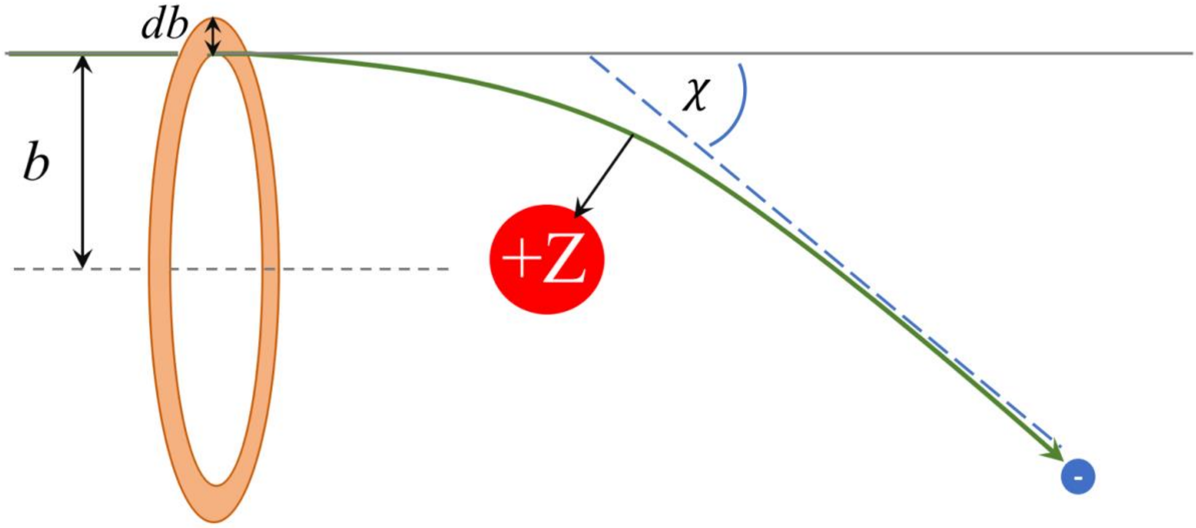
Problem sheet 3

Plasma Physics course
TU Dresden
Lecturer: Katerina Falk
Summer semester April – July 2021

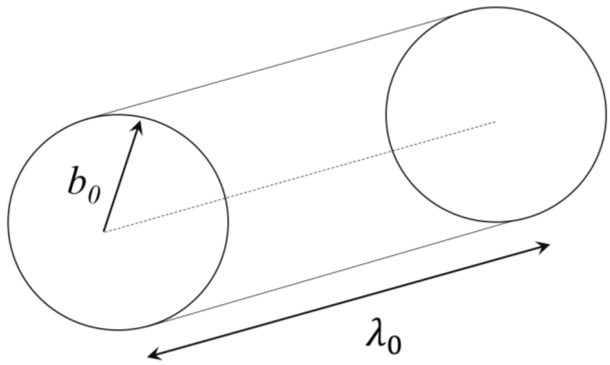
Question 1:



From conservation of kinetic ($\frac{1}{2}m_e v^2$) and potential energy ($\frac{Ze^2}{4\pi\varepsilon_0 r}$) follows that the Rutherford scattering angle of an electron scattered by an ion in plasma is:

$$\cot\left(\frac{\chi}{2}\right) = \frac{4\pi\varepsilon_0 m_e v_e^2}{Ze^2}$$

Derive the expression for the impact parameter b_0 of large angle deflections for electrons colliding with ions with $\chi = 90°$ and obtain a new expression for the scattering angle in terms of b and b_0. Find the distance λ_0 travelled by the electron until the large angle collision has taken place, i.e. the collision time time τ_0. Hint: By definition the average number of ions in volume V is: $n_i \pi b_0^2 \lambda_0 = 1$.

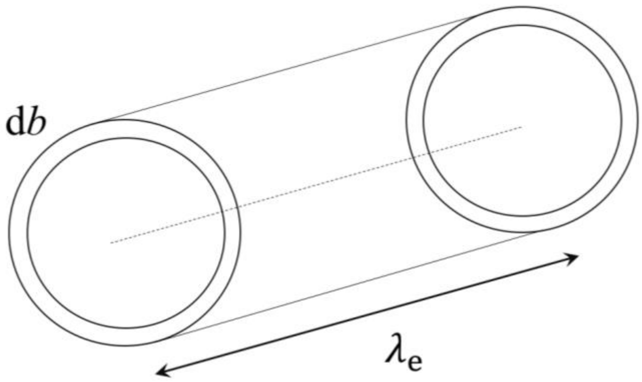


Question 2:

Obtain an alternative derivation of scattering of particles in plasma for an electron colliding with an ion, starting from computing the scattering angle χ in terms of the impact parameter b.

The r.m.s. angle of the small deflections is: $\langle \Delta\theta^2 \rangle = N(b) \cdot \chi^2(b)$, where the number of ions between b and b+db is $N(b) = n_i 2\pi b \lambda_e \mathrm{d}b$. And for small angles: cot $\left(\chi/_2\right) \approx {}^2/_\chi$.

Assuming a large number of small angle deflections, find the distance λ_e travelled before the r.m.s. deflection is $90°$ by integrating over all impact parameters. Do this through computing the total angle accumulated during collisions in terms of the impact parameter b. Integrate with limits, defining the Coulomb logarithm:



b_{max} = Debye length

b_{min} = deBroglie length

Obtain the collision time τ_e in terms of the electron velocity v_e.

Question 3:

Estimate the collision time τ_0 of the large angle deflections and show that the small angle deflection probability is much higher than for large angle deflections with $\chi = 90°$.