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Reduced mobility for Ar^+ ions in argon gas

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Goal

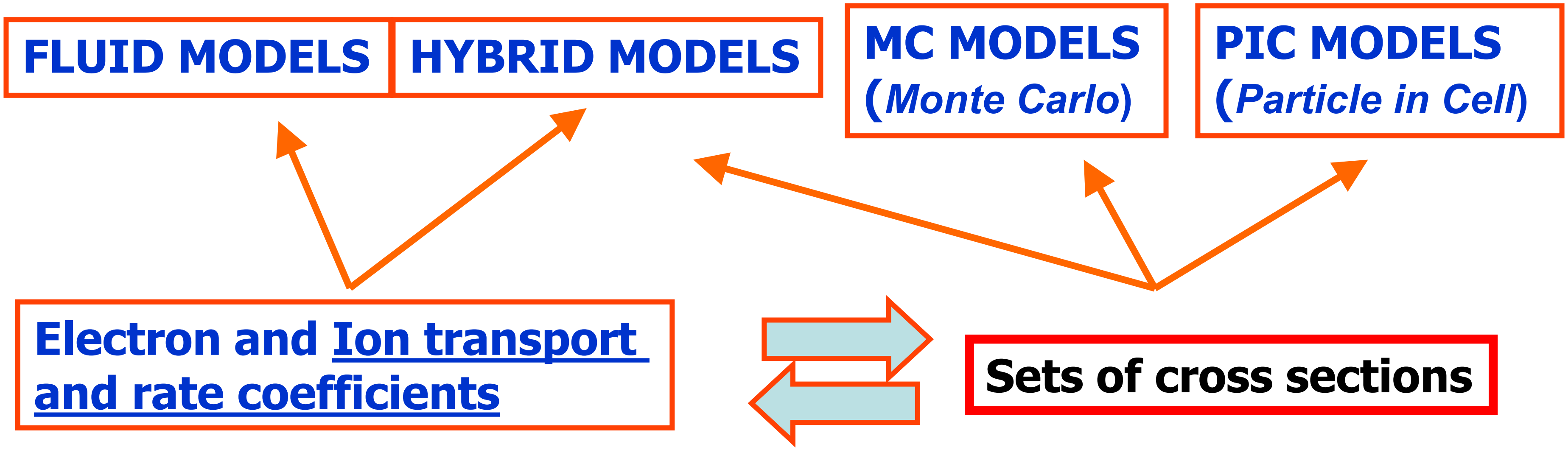
In this work we present a complete cross sections dataset and transport properties for Ar^+ ions in argon gas. These data are needed for modeling in numerous applications of technological importance. A Monte Carlo simulation method is applied to accurately calculate transport parameters in hydrodynamic regime. We discuss new data for Ar^+ ions in argon gas where the drift velocity, characteristic energy, specially flux and bulk values of reduced mobility and rate coefficients are given as a function of low, moderate and high reduced electric fields E/N (E-electric field strength, N-gas number density). Ion mobility (K) is defined as the proportionality factor between the ion drift velocity and the electric field. One often exploits the reduced or standard mobility defined as:

$$K_0 = \frac{v_d}{N_0 E} N$$

Introduction

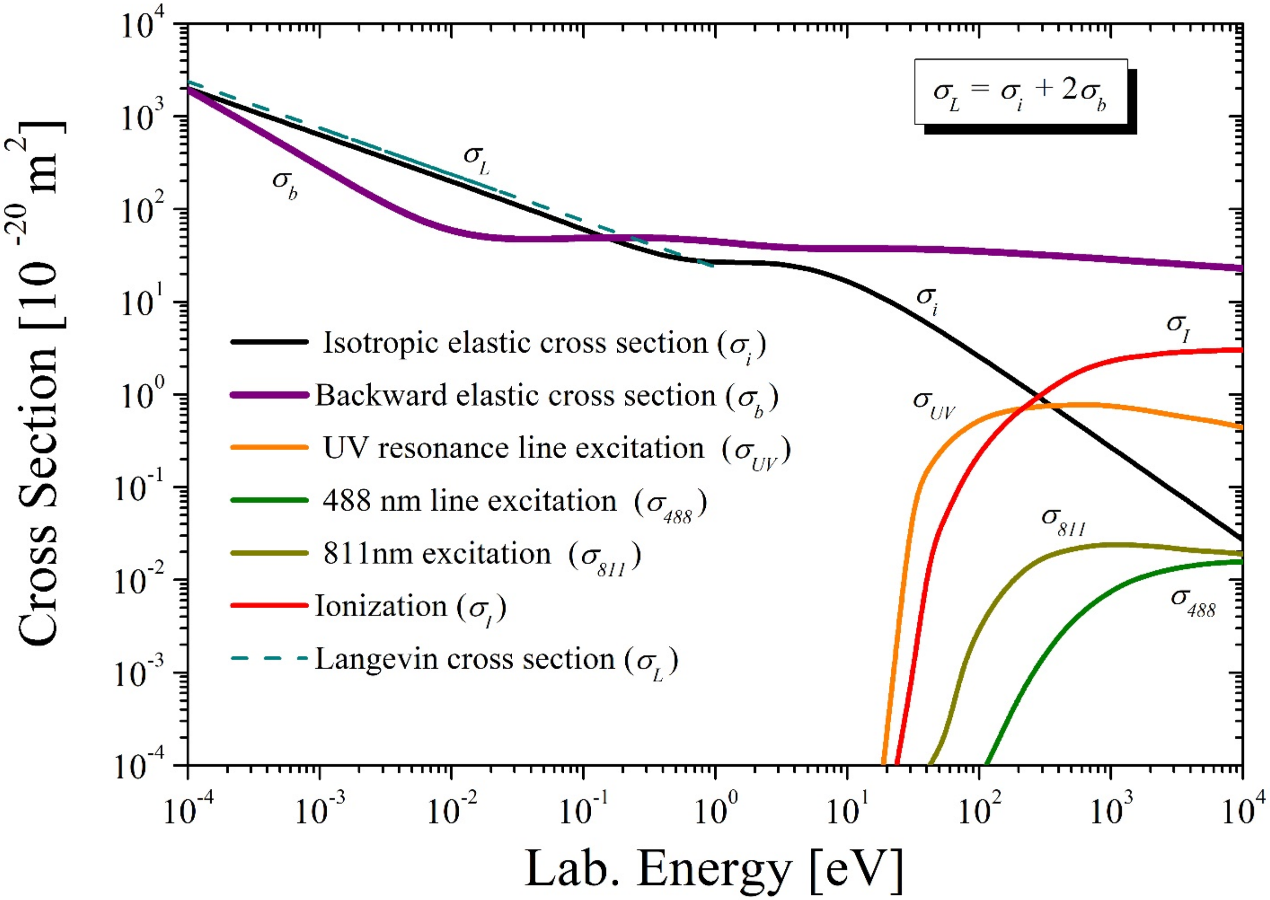
- Ion charge transfer reactions with molecules are unavoidable elementary processes in modeling kinetics in terrestrial, industrial and astrophysical plasma in the detection of dark matter.
- Motivational factors for this study have been identified and this paper reports on a topic important for both basic studies and application.

- Cold plasmas are frequently used in new technologies where they open up the possibilities of non-intrusive production or modification of various substances [1]. These plasmas have a high electron temperature and low gas temperature so non-equilibrium behavior of a large number of species becomes important [2].
- Transport of Ar^+ plays a significant role in various etching and deposition processes [3], in dark matter detection [4] and in many other scientific and technological applications. In this letter, the objective will be to study transport of Ar^+ in Ar gas.
- Complete cross section sets for ion transport are scarce in spite of a broad range of specific methods relevant for quantification of particular cross sections. The main problem in heavy particle scattering, easily and precisely selecting the state of the projectile and target before the collision, is still very complicated for a range of conditions, so databases for ion scattering [5], are still devoid of such data.
- In Figure 1 we present complete cross sections for collisions of Ar^+ with Ar versus laboratory energy of Ar^+ of Ar. The symbols and collisional processes are: isotropic elastic cross section σ_i, backward elastic σ_b, UV resonance line excitation σ_{uv}, 488 nm line excitation, 811 nm line excitation, ionization σj and Langevin cross section σ_L.

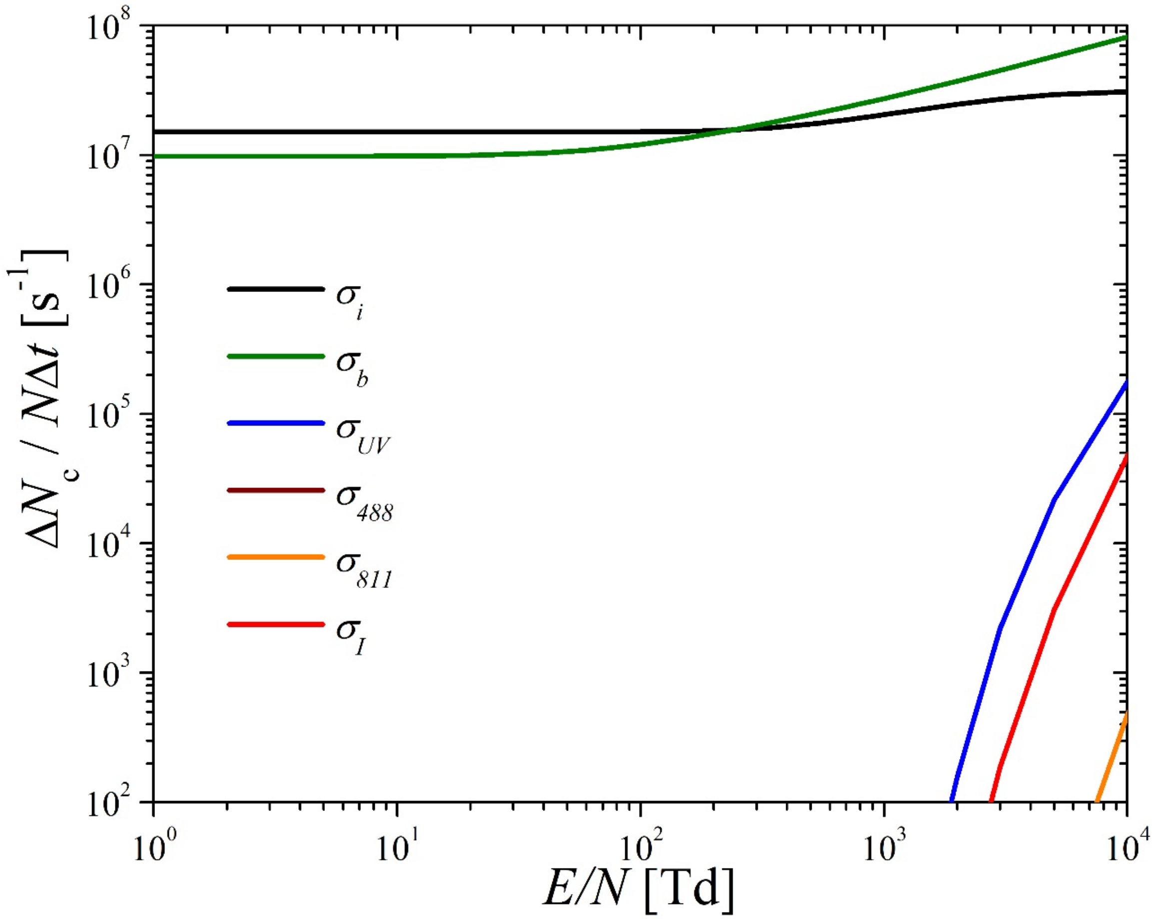


Calculated cross sections will be taken as basis for interpretation and modeling of electron kinetics plasma applications.

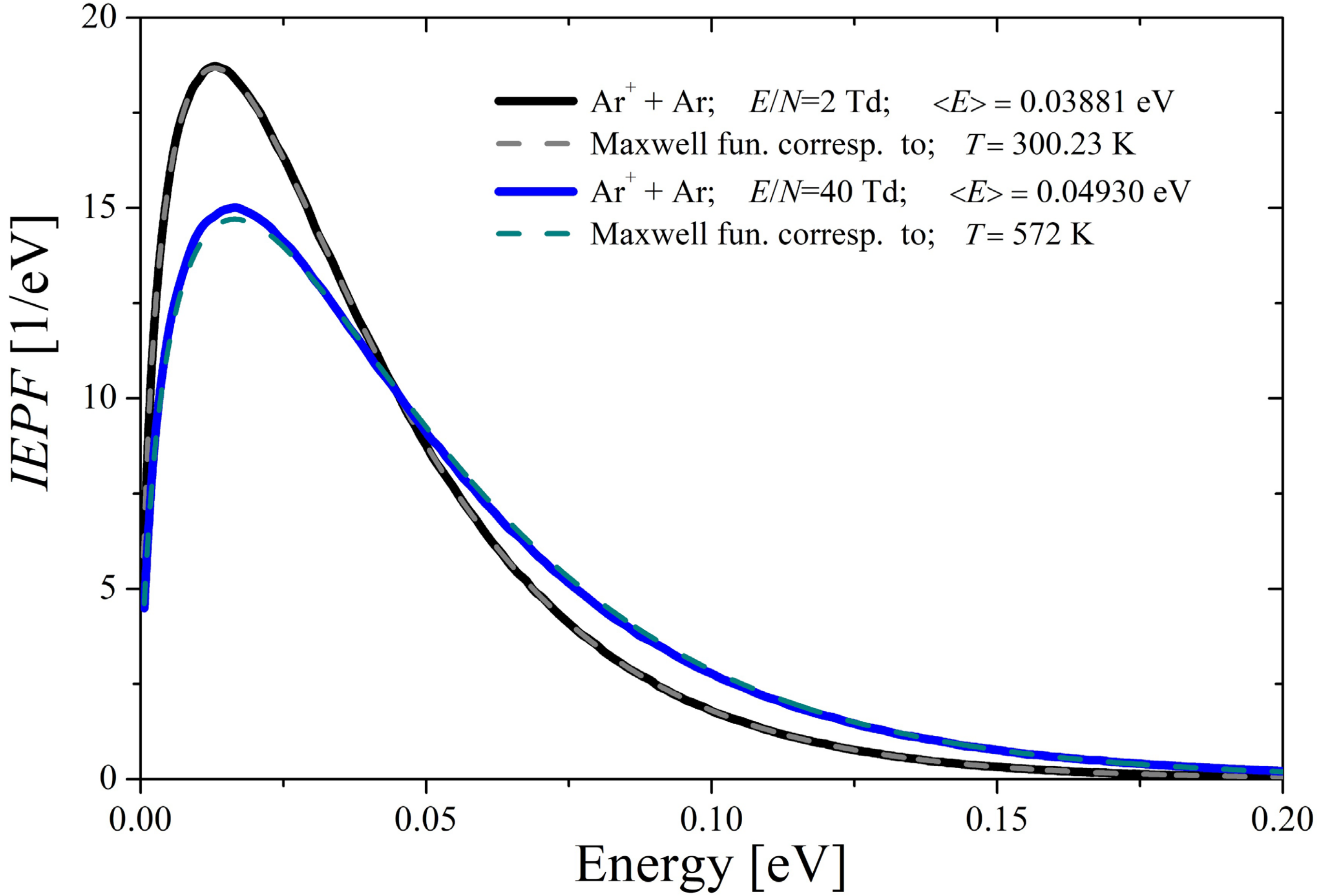
Calculation of rate coefficients in DC fields by Monte Carlo simulations.



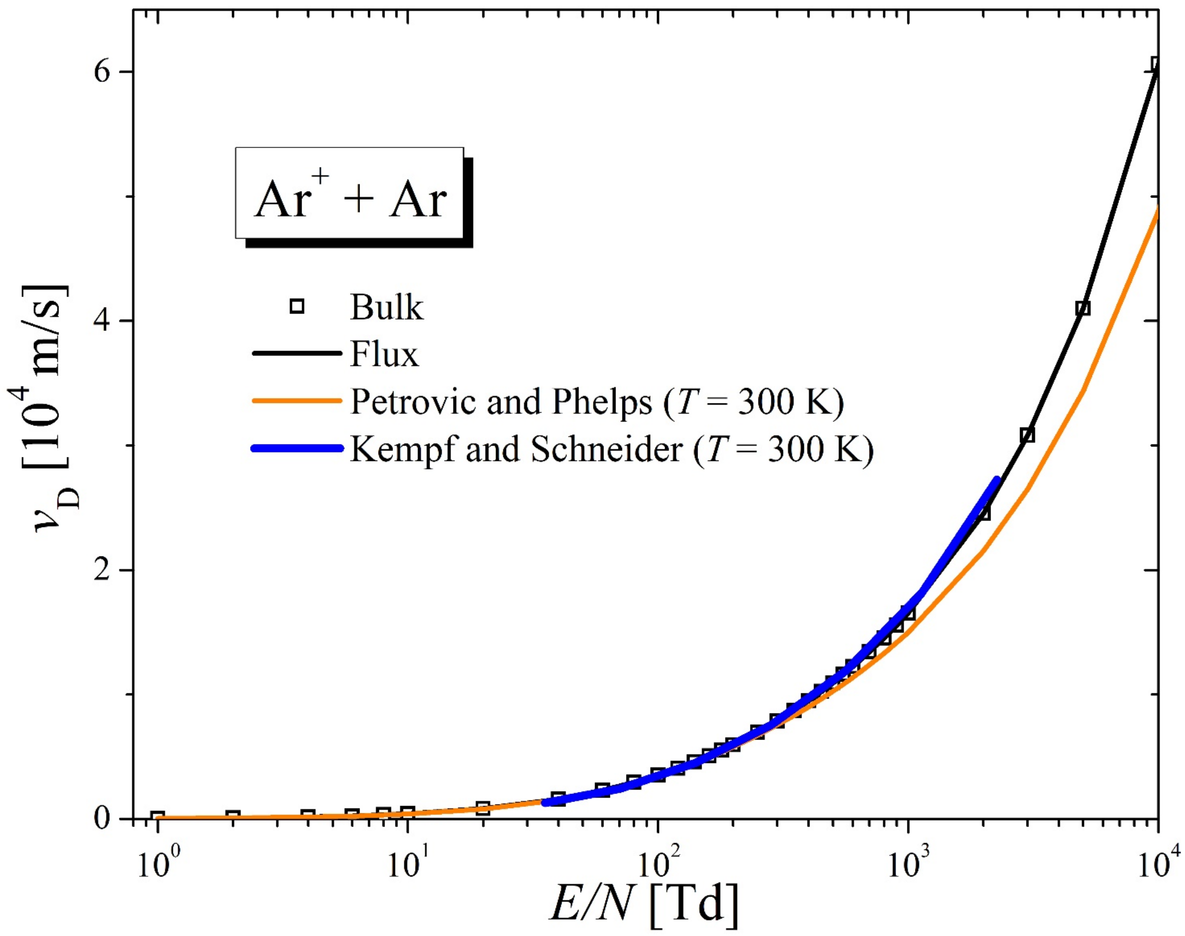
•Figure 1. Cross section set for $Ar^{+} + Ar$.



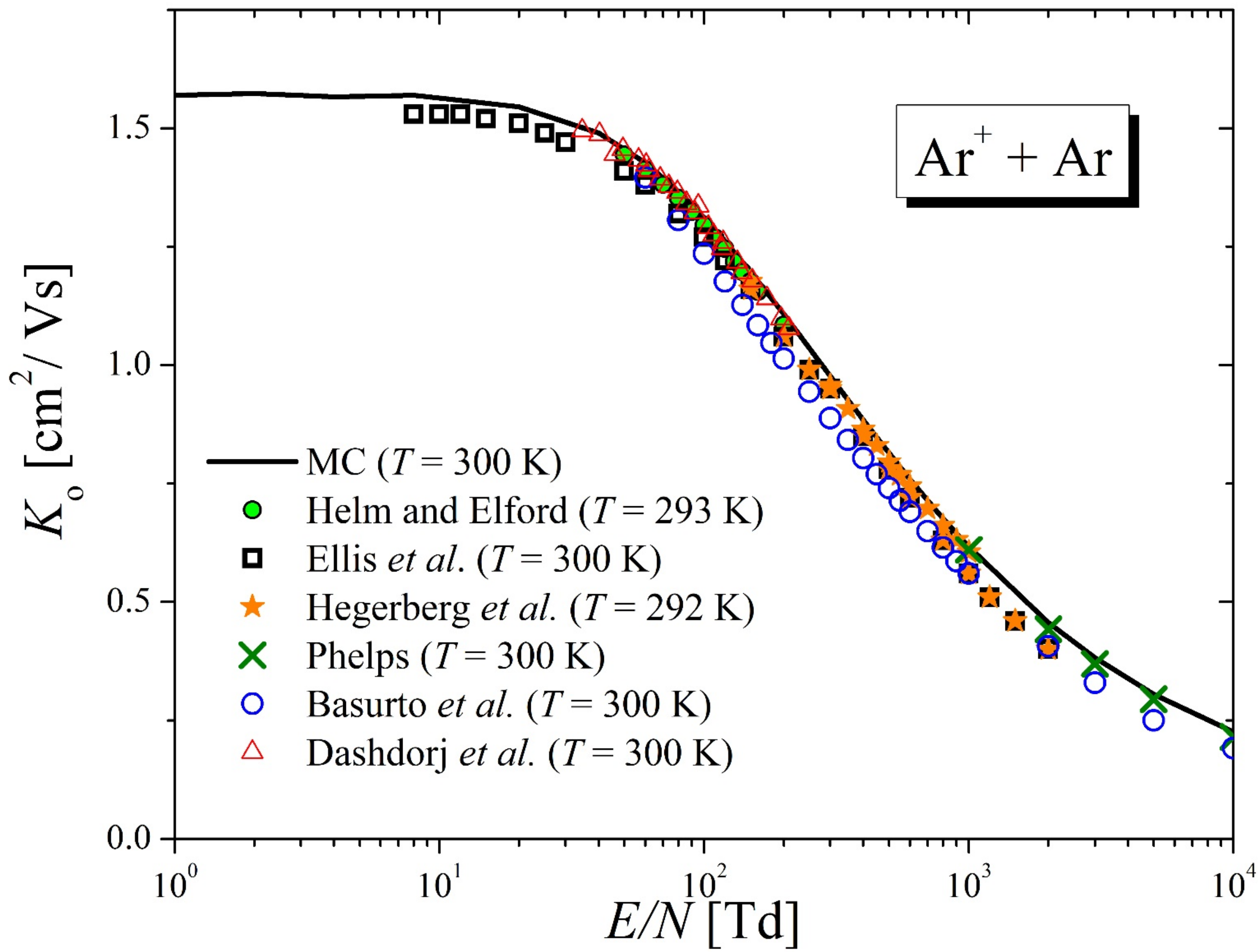
•Figure 2. Rate coefficients for Ar^+ in Ar a function of *E/N* at 300 K.



•Figure 3. Ion energy probability function (*IEPF)* for Ar^+ in Ar a function of low *E/N*.



•Figure 4. Bulk and flux drift velocity for Ar^+ in Ar at 300 K.



$$K_0 = \frac{v_d}{N_0 E} N$$

•Figure 5. Reduced mobility for Ar^+ in Ar a function of *E/N*.

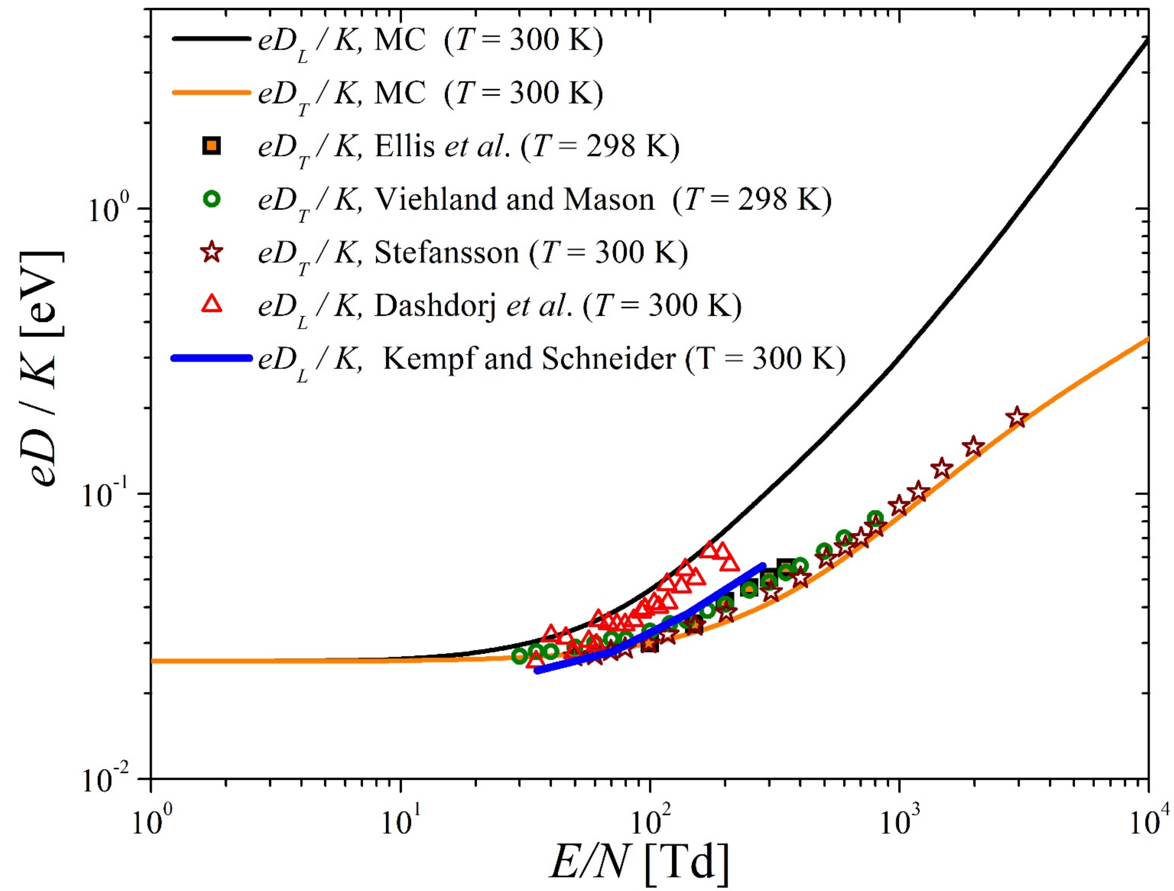
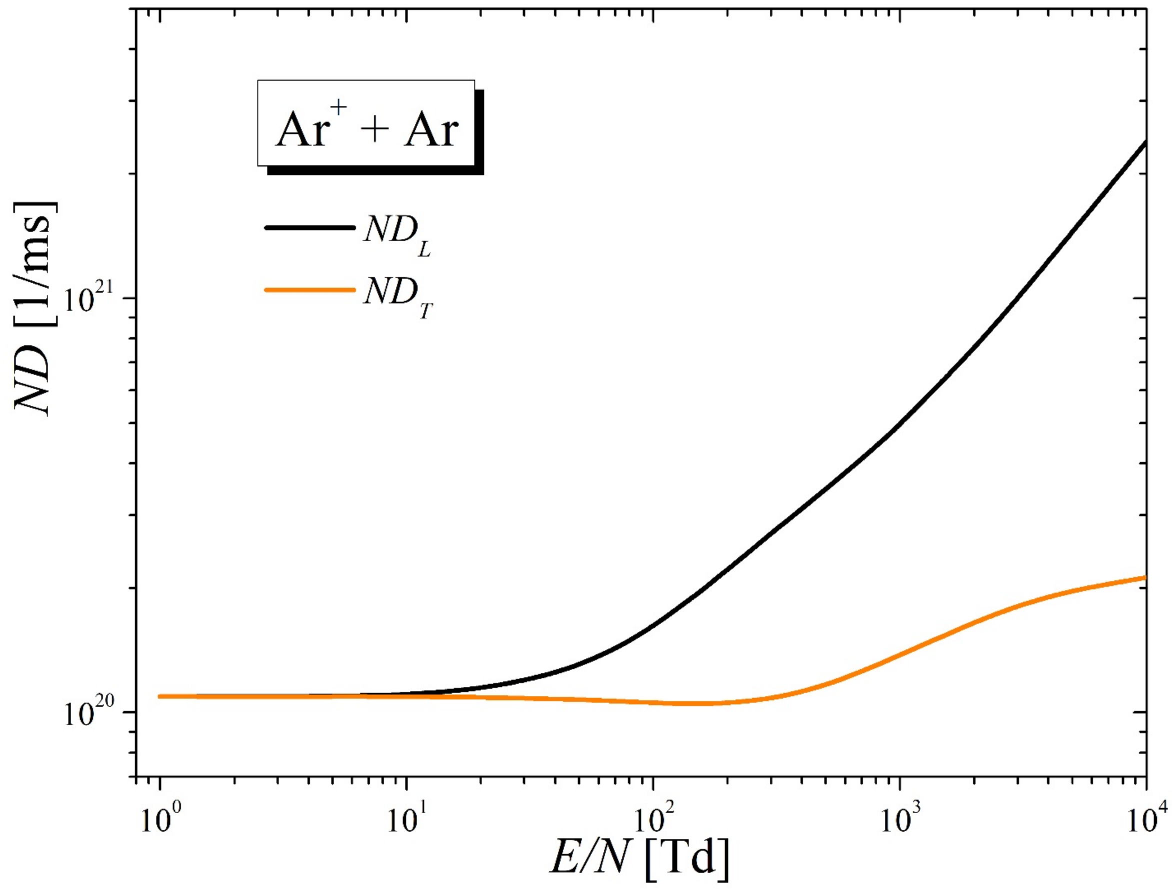


Figure 6. Characteristic energy for Ar^+ in Ar a function of *E/N*.



•Figure 7. Longitudinal diffusion coefficients for Ar^+ in Ar a function of *E/N*.

Conclusion

- The Monte Carlo technique was applied to carry out calculations of the mean energy, drift velocity, bulk and flux reduced mobility and rate coefficients as a function of reduced DC electric field. The results are believed to be a good base for modeling, which could be further improved when measured values of transport coefficients become available and then we could perform this analysis again.

References

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