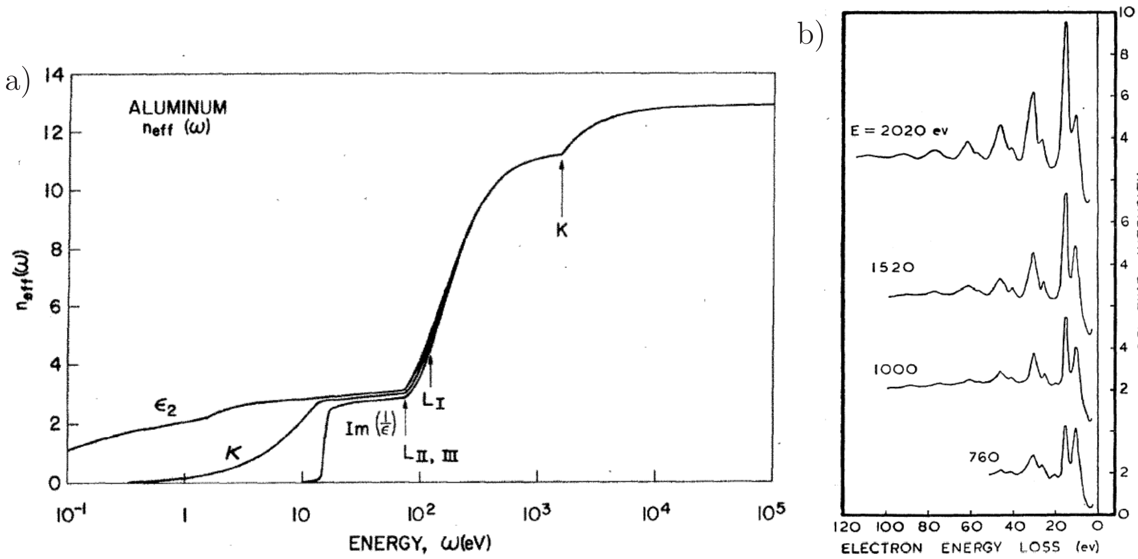

Figure 4.3: Optical properties of aluminum: **a)** Effective number of valence electrons defined via partial sum rules (Smith and Shiles, 1978). **b)** Experimental electron energy loss spectrum (reflection mode) with different incident electron energies E (Powell and Swan, 1959).

electrons per atom. A corresponding plot is also shown in the inset of Fig. 4.1 b for the Lorentz oscillator model.

Figure 4.3 b shows EELSdata obtained in reflection mode (Powell and Swan, 1959). One can clearly distinguish a peak at $\hbar\omega \approx 15$ eV corresponding to the peak of the electronic energy loss function derived from reflectance data shown earlier in Fig. 4.2 d. Additional peaks at multiples of this energy are associated with multiple energy losses. Additionally, a peak at $\hbar\omega \approx 10$ eV is seen which signals the excitation of a surface plasmon with $\omega_{p,\mathrm{surface}} \approx \omega_{p,\mathrm{bulk}}/\sqrt{2}$. Evidently, the relative weights of these peaks change upon changing the incident electron energy: with decreasing beam energy, the relative probability for multiple scattering decreases while the importance of surface effect increases. In general, it is difficult to extract even the shape of the linear-response electronic energy loss function from EELS; an unknown prefactor then has to be estimated from the sum rule (4.20). More reliable results may be obtained in transmission EELS experiments, where the contribution from multiple scattering vanishes with decreasing sample thickness and also momentum-dependent dielectric functions can be measured (Batson and Silcox, 1983).

4.1.4 Impact of Electronic Model Abstractions

In the previous subsections we have seen that the dielectric functions have important universal properties and relations. Even the full plasma frequency ω_p was found to be universal, i.e., only dependent on the total electron density, at least in the non-relativistic limit (this point will be further investigated in subsection 4.2.1). Model