TU KAISERSLAUTERN
Department of Physics

Winter Term 2022/2023

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Quantum Mechanics II — Problem Sheet 7

Problem 18: Born Approximation in 1D (6 points)

Derive the Born approximation for a one-dimensional scattering problem:

a) Write down the one-dimensional Schrödinger equation in integral form.

b) Determine the one-dimensional Green function.

c) Which result do you then get for the reflexion and the transmission coefficient in Born approximation?

Problem 19: Even Potentials (6 points)

Work out for even potentials a theory for scattering in 1D within the Born approximation, which is based on phase shifts. Show that the reflection and transmission coefficients are completely determined by asymptotic phase shift of even and odd solutions of the Schrödinger equations. Consider as a concrete example the one-dimensional form of **Problem 15**.

Problem 20: Delta Potential in 1D (4 points)

Determine the scattering amplitude $f(\vartheta)$ for a scattering at the potential $V(r) = \alpha\delta(r-a)$ in Born approximation. Calculate the total cross-section for small particle energies and compare your result with the one from **Problem 16**.

Problem 21: Delta Potential in 3D (4 points)

Determine in Born approximation both the differential and the total cross-section of the potential $V(\mathbf{r}) = \alpha\delta(\mathbf{r})$. What is the phase shift for s-wave scattering δ_0 in the limit of small energies?

Problem 22: Neutron-Neutron Scattering (4 points)

The neutron-neutron scattering is modelled by the Yukawa potential $V(r) = V_0 e^{-\mu r}/r$. Determine in Born approximation the differential cross-section for both a singulett and the triple state of the system. **Hint:** Take into account that neutrons are identical particles of spin 1/2.

Drop the solutions in the post box on the 5th floor of building 46 or, in case of illness/quarantine, send them via email to jkrauss@rhrk.uni-kl.de until December 12 at 12.00.