Comparisons of sets of electron-neutral scattering cross sections and calculated swarm parameters in Helium and Neon

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Introduction
In the context of the recently initiated GEC Plasma Data Exchange project, we compare measured swarm parameters with those calculated using sets of cross sections, compiled by different authors, in helium and neon. These data are on-line at www.laplace.univ-tlse.fr. The cross section compilations for electron scattering from ground state helium or neon vary mainly in the level of detail provided for inelastic excitation, ranging from one effective excitation level to many individual levels. The swarm parameters were calculated using a 2-term Boltzmann solver and a Monte Carlo simulation. Calculated swarm parameters from the various compilations show good agreement among themselves in both gases, and generally good agreement is obtained between calculated and measured parameters except for ionization coefficients at low E/N where measured ionization coefficients in both gases show strong influences of Penning ionization of impurities.

We conclude that the cross section compilations and their use in a 2-term Boltzmann solver yield results sufficiently accurate for plasma modeling purposes.

"Complete" sets of cross sections available on LXCat for electron scattering from helium and neon

<table>
<thead>
<tr>
<th>Database name</th>
<th>Level of detail for excitation</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Puech (SIGLO data are from Puech)</td>
<td>1 effective excitation level</td>
<td>For use with 2-term Boltzmann solver</td>
</tr>
<tr>
<td>Morgan</td>
<td>2 levels (resonant and nonresonant)</td>
<td>For use with 2-term Boltzmann solver</td>
</tr>
<tr>
<td>Biagi v8.9</td>
<td>2 excitation levels (nonresonant and resonant)</td>
<td>For use with Monte Carlo or multi-term Boltzmann solver</td>
</tr>
<tr>
<td>Biagi v7.1</td>
<td>69 levels</td>
<td>For use with Monte Carlo or multi-term Boltzmann solver</td>
</tr>
<tr>
<td>SIGLO</td>
<td>2 levels (resonant and nonresonant)</td>
<td>For use with Monte Carlo or multi-term Boltzmann solver</td>
</tr>
<tr>
<td>Biagi v8.9</td>
<td>9 excitation levels</td>
<td>For use with Monte Carlo or multi-term Boltzmann solver</td>
</tr>
<tr>
<td>Puech</td>
<td>67 levels</td>
<td>For use with 2-term Boltzmann solver</td>
</tr>
<tr>
<td>Biagi v7.1</td>
<td>1 effective excitation level</td>
<td>For use with 2-term Boltzmann solver</td>
</tr>
</tbody>
</table>

Databases containing cross sections

Transport and rate coefficients calculated using LXCat input data and comparisons with experiment

These calculations were performed using BOLSIG+, a 2-term Boltzmann solver

He

Helium

Ne

Neon

Calculations

- Biagi v8.9
- Biagi v7.1
- Morgan

Experiments

- Tachibana 1987
- Bhattacharaya
- Dutton
- Chanin
- Kruithof

Conclusions

- **He**: Theoretical cross sections for excitation are now more accurate than experiment. This is our opinion that theory is more accurate than experiment for swarm data in helium below 100 Td (except maybe for data obtained at ANU).

- **Ne**: The different sets of cross sections essentially agree in the total excitation cross section and in the predicted transport coefficients, but there are some differences in cross sections for the individual processes.

- The divergence of the calculation (Biagi) of the Townsend coefficient for helium and neon at low electric fields from the measured Townsend coefficients is caused by Penning transfers to impurities in the gases. The impurity concentration required to bring agreement between the experiment and theory is only at the level of 20 ppm impurity. It would be beneficial if modern experiments with less than 1 ppm impurities could be carried out to corroborate these conclusions.

References for codes:

- 2-term Boltzmann: Hagelaar, BOLSIG+ (full version downloadable from LXCat site)
- Biagi-Monte Carlo: Magboltz (available from the CERN website)
- Hagelaar Monte Carlo: coming soon to the LXCat site

Intercomparison of Boltzmann and Monte Carlo codes

The generally good agreement serves to validate the various codes and shows that 2-term Boltzmann solvers are perfectly fine for He and Ne up to some 100s of Td. Runaway becomes an issue in helium for E/N some 200 Td (PT, higher if SST).