Advanced quantum mechanics
SS 2019 – Prof. Dr. Marc Wagner

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Exercise sheet 7

To be handed in 06.06.19 before the lecture.
To be discussed in the week of 10.06.19.
30.05.19

Exercise 1 [*Yukawa potential, Born approximation (continued)*] (3+2+4+3+4=16 pts.)

Consider the Yukawa potential from sheet 6, exercise 2, with $\lambda > 0$. Carry out the following exercises for each of the two cases $k/\lambda = 3.0$ and $k/\lambda = 0.2$.

(a) Determine approximately for which values of A the Born approximation is applicable. You can either use your computer or do a crude analytical estimate.

(b) Discuss whether one can expect that the sum of partial waves σ_l is a reasonable approximation of the total cross-section.

(c) Calculate the phase shifts $\delta_l(E)$ for $l = 0, 1, 2, 3$ in the Born approximation. Use a computer to solve the corresponding 1-dimensional integrals numerically.

(d) Use the result from sheet 6, exercise 2(b), to calculate the total cross-section. It is possible, but not straightforward, to solve the corresponding integral analytically. Thus, you are also allowed to solve the integral numerically.

(e) Compare the partial wave contributions σ_l to the total cross-section with your result for σ from (d). Do your numerical results agree with your theoretical expectation?

Hints: To solve an integral numerically, it is useful to first eliminate dimensionful quantities by introducing appropriate dimensionless ratios or products. It is straightforward to solve 1-dimensional definite integrals numerically, e.g. using Mathematica, Maple, or Python with the SciPy package. On the websites `https://www.wolframalpha.com/` *or* `http://www.tutorialspoint.com/execute_python_online.php` *you can run Mathematica-syntax or Python-code inside your browser.*

Exercise 2 [*Scattering theory, summary*] (4 pts.)

For each section of the lecture notes about scattering theory in three dimensions (3.2.1 to 3.2.9), give a brief summary of the main statements and formulas (in total it should not be more than 1 page).