Exercise 6

Exercise 6.1:

Your expression $\langle k_1', k_2'|\rho(q)|k_1, k_2\rangle \equiv \langle k_1'|\rho(q)|k_1\rangle = \langle P'|\rho(q)|k_1\rangle$ is not correct. (-1P) To see this remember what k_i and the P, p are:

1. k_i momentum of compound particle i
2. Jacobi momenta
    1. $P = k_1 + k_2$
    2. $p = \frac{1}{2}(k_1 - k_2)$

Consequently, you have a change of frame (to the Centre of Mass frame). But the evaluation of $\langle p', P'|\rho(q)|p, P\rangle$ is not as trivial as displayed. Formally, one can show your conclusion ($\langle \Psi P'|\rho(q)|\Psi P\rangle = \langle \Psi P'|\Psi P\rangle \delta(P' - P - q)$) using completeness relations.

Further, your derivation of the integral form can not match up. (-1P) To see this consider your conclusion "In integral notation"

$$\langle \Psi(p')|\Psi(p' - \frac{1}{2}q) = \int \Psi^*(p')\Psi(p' - \frac{1}{2}q)$$

Here on the RHS you have no dependency on p' (it is integrated out!) but your LHS appears to have it. In the end the form factor (which your LHS should define) must only depend on q.

I believe the missunderstanding comes from the abuse of notation that $|\Psi P\rangle \equiv |p, P\rangle$ denotes the jacobi momentum state of the compount particle.

Points: (0/2)

Exercise 6.2:

One detail is missing, what leaves us the chance to saz that the integral is independend of Φ? (-1P) This comes from the fact that we are using the Breit frame.

Points: (2/3)

Exercise 6.3:

Following your plots it seems that your code has some error. The steps to compute the form factor are correct. So I assume the error is somewhere in the interpolation. If I am correct you are not correctly projecting to [-1,1] (compare lecture 7 page 123 (8)). (-1P)

Points: (6/7)

Exercise 6.4:

To tst the numerical precision you should have compared one example for multiple number of angular grid points. (-2P)

Points:(0/2)

Exercise 6.5:

The argument about the normalization is correct.

Your derivation for $\langle r^2 \rangle$ can not lead to the result bacause you don't know the solution to the radial part $\Psi_l(p)$. (-2P) The idea is to considere that

$$\langle r^2 \rangle = \int r^2 |\Psi(r)|^2 d^3 r$$

which you can get by inserting the backwards Fourier trafo of $\Psi(p)$ and then take the two defined derivative i.r.t. q.

Points: (1/3)

Exercise 6.6:

I see that you have plotted the form factors for several cutoffs. Unfortunately, your conclusions are not correct as your form factors are wrong. You point out correctly, that the form factor depends on the cutoff, and that should be dependend on q (small q are fine).

Points (2/3)

Summary

Total Points (11/20) (55%)