

SHORT HW 3: Mass

COURSE: Physics 165, *Introduction to Particle Physics* (2020)

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DUE BY: **Thursday**, Feb 13

Note that this short assignment is due in class on Thursday. You have only *two days* to do it. This should be quick, I recommend doing it right after class on Tuesday.

1 Electroweak theory... is massless?

The symmetries of electroweak theory seem to prohibit matter particles from having mass. This is clearly not true in the real world, and the resolution of this apparent discrepancy has to do with the Higgs.

Fact: A particle can have a mass if you can write an invariant combination of *only* the particle and its antiparticle (and no additional particles).

For example: if I have a scalar particle Φ with hypercharge q_Y and no indices, then it has an antiparticle Φ^\dagger with hypercharge $-q_Y$. The product $\Phi^\dagger\Phi$ is invariant, and thus the Φ particle can have a mass. Similarly, if I have a scalar SU(2) doublet D^a with no other indices/charges, then the antiparticle $(D^\dagger)_a$ is an ‘anti-doublet’ with a lower index, and I can form the invariant product $(D^\dagger)_a D^a$.

Explain why electroweak theory (as we have developed so far in class) (i) allows the Higgs particle to have a mass and (ii) prohibits the spin-1/2 matter particles from having mass.