Massachusetts Institute of Technology

Department of Physics

Course:	8.701 – Introduction to Nuclear and Particle Physics
Term:	Fall 2020
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Discussion Problems
from recitation on **September 10th, 2020**

Problem 1:   W boson branching fraction

The W boson decays via the weak interaction to leptons and neutrinos $[(e^+\nu_e), (\mu^+\nu_\mu), (\tau^+\nu_\tau)]$, or pairs of quarks $[(u,\bar{d}),(c,\bar{s})]$ - why not $(t,\bar{b})$? While we will study the weak interaction in much more details, we can already calculate branching fractions assuming that all fermions have the same weak charge. What is the branching fraction $\mathcal{B}(W^+ \to \mu^+\nu_\mu)$?

Problem 2:   Cross section and impact paramater

A beam of small balls (mass m and radius r) scatters elastically of a larger ball (mass M and radius R) with $M \gg m$ and $R \gg r$

a)
Calculate the differential and total geometrical cross section. Hint: use $\sin(x + y) = \sin(x)\cos(y) + \cos(x)\sin(y)$).

b)
How large is the fraction of small balls scattering under a scattering angle of $\theta \leq 30°$?

c)
The total cross-section for electron-proton scattering at HERA ($\sqrt{} =$) is about $10\,\mathrm{mb}$. Compare this to the geometrical cross-section of a proton assuming a radius of $0,862\,\mathrm{fm}$. What does the result mean?

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