Physics 714: Homework 3

Due Monday, March 20, 2023 [illegible]

1. A spinless dark m[illegible]ass M interactions weakly with the heavy nuclei in a detector. The effe[illegible]al for the interaction of χ with the nucleus is given by

$$[illegible] = G_F \ \delta^{(3)}(\vec{x}) \quad . \tag{1}$$

Following the logic [illegible]cattering in class, compute the cross section for the scattering of χ from [illegible] detector assuming the velocity of the dark matter particle is $\vec{v}$. For th[illegible] neglect the recoil, even though observation of the latter is critical for dark matter detection.

2. Consider the scattering of two scalar particles A and B for which the flux factor is

$$F = 4E_A E_B |\vec{v}_A - \vec{v}_B| \quad . \tag{2}$$

Show that F can be written in manifestly Lorentz invariant way as

$$F = 4\left[(p_A \cdot p_B)^2 - m_A^2 m_B^2\right]^{1/2} \quad . \tag{3}$$

3. Use the definition of the Greens function in Eq. (5.8) in the posted lecture notes to show that the equation of motion (5.20) for the free Greens function $G_0(x', x)$ implies that the wavefunction $\psi(x)$ satisfies the Schrodinger equation for a non-relativistic particle in a potential $V(x)$. (Please note that the equation numbers used in live lecture and those in the notes posted on Moodle differ by "chapter number". Please refer to the posted notes for the equation numbers in this problem.)

4. Use explicit computation of the contour integrals to show how the Feynman-Stuckelberg prescription yields Greens functions for relativistic, spinless particles that propagate positive frequency solutions to the Klein-Gordon equation forward in time and negative frequency solutions backward in time.