

Table 15.5 Properties of the Fundamental Point Particles

Particle		Approximate Rest Mass in Terms of Proton Mass ^a	Interactions Experienced ^b	Interaction Mediated	Electric Charge in Units of $ e $	Color Charge
Leptons	$\left\{ \begin{array}{l} e^-, \mu, \tau \\ \nu_e, \nu_\mu, \nu_\tau \end{array} \right.$	$\frac{1}{1836}, \frac{1}{9}, 1.9$ $<3 \times 10^{-9}, <4 \times 10^{-9},$ $<9 \times 10^{-9}$	EM, W W	None None	-1 0	No No
Quarks	$\left\{ \begin{array}{l} u, c, t \\ d, s, b \end{array} \right.$	$\frac{1}{2.8}, 1.6, 185$ $\frac{1}{2.8}, \frac{1}{1.7}, 5.3$	EM, W, S EM, W, S	None None	$+\frac{2}{3}$ $-\frac{1}{3}$	Yes Yes
All are fermions with spin $\frac{1}{2}$.						
Field Particles						
Photon	γ	0	EM	EM	0	No
Intermediate bosons	$\left\{ \begin{array}{l} W^\pm \\ Z^0 \end{array} \right.$	86 97	W, EM W	W W	± 1 0	No No
Gluons	g	0	S	S	0	Yes
All are bosons with spin 1.						

^aFor quarks these are inferred values because free quarks have never been observed.

^bEM = electromagnetic, W = weak, S = strong