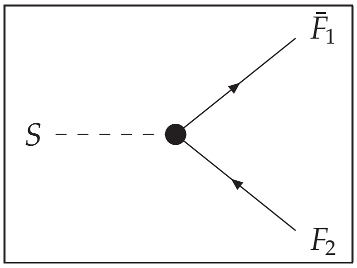
Scalar-Fermion-Fermion coupling in the electroweak Standard Model
Reference: A. Denner, Forts. Physik, **41** (1993) 307.



$$= \mathrm{i}e(G_{\omega_-}\omega_- + G_{\omega_+}\omega_+)$$

Generic Level

Classes Level

where for the following combinations of S, $\bar{F}_1$, and F_2
G_{ω_+} and G_{ω_-} take these values:

$$\mathrm{H}\bar{f}_i f_j \;:\; \begin{cases} G_{\omega_+} = -\frac{1}{2s}\frac{1}{M_\mathrm{W}}\Big[\delta_{ij} m_{f,i}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{f,i}}{m_{f,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}} + \frac{1}{2}\delta Z^\mathrm{H}\Big) \\ \qquad + \frac{1}{2}(m_{f,i}\delta Z^{f,R}_{ij} + \delta Z^{f,L\dagger}_{ij} m_{f,j})\Big], \\ G_{\omega_-} = -\frac{1}{2s}\frac{1}{M_\mathrm{W}}\Big[\delta_{ij} m_{f,i}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{f,i}}{m_{f,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}} + \frac{1}{2}\delta Z^\mathrm{H}\Big) \\ \qquad + \frac{1}{2}(m_{f,i}\delta Z^{f,L}_{ij} + \delta Z^{f,R\dagger}_{ij} m_{f,j})\Big], \end{cases}$$

$$\chi\bar{f}_i f_j \;:\; \begin{cases} G_{\omega_+} = \mathrm{i}\frac{1}{2s}2I^3_{\mathrm{W},f}\frac{1}{M_\mathrm{W}}\Big[\delta_{ij} m_{f,i}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{f,i}}{m_{f,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) \\ \qquad + \frac{1}{2}(m_{f,i}\delta Z^{f,R}_{ij} + \delta Z^{f,L\dagger}_{ij} m_{f,j})\Big], \\ G_{\omega_-} = -\mathrm{i}\frac{1}{2s}2I^3_{\mathrm{W},f}\frac{1}{M_\mathrm{W}}\Big[\delta_{ij} m_{f,i}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{f,i}}{m_{f,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) \\ \qquad + \frac{1}{2}(m_{f,i}\delta Z^{f,L}_{ij} + \delta Z^{f,R\dagger}_{ij} m_{f,j})\Big], \end{cases}$$

$$\phi^+\bar{u}_i d_j \;:\; \begin{cases} G_{\omega_+} = -\frac{1}{\sqrt{2}s}\frac{1}{M_\mathrm{W}}\Big[V_{ij} m_{d,j}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{d,j}}{m_{d,j}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) + \delta V_{ij} m_{d,j} \\ \qquad + \frac{1}{2}\sum_k(\delta Z^{u,L\dagger}_{ik} V_{kj} m_{d,j} + V_{ik} m_{d,k}\delta Z^{d,R}_{kj})\Big], \\ G_{\omega_-} = \frac{1}{\sqrt{2}s}\frac{1}{M_\mathrm{W}}\Big[m_{u,i} V_{ij}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{u,i}}{m_{u,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) + m_{u,i}\delta V_{ij} \\ \qquad + \frac{1}{2}\sum_k(\delta Z^{u,R\dagger}_{ik} m_{u,k} V_{kj} + m_{u,i} V_{ik}\delta Z^{d,L}_{kj})\Big], \end{cases}$$

$$\phi^-\bar{d}_j u_i \;:\; \begin{cases} G_{\omega_+} = \frac{1}{\sqrt{2}s}\frac{1}{M_\mathrm{W}}\Big[V^\dagger_{ji} m_{u,i}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{u,i}}{m_{u,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) + \delta V^\dagger_{ji} m_{u,i} \\ \qquad + \frac{1}{2}\sum_k(\delta Z^{d,L\dagger}_{jk} V^\dagger_{ki} m_{u,i} + V^\dagger_{jk} m_{u,k}\delta Z^{u,R}_{ki})\Big], \\ G_{\omega_-} = -\frac{1}{\sqrt{2}s}\frac{1}{M_\mathrm{W}}\Big[m_{d,j} V^\dagger_{ji}\Big(1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{d,j}}{m_{d,j}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}}\Big) + m_{d,j}\delta V^\dagger_{ji} \\ \qquad + \frac{1}{2}\sum_k(\delta Z^{d,R\dagger}_{jk} m_{d,k} V^\dagger_{ki} + m_{d,j} V^\dagger_{jk}\delta Z^{u,L}_{ki})\Big], \end{cases}$$

$$\phi^+\bar{\nu}_i l_j \;:\; \begin{cases} G_{\omega_+} = -\frac{1}{\sqrt{2}s}\frac{m_{l,i}}{M_\mathrm{W}}\delta_{ij}\Big[1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{l,i}}{m_{l,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}} + \frac{1}{2}(\delta Z^{\nu,L\dagger}_{ii} + \delta Z^{l,R}_{ii})\Big], \\ G_{\omega_-} = 0, \end{cases}$$

$$\phi^-\bar{l}_j \nu_i \;:\; \begin{cases} G_{\omega_+} = 0, \\ G_{\omega_-} = -\frac{1}{\sqrt{2}s}\frac{m_{l,i}}{M_\mathrm{W}}\delta_{ij}\Big[1 + \delta Z_e - \frac{\delta s}{s} + \frac{\delta m_{l,i}}{m_{l,i}} - \frac{\delta M_\mathrm{W}}{M_\mathrm{W}} + \frac{1}{2}(\delta Z^{l,R\dagger}_{ii} + \delta Z^{\nu,L}_{ii})\Big]. \end{cases}$$

Particles Level: Insert integers for i and j (1, 2, 3 in this case)