08.128.742 Quantum Field Theory III
The Standard Model and Electroweak Theory

Homework set 1

Due November 12, 2020; e-mail (photo or scan) to yu001@uni-mainz by start of discussion session
Please note how long it took you to solve each problem

1-1, 50 pts. A. Using the mass basis for the electroweak gauge bosons, decompose the electroweak field strength kinetic terms into the corresponding kinetic field strengths for the $W^{\pm}$, Z, and γ gauge bosons, as well as the cubic and quartic interaction terms. (The answer is in equation 29.9 of Schwartz.) B. Also expand the Higgs kinetic term around the Higgs vev in the gauge boson mass basis. (The answer is given in equation 29.14 of Schwartz.) C. How would the answer to part A change with the introduction of a W' gauge boson? For concreteness, you can consider augmenting the Standard Model by a gauged $SU(2)_R$ group.

1-2, 50 pts. Calculate the $h \to gg$ decay width at one loop mediated by the top quark. (The answer is in equation 2.58 of arXiv/0503172 by A. Djouadi.) Demonstrate that an infinitely heavy top quark still gives a non-vanishing contribution to the $h \to gg$ decay width. (This equally implies that an infinitely heavy top quark would give a non-vanishing contribution to $gg \to h$ production.) This is known as *non-decoupling.* In the Standard Model, the number of chiral generations is not known a priori. How would you probe the existence of a fourth (or more) generations of chiral fermions? Is it allowed or excluded by the current ATLAS and CMS collider results?