



## Theory of Fundamental Interactions

### Exercises III

#### Esercizio 1

Study the  $W$  boson decay by addressing the following points:

1. Compute the differential decay width to positron and neutrino

$$W^+ \rightarrow e^+ \nu_e,$$

of a  $W^+$  at rest with spin  $+1$ ,  $-1$  e  $0$  along the  $z$  axis. Neglect the positron and electron masses. Verify explicitly that the result violates the parity symmetry  $P$ .

Compute the polarised differential rates also for the process

$$W^- \rightarrow e^- \bar{\nu}_e,$$

and check that Charge Conjugation  $C$  is also broken, while  $CP$  is preserved.

2. Compute now the *unpolarised* widths, defined as the average of the polarised ones, by employing the completeness relation for the  $W$  polarisation vectors. Check that the same result is obtained as the average of the polarised widths computed at point 1).
3. The main decay channels of the  $W$  are:

$$W \rightarrow e \nu_e, \mu \nu_\mu, \tau \nu_\tau, ud, cs,$$

compute the total decay width, neglecting the masses of all final states and check that it approximately reproduces the experimental value

$$\Gamma_W \simeq 2 \text{ GeV},$$