with the Boltzmann or Fokker-Planck collision term are the same, within a constant of order unity. Since an arbitrary cut-off is often invoked in connection with these equations, we can call this the "cut-off" method. The above definition of Λ corresponds to inserting average values of the relative speed in the logarithmic term occurring in the $Q^{(\ell)}$ integrals of Eq. (2).

An alternative method of deducing these cross sections is to employ the Boltzmann operator with the Debye-shielded Coulomb potential for distant encounters. Asymptotic (to order unity) formulae (Liboff[24]-Kihara[25]) as well as numerically exact collision integrals[4] are available for this case. Lastly, a collision operator which correctly allows for dynamic shielding has been used[26] to obtain asymptotic expressions (to order unity) for the collision integrals.

When $\ell n\Lambda$ becomes of order unity, as it does for pressures above near atmospheric, then difficulties arise in applying expressions derived with the above methods. Properties computed with the asymptotic expressions increase without bound as $\ell n\,\Lambda$ approaches unity, since terms of the form $\ell n\,\Lambda - 0(1)$ occur in the denominator of all expressions (See Fig. 8). The cut-off expressions, which neglect the 0(1) terms, do not display this behavior, but would be expected to be inaccurate since they are derived on the basis of $\ell n\,\Lambda \gg 1$. Of course, expressions so derived also increase without bound as $\Lambda \rightarrow 1$, but electron degeneracy would probably become important before such a limit were reached.

It seems preferable, then, to use the collision integrals numerically evaluated for the shielded-Coulomb potential for the properties at pressures where the condition $\ell n\Lambda \gg 1$ is not fulfilled. This is not an altogether satisfactory procedure, since it is clear that dynamic effects in the collisions distort the effective potential from this form.

Adopting now the shielded-Coulomb potential as the model of the charged-particle interaction, we must decide which charged particles participate in the shielding. In the Debye-Hückel theory, applicable to the computation of the composition of a dilute gas in local thermodynamic equilibrium,[27] all charged particles participate in the screening and the Debye length is computed from

$$d' = \left[\frac{k\,T}{4\pi e^2 (n_e + \Sigma z_j^2 n_j)} \right]^{\frac{1}{2}} \tag{11}$$

where the sum runs over all ions with charge ez_j. It can be argued that the collisions in a gas are a dynamic process and the ions, because of their relatively large mass, are much less effective than the electrons in the shielding process. If we neglect them completely, then the Debye length is given by

$$d = \left(\frac{k\,T}{4\pi e^2 n_e} \right)^{\frac{1}{2}} \tag{12}$$

which yields $\sqrt{2}\,d'$ in the case of an electrically neutral partially ionized gas.

In the present work it was decided to adopt d as the shielding length. This was arrived at mainly from a comparison of the electrical conductivity and electron thermal conductivity of argon at 1 atm pressure as computed with the asymptotic expressions containing dynamic shielding[26] and those using the static shielding as in Eq. (4) with (1) $\rho = d'$ or (2) $\rho = d$. Best though not perfect agreement was obtained with $\rho = d$. Actually, the results indicate that the effective Debye length for the electrical conductivity is slightly larger than d and that for the electron thermal conductivity slightly smaller. Similar conclusions were reached in computations of the properties of partially ionized hydrogen.[28] Additional support for this choice comes from a comparison of theoretical and experimental values of electrical conductivity (See Fig. 9 and Discussion section).

As insufficient cross sections are given in Ref. 4 for the third approximation to the transport coefficients, it was necessary to compute those lacking in connection with the present work. It was possible to make use of the relation

$$\overline{Q}^{(\ell, s+1)} = \overline{Q}^{(\ell, s)} + \frac{kT}{s+2} \frac{d\,\overline{Q}^{(\ell, s)}}{d\,(kT)} \tag{13}$$