



Homework of Teoria de Campo

Curso de Física Tecnológica - 2017/2018

Hand in until 4/6/2018 at 18:00

The problem is in the framework of the Standard Model (SM). The couplings are in the book. The masses and widths can be found in the *Particle Data Group* (PDG) at <http://pdg.lbl.gov/>.

- The Homework is individual
- You should justify all answers and describe the plots
- On any of the questions you can use all the available software, on the condition that you present the codes used in an usable format.

Consider the process

$$e^-(p_1) + e^+(p_2) \rightarrow W^-(p_3) + W^+(p_4)$$

In this problem **neglect** the electron mass.

- Use **qgraf** to find the diagrams contributing in lowest order.
- Using the method of your choice determine $\langle |\mathcal{M}|^2 \rangle$ and the differential cross section in the CM frame, $d\sigma/d\Omega$.
- Make a plot of the **total** cross section, $\sigma(e^-e^+ \rightarrow W^+W^-)$, in *pb* for $\sqrt{s} \in [161, 2000]$ GeV.
- In one plot compare the total cross section with the t-channel in the smaller interval $\sqrt{s} \in [161, 300]$ GeV. Use linear scales. Comment on your results.
- Use the program **CalcHEP** to evaluate the same process and superimpose the points obtained with **CalcHEP** on your previous plot for the interval $\sqrt{s} \in [161, 2000]$ GeV. Make sure that you use the same constants in both cases.
- In one plot compare your results for the total cross section with those of **CalcHEP** in the smaller interval $\sqrt{s} \in [161, 300]$ GeV. Use linear scales.

NOTES

- In the web page <http://porthos.ist.utl.pt/CTQFT/> you can find useful examples.
- The program **CalcHEP** uses a trick to evaluate the sum of helicities for spin one particles. As a consequence only the total result can be compared, not the individual contributions.