Problems (for 22 January)

1. Consider the scattering of the Gaussian wave—packet by the Yukawa potential. The wave packet in the initial state is given by:

$$\Psi_{in}(\boldsymbol{r}) = C\, e^{-\frac{1}{2}(\rho-\rho_0)^2/b^2}\, e^{-\frac{1}{2}(z/b)^2}\, e^{ip_0 z}$$

$$\Psi_{in}(\boldsymbol{p}) = C\, e^{-\frac{1}{2}(\boldsymbol{b}\,\boldsymbol{p}_\perp)^2}\, e^{-\frac{1}{2}b^2(p_z-p_0)^2}\, e^{-ip_\perp \rho_0}$$

Obtain the general formula for the cross section. Find the condition at which the cross section can be simplified as:

$$\frac{d\sigma}{d\Omega} = \int d^3 p'\, \frac{p'}{p'_z}\, |\Phi_0(\boldsymbol{p}')|^2\, |f(p',p)|^2 = |f(p',p)|^2$$

2. Calculate the density of (free-electron) states, described by the wave-function $\varphi_k(\boldsymbol{r}) = e^{i\boldsymbol{k}\boldsymbol{r}}$.