Feynman Rules Clover

(Written by Maximilian Ammer, 2023)
This notebook generates the fermionic Feynman rules for the qqg-, qqgg-, and qqggg-vertices in lattice perturbation theory for the clover term.
The resulting functions are saved to files, which can be loaded by other notebooks for further calculations.

```
SetDirectory["~path~"];
```

In[•]:=
```
Get["myLPT.m"]
Clear[p, q, k, 𝕀, 𝔤, σ]
```

Clover term

In[•]:=
```
(* Plaquette *)
P[mu_, nu_] :=
 U[1, mu, x] × U[2, nu, x + e[mu]] × U[3, -mu, x + e[mu] + e[nu]] × U[4, -nu, x + e[nu]]
```

In[•]:=
```
(* Clover *)
Q[mu_, nu_] := P[mu, nu] + P[nu, -mu] + P[-mu, -nu] + P[-nu, mu]
```

In[•]:=
```
(* Clover field strength *)
F[mu_, nu_] := -I / 8 (Q[mu, nu] - Q[nu, mu])
```

In[•]:=
```
(* Clover term in position space *)
SClover = -ψbar[x] × δ[x, y] r csw / 4 SUM[nu0] × σ[mu, nu0] × F[mu, nu0] × ψ[y]
```

Out[•]=

$$\frac{1}{32}\,\mathbb{i}\,\text{csw r SUM}[\text{nu0}]$$
$$\begin{aligned}
&(-U[1,\text{nu0},x]\times U[2,\text{mu},x+e[\text{nu0}]]\times U[3,-\text{nu0},x+e[\text{mu}]+e[\text{nu0}]]\times\\
&\quad U[4,-\text{mu},x+e[\text{mu}]]+U[1,-\text{nu0},x]\times U[2,\text{mu},x+e[-\text{nu0}]]\times\\
&\quad U[3,\text{nu0},x+e[\text{mu}]+e[-\text{nu0}]]\times U[4,-\text{mu},x+e[\text{mu}]]+\\
&\quad U[1,\text{nu0},x]\times U[2,-\text{mu},x+e[\text{nu0}]]\times U[3,-\text{nu0},x+e[-\text{mu}]+e[\text{nu0}]]\times\\
&\quad U[4,\text{mu},x+e[-\text{mu}]]-U[1,-\text{nu0},x]\times U[2,-\text{mu},x+e[-\text{nu0}]]\times\\
&\quad U[3,\text{nu0},x+e[-\text{mu}]+e[-\text{nu0}]]\times U[4,\text{mu},x+e[-\text{mu}]]+U[1,\text{mu},x]\times\\
&\quad U[2,\text{nu0},x+e[\text{mu}]]\times U[3,-\text{mu},x+e[\text{mu}]+e[\text{nu0}]]\times U[4,-\text{nu0},x+e[\text{nu0}]]-\\
&\quad U[1,-\text{mu},x]\times U[2,\text{nu0},x+e[-\text{mu}]]\times U[3,\text{mu},x+e[-\text{mu}]+e[\text{nu0}]]\times\\
&\quad U[4,-\text{nu0},x+e[\text{nu0}]]-U[1,\text{mu},x]\times U[2,-\text{nu0},x+e[\text{mu}]]\times\\
&\quad U[3,-\text{mu},x+e[\text{mu}]+e[-\text{nu0}]]\times U[4,\text{nu0},x+e[-\text{nu0}]]+\\
&\quad U[1,-\text{mu},x]\times U[2,-\text{nu0},x+e[-\text{mu}]]\times U[3,\text{mu},x+e[-\text{mu}]+e[-\text{nu0}]]\times\\
&\quad U[4,\text{nu0},x+e[-\text{nu0}]])\,\delta[x,y]\times\sigma[\text{mu},\text{nu0}]\times\psi[y]\times\psi\text{bar}[x]
\end{aligned}$$

In[ ]:=
```
(* Clover term in momentum space *)
SCloverFT = SClover // myExpandU // myFourierTransform
```

Out[ ]=

$$-\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x-\frac{e[mu]}{2}-e[nu0]\right)}\,g0\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times \text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},nu0]\times\Psi[p]\times\Psi\text{bar}[q]-$$
$$\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+\frac{e[mu]}{2}-e[nu0]\right)}\,g0\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times\text{Int}[p]\times \text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},nu0]\times\Psi[p]\times\Psi\text{bar}[q]+\cdots 283\cdots+$$
$$\frac{1}{96}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+e[mu]+\frac{e[nu0]}{2}\right)+i\,k2\left(x+e[mu]+\frac{e[nu0]}{2}\right)+i\,k3\left(x+e[mu]+\frac{e[nu0]}{2}\right)}\,g0^3\,r\,A[a,nu0,k1]\times A[b,nu0,k2]\times A[c,nu0,k3]\times\text{Int}[k1]\times\text{Int}[k2]\times\text{Int}[k3]\times \text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a,b,c]\times\sigma[\text{mu},nu0]\times\Psi[p]\times\Psi\text{bar}[q]$$

Size in memory: 0.5 MB | + Show more | Show all | Iconize | Store full expression in notebook

Vertices

QQG Vertex

In[•]:=
```
V1 = g0 Coefficient[SCloverFT, g0]
```

Out[•]=

$$g0\left(-\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x-\frac{e[mu]}{2}-e[nu0]\right)}\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]-\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+\frac{e[mu]}{2}-e[nu0]\right)}\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]+\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x-\frac{e[mu]}{2}+e[nu0]\right)}\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]+\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+\frac{e[mu]}{2}+e[nu0]\right)}\,r\,A[a,\text{mu},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]+\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x-e[mu]-\frac{e[nu0]}{2}\right)}\,r\,A[a,\text{nu0},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]-\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+e[mu]-\frac{e[nu0]}{2}\right)}\,r\,A[a,\text{nu0},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]+\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x-e[mu]+\frac{e[nu0]}{2}\right)}\,r\,A[a,\text{nu0},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]-\frac{1}{16}\,\text{csw}\,e^{-i\,q\,x+i\,s\,(x-y)+i\,p\,y+i\,k1\left(x+e[mu]+\frac{e[nu0]}{2}\right)}\,r\,A[a,\text{nu0},k1]\times\text{Int}[k1]\times\text{Int}[p]\times\text{Int}[q]\times\text{Int}[s]\times\text{SUM}[nu0]\times T[a]\times\sigma[\text{mu},\text{nu0}]\times\Psi[p]\times\Psi\text{bar}[q]\right)$$

In[•]:=
```
V1f = myFRintegrate[V1] // myFRbreakdown // Simplify
```

Out[•]=

$$\frac{1}{2}\,i\,\text{csw}\,g0\,r\,\text{Cos}\left[\frac{1}{2}\,(p[\text{mu}]-q[\text{mu}])\right]T[a]\,(\text{Sin}[p[1]-q[1]]\,\sigma[\text{mu},1]+\text{Sin}[p[2]-q[2]]\,\sigma[\text{mu},2]+\text{Sin}[p[3]-q[3]]\,\sigma[\text{mu},3]+\text{Sin}[p[4]-q[4]]\,\sigma[\text{mu},4])$$

In[•]:=
```
(* Preparing for saving and loading *)
V1Out = V1f /. T[a__] :→ 1 // ExpandAll
```

Out[•]=

$$\frac{1}{2}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\mathrm{Sin[p[1]-q[1]]}\,\sigma\mathrm{[mu,\,1]}+$$
$$\frac{1}{2}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\mathrm{Sin[p[2]-q[2]]}\,\sigma\mathrm{[mu,\,2]}+$$
$$\frac{1}{2}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\mathrm{Sin[p[3]-q[3]]}\,\sigma\mathrm{[mu,\,3]}+$$
$$\frac{1}{2}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\mathrm{Sin[p[4]-q[4]]}\,\sigma\mathrm{[mu,\,4]}$$

In[•]:=
```
(* Saving *)
V1Clover[mu_, p_, q_] := Evaluate[V1Out]
DumpSave["V1_Clover.mx", V1Clover]
```

Out[•]=
```
{V1Clover}
```

QQGG Vertex

In[•]:=
```
V2 = g0^2 Coefficient[SCloverFT, g0^2];
```

In[•]:=
```
V2f = myFRintegrate[V2] // myFRbreakdown;
```

In[ ]:=
```
(* Preparing for saving and loading *)
V2Out = V2f /. T[a__] :> 1 // ExpandAll
```

Out[ ]=

$$-\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[1]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 1] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[1]+p[1]-q[1]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 1] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[2]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 2] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[2]+p[2]-q[2]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 2] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[3]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 3] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[3]+p[3]-q[3]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 3] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[4]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 4] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, \delta_{mu,nu}\, Sin[k2[4]+p[4]-q[4]]\, Sin\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, 4] -$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, Cos\left[\frac{k2[nu]}{2}\right] Cos\left[\frac{k2[mu]}{2}+\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \sigma[mu, nu] +$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, Cos\left[\frac{k2[nu]}{2}\right] Cos\left[\frac{k2[mu]}{2}-\frac{p[mu]}{2}+\frac{q[mu]}{2}\right] \sigma[mu, nu] +$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, Cos\left[\frac{k2[mu]}{2}+\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] Cos\left[\frac{k2[nu]}{2}+p[nu]-q[nu]\right] \sigma[mu, nu] +$$
$$\frac{1}{4} i\, csw\, g0^2\, r\, Cos\left[\frac{k2[mu]}{2}-\frac{p[mu]}{2}+\frac{q[mu]}{2}\right] Cos\left[\frac{k2[nu]}{2}+p[nu]-q[nu]\right] \sigma[mu, nu]$$

In[ ]:=
```
(* Saving *)
V2Clover[mu_, nu_, p_, q_, k1_, k2_] := Evaluate[V2Out]
DumpSave["V2_Clover.mx", V2Clover]
```

Out[ ]=
```
{V2Clover}
```

QQGGG Vertex

In[ ]:=
```
(* QQG Vertex *)
V3 = g0^3 Coefficient[SCloverFT, g0^3];
```

In[ ]:=
```
V3f = myFRintegrate[V3] // myFRbreakdown;
```

In[ ]:=
```
(* Preparing for saving and loading *)
V3Out = V3f /. T[a__] :> 1 // ExpandAll
```

Out[ ]=

$$\frac{1}{8} i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \delta_{mu,nu}\, \delta_{mu,rho}\, Sin[k3[1]]\, \sigma[mu, 1] -$$
$$\frac{1}{8} i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right] \delta_{mu,nu}\, \delta_{mu,rho}\, Sin[k2[1]+k3[1]]\, \sigma[mu, 1] -$$

$$\frac{1}{12}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[p[1]-q[1]]\,\sigma[mu,1]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[1]+p[1]-q[1]]\,\sigma[mu,1]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[1]+k3[1]+p[1]-q[1]]\,\sigma[mu,1]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[2]]\,\sigma[mu,2]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[2]+k3[2]]\,\sigma[mu,2]-$$
$$\frac{1}{12}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[p[2]-q[2]]\,\sigma[mu,2]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[2]+p[2]-q[2]]\,\sigma[mu,2]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[2]+k3[2]+p[2]-q[2]]\,\sigma[mu,2]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[3]]\,\sigma[mu,3]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[3]+k3[3]]\,\sigma[mu,3]-$$
$$\frac{1}{12}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[p[3]-q[3]]\,\sigma[mu,3]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[3]+p[3]-q[3]]\,\sigma[mu,3]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[3]+k3[3]+p[3]-q[3]]\,\sigma[mu,3]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[4]]\,\sigma[mu,4]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[4]+k3[4]]\,\sigma[mu,4]-$$
$$\frac{1}{12}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[p[4]-q[4]]\,\sigma[mu,4]+$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k3[4]+p[4]-q[4]]\,\sigma[mu,4]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{mu,nu}\,\delta_{mu,rho}\, Sin[k2[4]+k3[4]+p[4]-q[4]]\,\sigma[mu,4]-$$
$$\frac{1}{8}\, i\, csw\, g0^3\, r\, Cos\left[\frac{k2[mu]}{2}+\frac{k3[mu]}{2}+\frac{p[mu]}{2}-\frac{q[mu]}{2}\right]\delta_{nu,rho}\, Sin\left[\frac{k2[nu]}{2}+\frac{k3[nu]}{2}\right]$$
$$\sigma[mu,nu]+\frac{1}{4}\, i\, csw\, g0^3\, r\, Cos\left[\frac{k2[mu]}{2}-\frac{k3[mu]}{2}-\frac{p[mu]}{2}+\frac{q[mu]}{2}\right]$$
$$\delta_{nu,rho}\, Sin\left[\frac{k2[nu]}{2}+\frac{k3[nu]}{2}\right]\sigma[mu,nu]-\frac{1}{8}\, i\, csw\, g0^3\, r$$
$$Cos\left[\frac{k2[mu]}{2}+\frac{k3[mu]}{2}-\frac{p[mu]}{2}+\frac{q[mu]}{2}\right]\delta_{nu,rho}\, Sin\left[\frac{k2[nu]}{2}+\frac{k3[nu]}{2}\right]\sigma[mu,nu]+$$
$$\frac{1}{4}\, i\, csw\, g0^3\, r\, Cos\left[\frac{k2[nu]}{2}+k3[nu]\right]\delta_{mu,rho}\, Sin\left[\frac{k2[mu]}{2}-\frac{p[mu]}{2}+\frac{q[mu]}{2}\right]\sigma[mu,nu]+$$

$$\frac{1}{4}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k2[nu]}}{2}+\mathrm{k3[nu]}+\mathrm{p[nu]}-\mathrm{q[nu]}\right]\delta_{\mathrm{mu,rho}}\,\mathrm{Sin}\left[\frac{\mathrm{k2[mu]}}{2}-\frac{\mathrm{p[mu]}}{2}+\frac{\mathrm{q[mu]}}{2}\right]$$
$$\sigma[\mathrm{mu},\,\mathrm{nu}]-\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k2[mu]}}{2}+\frac{\mathrm{k3[mu]}}{2}+\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]$$
$$\delta_{\mathrm{nu,rho}}\,\mathrm{Sin}\left[\frac{\mathrm{k2[nu]}}{2}+\frac{\mathrm{k3[nu]}}{2}+\mathrm{p[nu]}-\mathrm{q[nu]}\right]\sigma[\mathrm{mu},\,\mathrm{nu}]-$$
$$\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k2[mu]}}{2}+\frac{\mathrm{k3[mu]}}{2}-\frac{\mathrm{p[mu]}}{2}+\frac{\mathrm{q[mu]}}{2}\right]\delta_{\mathrm{nu,rho}}$$
$$\mathrm{Sin}\left[\frac{\mathrm{k2[nu]}}{2}+\frac{\mathrm{k3[nu]}}{2}+\mathrm{p[nu]}-\mathrm{q[nu]}\right]\sigma[\mathrm{mu},\,\mathrm{nu}]+$$
$$\frac{1}{4}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\mathrm{k2[rho]}+\frac{\mathrm{k3[rho]}}{2}\right]\delta_{\mathrm{mu,nu}}\,\mathrm{Sin}\left[\frac{\mathrm{k3[mu]}}{2}+\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\sigma[\mathrm{mu},\,\mathrm{rho}]-$$
$$\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k3[rho]}}{2}\right]\delta_{\mathrm{mu,nu}}\,\mathrm{Sin}\left[\frac{\mathrm{k3[mu]}}{2}+\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\sigma[\mathrm{mu},\,\mathrm{rho}]-\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3$$
$$\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k3[rho]}}{2}+\mathrm{p[rho]}-\mathrm{q[rho]}\right]\delta_{\mathrm{mu,nu}}\,\mathrm{Sin}\left[\frac{\mathrm{k3[mu]}}{2}+\frac{\mathrm{p[mu]}}{2}-\frac{\mathrm{q[mu]}}{2}\right]\sigma[\mathrm{mu},\,\mathrm{rho}]-$$
$$\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}\,\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k3[rho]}}{2}\right]\delta_{\mathrm{mu,nu}}\,\mathrm{Sin}\left[\frac{\mathrm{k3[mu]}}{2}-\frac{\mathrm{p[mu]}}{2}+\frac{\mathrm{q[mu]}}{2}\right]\sigma[\mathrm{mu},\,\mathrm{rho}]-\frac{1}{8}\,\mathrm{i}\,\mathrm{csw}$$
$$\mathrm{g0}^3\,\mathrm{r}\,\mathrm{Cos}\left[\frac{\mathrm{k3[rho]}}{2}+\mathrm{p[rho]}-\mathrm{q[rho]}\right]\delta_{\mathrm{mu,nu}}\,\mathrm{Sin}\left[\frac{\mathrm{k3[mu]}}{2}-\frac{\mathrm{p[mu]}}{2}+\frac{\mathrm{q[mu]}}{2}\right]\sigma[\mathrm{mu},\,\mathrm{rho}]$$

In[ ]:=
```
(* Saving *)
V3Clover[mu_, nu_, rho_, p_, q_, k1_, k2_, k3_] := Evaluate[V3Out]
DumpSave["V3_Clover.mx", V3Clover]
```

Out[ ]=
```
{V3Clover}
```