Srednicki Chapter 12

QFT Problems & Solutions

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Srednicki 12.1. Express $\hbar c$ in GeV fm, where 1 fm = 1 fermi = 10^{-13} cm.

A published value of hc is $1.239 eV \mu m$. Multiply by 10^{-9} to get to GeV μm and by 10^9 to get to GeV fm, and divide by 2π to get to $\hbar$ rather than h. Then,

$$\hbar c = .197 \text{ GeV fm}$$

Srednicki 12.2. Express the masses of the proton, neutron, pion, electron, muon, and tau in GeV.

Just look up the masses in kg, multiply by c^2, and convert to GeV. Alternatively, just look up the masses in GeV online. The results are:

$m_p = 0.938$ GeV
$m_n = 0.939$ GeV
$m_\pi = .139$ GeV
$m_e = .000511$ GeV
$m_\mu = .105$ GeV
$m_\tau = 1.777$ GeV

Srednicki 12.3. The proton is a strongly interacting blob of quarks and gluons. It has nonzero charge radius $\mathbf{r_p}$, given by $\mathbf{r_p^2 = \int d^3x \rho(r) r^2}$, where $\boldsymbol{\rho}(\mathbf{r})$ is the quantum expectation value of the electric charge distribution inside the proton. Estimate the value of $\mathbf{r_p}$, then look up its measured value. How accurate was your estimate?

We know the mass of the proton, .938 GeV, and we want units of distance, so we take $\frac{\hbar}{m_p c} = 1.32$ fm. The measured value is .877 fm, so we were off by about 50%. Not bad, considering that we didn't even use charge at all!