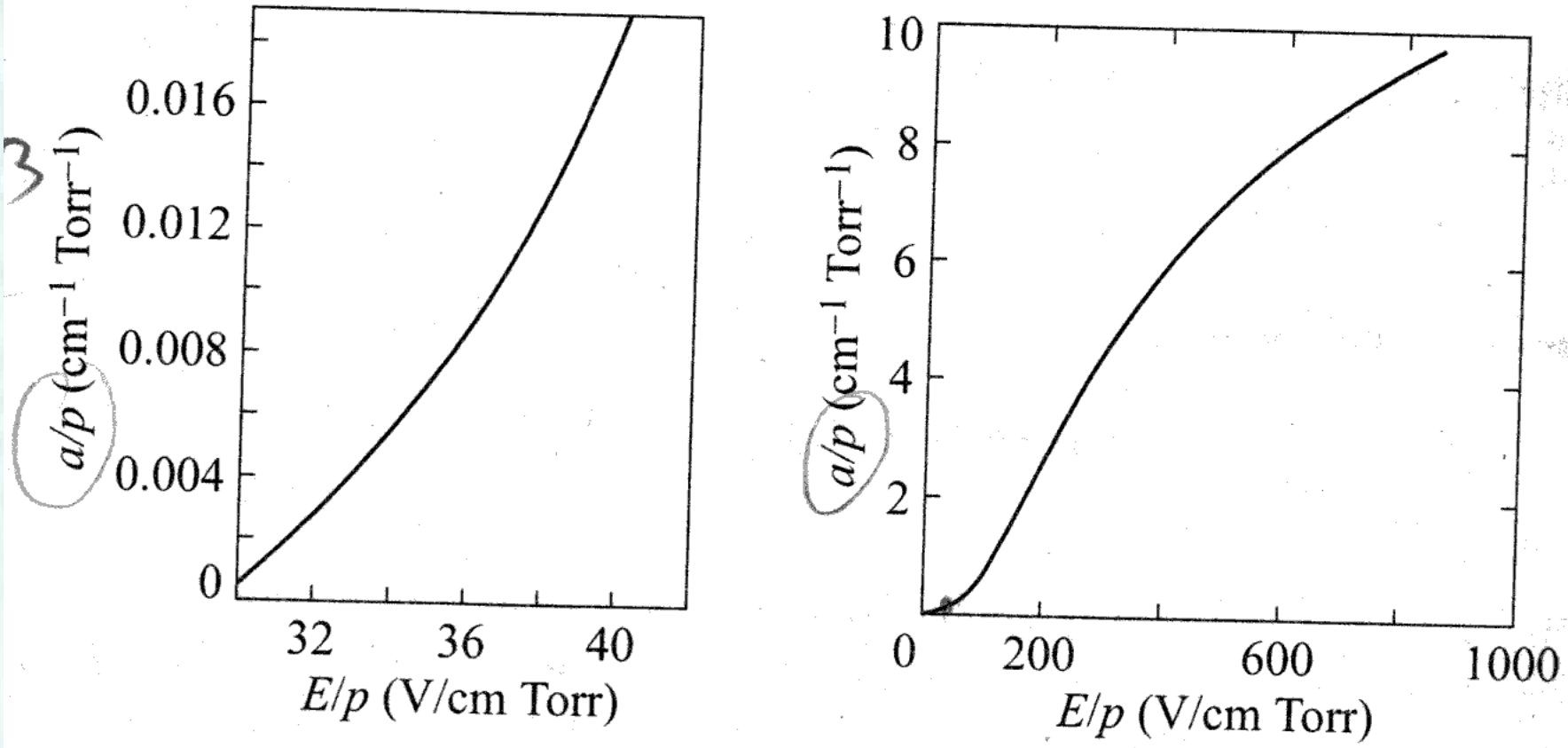


FIGURE 2.2
The Townsend ionization coefficient for air (from data of [2.4, 2.5]).

Bazelyan Figure 2.3
Figure always assume
Molecular nitrogen
In its ground state.

Cross section is always
Zero until electron
Reaches activation
Energy for excitation
Or ionization.

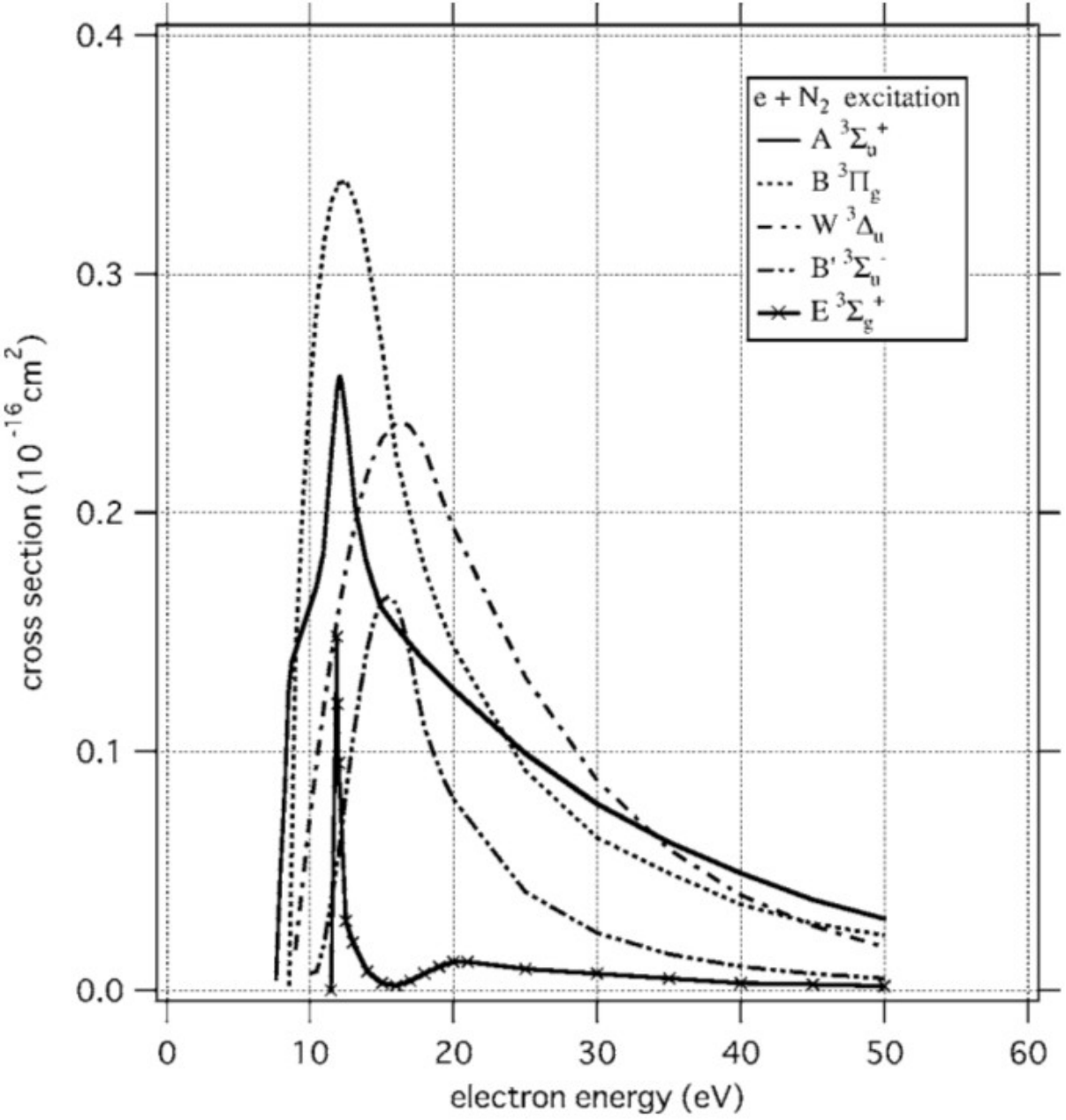
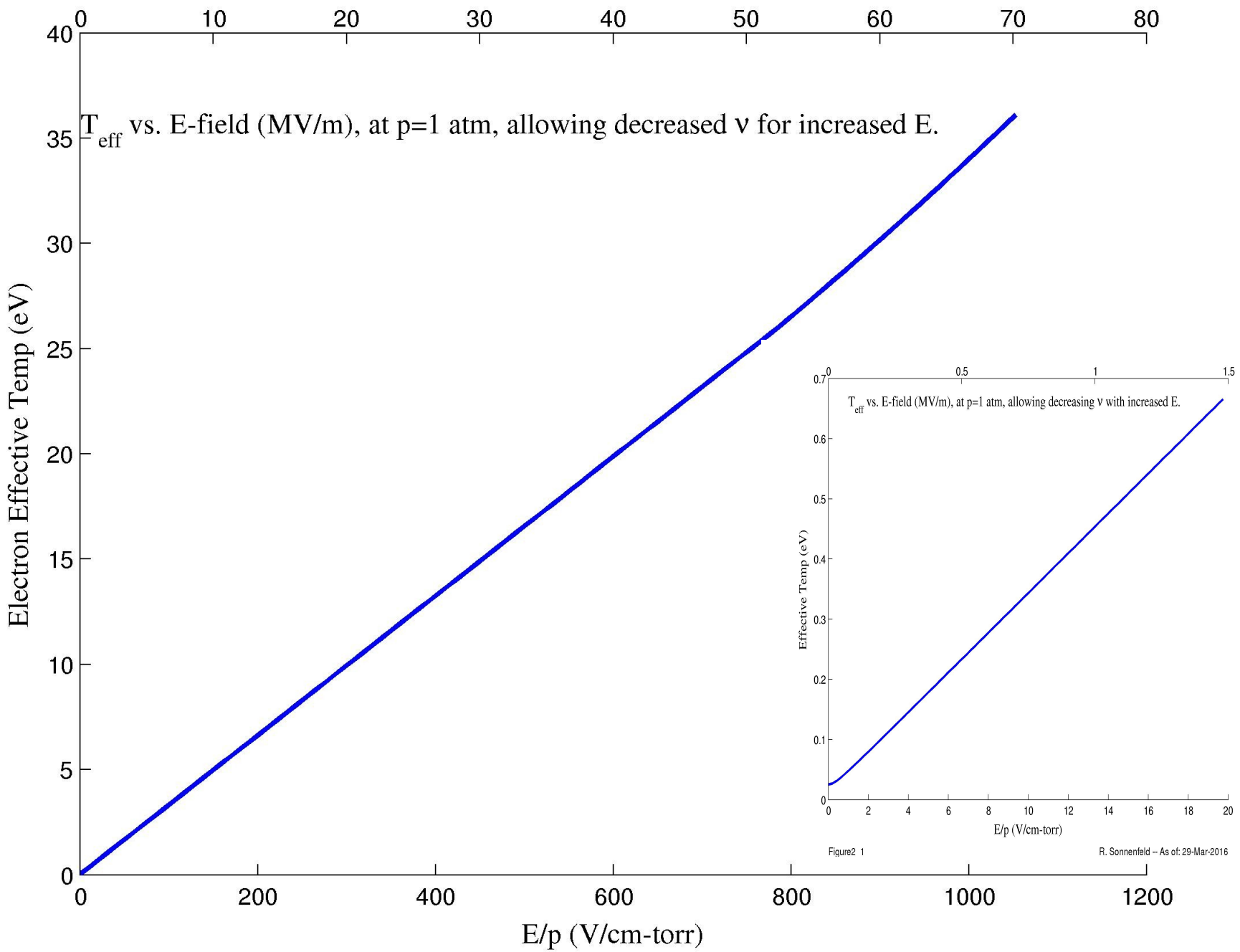
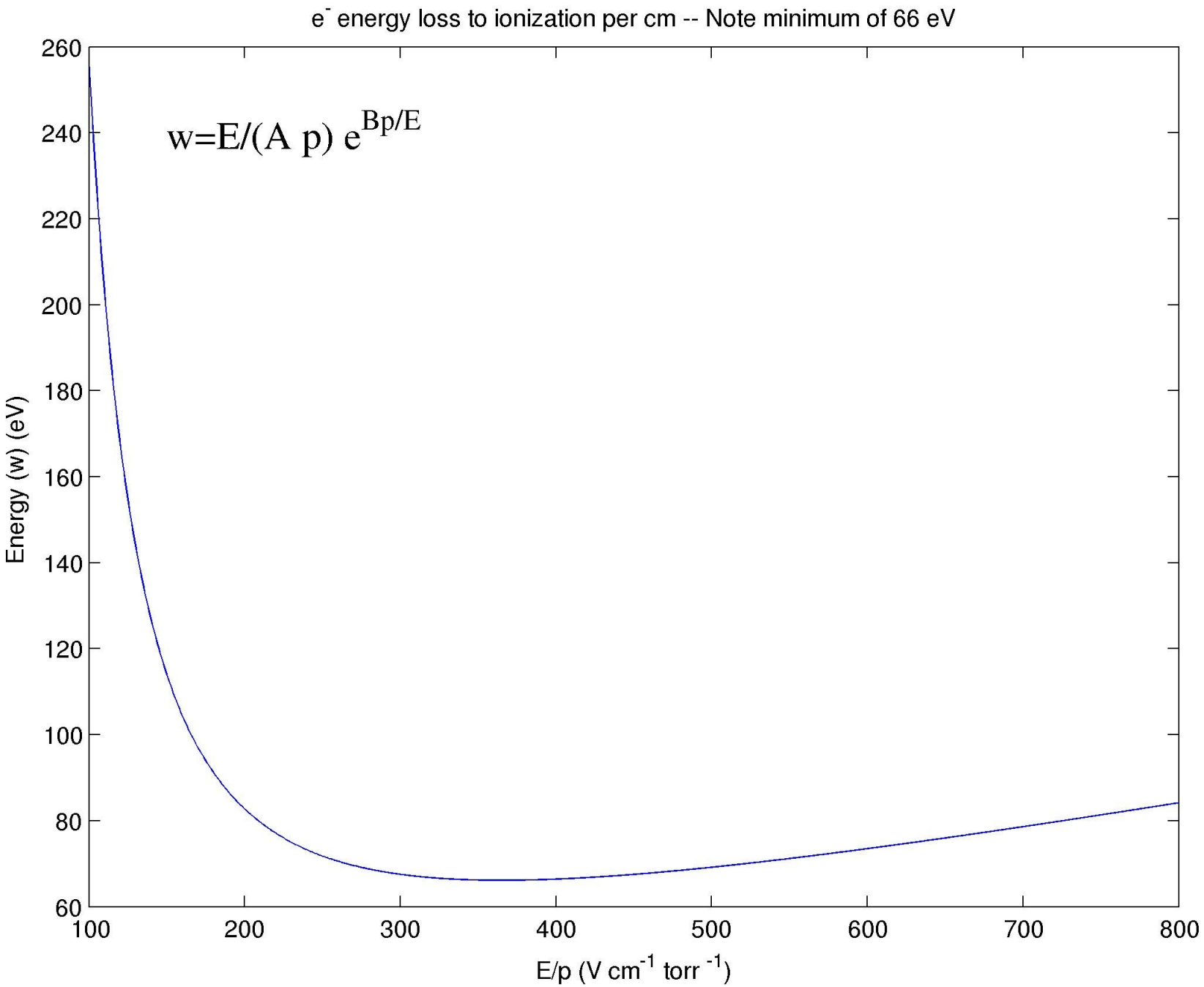


FIG. 8. Recommended values of the cross sections for the excitation of electronic states of N_2: $A\ ^3\Sigma_u^+$, $B\ ^3\Pi_g$, $W\ ^3\Delta_u$, $B'\ ^3\Sigma_u^-$, and $E\ ^3\Sigma_g^+$.


T_{eff} vs. E-field (MV/m), at p=1 atm, allowing decreased ν for increased E.
Electron Effective Temp (eV)
E/p (V/cm-torr)
0
5
10
15
20
25
30
35
40
0
200
400
600
800
1000
1200
0
10
20
30
40
50
60
70
80
T_{eff} vs. E-field (MV/m), at p=1 atm, allowing decreasing ν with increased E.
Effective Temp (eV)
E/p (V/cm-torr)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
2
4
6
8
10
12
14
16
18
20
0
0.5
1
1.5
Figure2 1
R. Sonnenfeld -- As of: 29-Mar-2016

Bazelyan 2.3

It is worth discussing how fields can be as high as we need them to be.


e- energy loss to ionization per cm -- Note minimum of 66 eV
w=E/(A p) e^Bp/E
Energy (w) (eV)
E/p (V cm-1 torr -1)
260
240
220
200
180
160
140
120
100
80
60
100
200
300
400
500
600
700
800