```
In[ ]:= Needs["Notation`"];

In[ ]:= Needs["MaTeX`"];

In[ ]:= (*$RecursionLimit=100*)

In[ ]:= (*p1 = {p10,p11,p12,p13};
        p2 = {p20,p21,p22,p23};
        q = {q0,q1,q2,q3};
        l = {l0, l1,l2, l3};
        b = {b0, b1,b2,b3};
        Q = {Q0,Q1,Q2,Q3};*)

In[ ]:= (*eta = DiagonalMatrix[{1,-1,-1,-1}];*)

In[ ]:= (*ClearAll[p1,p2,q,l,b, Q, eta];
        vecRules = {p1 → {p10,p11,p12,p13},
          p2 → {p20,p21,p22,p23},
          q → {q0,q1,q2,q3},
          l → {l0, l1,l2, l3},
          b → {b0, b1,b2,b3},
          (*Q → {Q0,Q1,Q2,Q3},*)
          Qp → {Qp0, Qp1, Qp2, Qp3},
          eta → DiagonalMatrix[{1,-1,-1,-1}]};*)

In[ ]:= (*RealQ[num_] := TrueQ[Refine[Element[num, Reals]]];
        IsReal[x_] := FreeQ[RealQ[x],x∈Reals];*)

In[ ]:= (*scalars = {x1, x2, m1, m2, S};
        IsScalar[x_]:=MemberQ[scalars, x]||NumberQ[x]*)
```

In[ ]:=
```
ClearAll[scalars];
scalars = {x1, x2, m1, m2, S, ℏ, ρ, γ, ϵ};

$Assumptions = And @@ (Element[#, Reals] & /@ scalars);

IsScalar[expr_] := Module[{vars, dotExp},
   vars = Variables[expr];
   dotExp = Cases[vars, holdDot[_, _]];
   vars = Complement[vars, dotExp];
   vars = Join[vars, HoldForm /@ dotExp];

   (vars === {} && NumericQ[expr]) || (vars =!= {} && SubsetQ[scalars, vars])
  ];

(*IsScalar[expr_]:=Module[{vars},
   vars=Variables[expr];

   (vars==={}&&NumericQ[expr])||(vars=!={}&&SubsetQ[scalars,vars])
  ];*)
```

In[ ]:=
```
scalars
```

Out[ ]=
```
{x1, x2, m1, m2, S, ℏ, ρ, γ, ϵ}
```

In[ ]:=
```
AddToScalars[expr_] :=
  (If[! MemberQ[scalars, HoldForm[expr]], scalars = Append[scalars, HoldForm[expr]]];
   expr);

AddDotProdToScalars[vectors_] := Module[{vecPairs},
   (*vecPairs = Subsets[vectors,{2}];*)
   vecPairs = DeleteDuplicatesBy[Tuples[vectors, 2], Sort];
   dotProdPairs = holdDot @@ # & /@ vecPairs;
   Do[AddToScalars[dotProd], {dotProd, dotProdPairs}];
  ];
```

In[ ]:=
```
holdDotDef := (
  ClearAll[holdDot];
  (*holdDot[a_,b_]:=Module[{aa=a,bb=b},If[OrderedQ[{aa,bb}],a.eta.b,b.eta.a]];*)
  (*holdDot/:holdDot[a_,b_]:=If[OrderedQ[{a,b}],holdDot[a,b],holdDot[b,a]];*)
  (*holdDot/:holdDot[a_,b_]:=0/;(PossibleZeroQ[a]||PossibleZeroQ[b]);
  holdDot/:holdDot[a_,b_]:=holdDot@@Sort[{a,b}]/;!OrderedQ[{a,b}];*)
  holdDot[a_, b_] := 0 /; (PossibleZeroQ[a] || PossibleZeroQ[b]);
  holdDot[a_, b_] := holdDot @@ Sort[{a, b}] /; ! OrderedQ[{a, b}];
  holdDot[a_ + b_, x_] := holdDot[a, x] + holdDot[b, x];
  holdDot[x_, a_ + b_] := holdDot[a, x] + holdDot[b, x];
  holdDot[x_, c_?IsScalar y_] := c holdDot[x, y];
  holdDot[c_?IsScalar x_, y_] := c holdDot[x, y];
  holdDot[x_, Times[holdDot[a_, b_], y_]] := holdDot[a, b] × holdDot[x, y];
  holdDot[Times[holdDot[a_, b_] x_], y_] := holdDot[a, b] × holdDot[x, y];
  (*holdDot[c_ x_,y_]:=c holdDot[x,y]/;FreeQ[c,_List];
holdDot[x_,c_ y_]:=c holdDot[x,y]/;FreeQ[c,_List];*)


  Notation[ParsedBoxWrapper[RowBox[{"a_", "⊙", "b_"}]] ⇔
    ParsedBoxWrapper[RowBox[{"holdDot", "[", "a_", ",", "b_", "]"}]]];
 )
```

In[ ]:=
```
holdDotDer := (
  (*ClearAll[holdDot];*)

  SetOptions[D, NonConstants → {holdDot, Wedge}];
(*D[expr_holdDot,vars__]^:=Module[{x,y,z},*)
  holdDot /: D[holdDot[a_, b_], vars__] := Module[{x = a, y = b, z},
    (*{x,y}=List@@expr;*)
    z = {vars}[[1]];
    Which[
     IsScalar[z] && x === q && y === q,
     holdDot[D[Q, {vars}[[1]]], y] + holdDot[x, D[Q, {vars}[[1]]]],
     IsScalar[z] && x === q,
     holdDot[D[Q, {vars}[[1]]], y],
     IsScalar[z] && y === q,
     holdDot[x, D[Q, {vars}[[1]]]],
     ! IsScalar[{vars}[[1]]],
     x × D[y, {vars}[[1]]] + y × D[x, {vars}[[1]]],
     True, 0]];
 )
```

In[ ]:=
```
holdDotDef
```

Notation: Future versions of the Notation package will no longer support ⇔, instead they will use ⟺. Please make this change to all your Notations.

In[ ]:=
```
vectors = {p1, p2, q, l, l1, l2, Qp}
```

Out[ ]=
```
{p1, p2, q, l, l1, l2, Qp}
```

In[ ]:=
```
AddDotProdToScalars[vectors]
```

In[ ]:=
```
scalars
```

Out[ ]=
```
{x1, x2, m1, m2, S, ℏ, ρ, γ, ϵ, p1⊙p1, p1⊙p2, p1⊙q, l⊙p1, l1⊙p1, l2⊙p1, p1⊙Qp,
 p2⊙p2, p2⊙q, l⊙p2, l1⊙p2, l2⊙p2, p2⊙Qp, q⊙q, l⊙q, l1⊙q, l2⊙q, q⊙Qp,
 l⊙l, l⊙l1, l⊙l2, l⊙Qp, l1⊙l1, l1⊙l2, l1⊙Qp, l2⊙l2, l2⊙Qp, Qp⊙Qp}
```

In[ ]:=
```
ClearAll[Wedge];

Wedge[x_, y_] := 0 /; (x === y || PossibleZeroQ[x] || PossibleZeroQ[y]);
Wedge[a_ + b_, x_] := Wedge[a, x] + Wedge[b, x];
Wedge[x_, a_ + b_] := Wedge[x, a] + Wedge[x, b];
Wedge[x_, c_?IsScalar y_] := c Wedge[x, y];
Wedge[c_?IsScalar x_, y_] := c Wedge[x, y];
Wedge[x_, y_] := -Wedge[y, x] /; OrderedQ[{y, x}];
Wedge[x_, Times[holdDot[a_, b_], y_]] := holdDot[a, b] × Wedge[x, y];
Wedge[Times[holdDot[a_, b_] x_], y_] := holdDot[a, b] × Wedge[x, y];
```

In[ ]:=
```
wedgeDer := (SetOptions[D, NonConstants → {holdDot, Wedge}];
(*D[expr_Wedge,vars__]^:=Module[{x,y,z},*)
  Wedge /: D[Wedge[a_, b_], vars__] := Module[{x = a, y = b, z},
    (*{x,y}=List@@expr;*)
    z = {vars}[[1]];
    Which[
     IsScalar[z] && x === q && y === q,
     Wedge[D[Q, {vars}[[1]]], y] + Wedge[x, D[Q, {vars}[[1]]]],
     IsScalar[z] && x === q,
     Wedge[D[Q, {vars}[[1]]], y],
     IsScalar[z] && y === q,
     Wedge[x, D[Q, {vars}[[1]]]],
     ! IsScalar[{vars}[[1]]],
     Wedge[x, D[y, {vars}[[1]]]] + Wedge[D[x, {vars}[[1]]], y],
     True, 0]];

 )
```

```
In[ ]:= aWedgeDb[expr_, a_, b_] := Wedge[a, D[expr, b]];
        aWedgeDb[expr_holdDot, a_, b_] := Module[{x, y}, {x, y} = List @@ expr;
          Wedge[a, y D[x, b]] + Wedge[a, x D[y, b]]];

In[ ]:= (*ClearAll[holdDot]*)
        (*SetAttributes[holdDot,HoldAll]*)

In[ ]:= (*holdDot[a_,b_]:=
          Module[{aa=a,bb=b},If[OrderedQ[{aa,bb}],HoldForm[a.eta.b],HoldForm[b.eta.a]]];*)
        (*holdDot[a_,b_]:=Module[{aa=a,bb=b},If[OrderedQ[{aa,bb}],a.eta.b,b.eta.a]];
        holdDot[a_+b_, x_]:=holdDot[a,x]+holdDot[b,x];
        holdDot[x_, a_+b_]:=holdDot[a,x]+holdDot[b,x];
        holdDot[x_, c_?NumberQ y_]:= c holdDot[x,y];
        holdDot[c_?NumberQ x_, y_]:= c holdDot[x,y];
        holdDot[c_ x_,y_]:=c holdDot[x,y]/;FreeQ[c,_List];
        holdDot[x_,c_ y_]:=c holdDot[x,y]/;FreeQ[c,_List];*)

In[ ]:= (*UpValues[holdDot]={};
        holdDot,Dt[holdDot[x_,y_], z,___]:=Which[
          x===q&&y===q,
           holdDot[D[Q, z],y]+holdDot[x,D[Q, z]],
          x===q,
          holdDot[D[Q,z],y],
          y===q,
          holdDot[x,D[Q, z]],
          True,
           0 ]*)

        (*holdDot/:D[holdDot[x_,y_],z_,NonConstants→_]:=D[holdDot[x,y],z]*)

In[ ]:= (*wrapDot[expr_ ] :=expr //.{(p1.eta.p1/.vecRules)→m1^2,(-p1.eta.p1/.vecRules)→-m1^2,
          (p2.eta.p2/.vecRules)→m2^2,(-p2.eta.p2/.vecRules)→-m2^2,
          (p1.eta.p2/.vecRules)→γ,(-p1.eta.p2/.vecRules)→-γ,
          (p1.eta.q/.vecRules)→p1.eta.q,(-p1.eta.q/.vecRules)→-p1.eta.q,
          (p2.eta.q/.vecRules)→p2.eta.q,(-p2.eta.q/.vecRules)→-p2.eta.q,
          (p1.eta.l/.vecRules)→p1.eta.l,(-p1.eta.l/.vecRules)→-p1.eta.l,
          (p2.eta.l/.vecRules)→p2.eta.l,(-p2.eta.l/.vecRules)→-p2.eta.l,
          (l.eta.q/.vecRules)→l.eta.q,(-l.eta.q/.vecRules)→-l.eta.q,
          (l.eta.l/.vecRules)→l.eta.l,(-l.eta.l/.vecRules)→-l.eta.l,
          (q.eta.q/.vecRules)→q.eta.q,(-q.eta.q/.vecRules)→-q.eta.q}*)
```

```
In[ ]:= (*holdDot[a_, b_]:=a.eta.b//
    FullSimplify//.{p1.eta.p2→HoldForm[HoldPattern[γ],-p1.eta.p2→-HoldForm[γ],
        p1.eta.q→HoldForm[p1.eta.q],-p1.eta.q→-HoldForm[p1.eta.q],
        p2.eta.q→HoldForm[p2.eta.q],-p2.eta.q→-HoldForm[p2.eta.q],
        p1.eta.l→HoldForm[p1.eta.l],-p1.eta.l→-HoldForm[p1.eta.l],
        p2.eta.l→HoldForm[p2.eta.l],-p2.eta.l→-HoldForm[p2.eta.l],
        l.eta.q→HoldForm[l.eta.q],-l.eta.q→-HoldForm[l.eta.q]}*)

In[ ]:= (*wrapDot[expr_, ] :=expr //.{p1.eta.p2→HoldForm[γ],-p1.eta.p2→-HoldForm[γ],
    p1.eta.q→HoldForm[p1.eta.q],-p1.eta.q→-HoldForm[p1.eta.q],
    p2.eta.q→HoldForm[p2.eta.q],-p2.eta.q→-HoldForm[p2.eta.q],
    p1.eta.l→HoldForm[p1.eta.l],-p1.eta.l→-HoldForm[p1.eta.l],
    p2.eta.l→HoldForm[p2.eta.l],-p2.eta.l→-HoldForm[p2.eta.l],
    l.eta.q→HoldForm[l.eta.q],-l.eta.q→-HoldForm[l.eta.q],
    l.eta.l→HoldForm[l.eta.l],-l.eta.l→-HoldForm[l.eta.l],
    q.eta.q→HoldForm[q.eta.q],-q.eta.q→-HoldForm[q.eta.q]}*)

In[ ]:= (*holdDot[expr_] :=
  Simplify[expr ,{p1.eta.p2→HoldForm[γ],p1.eta.q→HoldForm[p1.eta.q],
    p2.eta.q→HoldForm[p2.eta.q],p1.eta.l→HoldForm[p1.eta.l],
    p2.eta.l→HoldForm[p2.eta.l],l.eta.q→HoldForm[l.eta.q]}]*)

In[ ]:= holdDotDef
```

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```
In[ ]:= α1 = (γ x2 - m2^2 x1) / S;
        α2 = (γ x1 - m1^2 x2) / S;
        Q = α1 p1 + α2 p2 + Qp;
        q == Q;

In[ ]:= holdDotDer

In[ ]:= wedgeDer

In[ ]:= D[holdDot[p1, q] / holdDot[p2, q], x1]
Out[ ]=
```

$$-\frac{p1\odot q\left(-\frac{m2^2\, p1\odot p2}{S}+\frac{\gamma\, p2\odot p2}{S}\right)}{(p2\odot q)^2}+\frac{-\frac{m2^2\, p1\odot p1}{S}+\frac{\gamma\, p1\odot p2}{S}}{p2\odot q}$$

```
In[ ]:= onShellP[expr_] :=
         expr //. {p1⊙q → 0, p2⊙q → 0, p1⊙p2 → γ, p1⊙p1 → m1^2, p2⊙p2 → m2^2}
        (*onShellP[expr_]:=expr//.{HoldForm[p1.eta.q]→0, HoldForm[p2.eta.q]→0}*)
```

In[ ]:=
```
(*simplifiedForm[expr_]:=expr/.{(-m1^2 m2^2/S+γ^2/S)→1,(m1^2 m2^2/S-γ^2/S)→-1}/.
  {(coef1_ ϵ+coef2_ l⊙p1)^(n_)→(coef2)^n*(ϵ*(coef1/coef2)/Abs[coef1/coef2]+l⊙p1)^n,
   (coef1_ ϵ+coef2_ l⊙p2)^(n_)→(coef2)^n*(ϵ*(coef1/coef2)/Abs[coef1/coef2]+l⊙p2)^n}*)
```

In[ ]:=
```
(-m1^2 m2^2/(W*S) + γ^2/(W*S)) /. (T1 : -m1^2 m2^2 / c_.) + (T2 : γ^2 / c_.) :> S / c
```

Out[ ]=

$$-\frac{m1^2\, m2^2}{S\, W}+\frac{\gamma^2}{S\, W}$$

In[ ]:=
```
simplifiedForm[expr_] :=
  expr /. {(-m1^2 m2^2/S + γ^2/S) → 1, (m1^2 m2^2/S - γ^2/S) → -1, -m1^2 m2^2 + γ^2 → S, m1^2 m2^2 - γ^2 → -S} //.
   {(coef1_. ϵ + coef2_. l1dot_ + rest_.)^(n_.) :> (coef2)^n *
       (ϵ * (coef1 / coef2) / Abs[coef1 / coef2] + l1dot + Distribute[rest / coef2])^n /;
      l1dot == l ⊙ p1 || l1dot == l ⊙ p2 || l1dot == l1 ⊙ p1 || l1dot == l1 ⊙ p2 ||
       l1dot == l2 ⊙ p1 || l1dot == l2 ⊙ p2}
```

In[ ]:=
```
cancelFactors[expr_] :=
  expr //. {dot1 : d1_^(n_.) * (c1_. ϵ + dot2 : d2_ + d3___)^(m_) /; d1 == d2 + d3 →
     If[Abs[n] < Abs[m], (c1 ϵ + d1)^(m + n), d1^(m + n)]}
```

In[ ]:=
```
factorRho[exp_] :=
  exp /. {(expr_Plus)^(n_) :> Factor[expr]^n /; ContainsAll[Variables[expr], {ϵ, l ⊙ p1}] ||
       ContainsAll[Variables[expr], {ϵ, l ⊙ p2}]}
```

In[ ]:=
```
simplifyTerm[expr_] := expr //. {(num_ a_) / (Power[den_, -n_]) :>
     num / (den^(-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l ⊙ p1 || a == l ⊙ p2}
```

In[ ]:=
```
simplifyTerm[expr_] := expr //.
   {(num_ Power[a_, m_ : 1]) / (Power[den_, -n_ : 1]) :> num Power[a, m - 1] / (den^(-n - 1)) /;
      ContainsAll[Variables[den], {ϵ, a}] /; a == l ⊙ p1 || a == l ⊙ p2}
```

In[ ]:=
```
simplifyTerm[expr_] := (lst = {};
   Do[AppendTo[lst, expr[[i]] //. {(num_ Power[a_, m_ : 1]) / (Power[den_, -n_ : 1]) :>
          num Power[a, m - 1] / (den^(-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /;
           a == l ⊙ p1 || a == l ⊙ p2}], {i, 1, Length[expr]}];
   Total[lst]);
```

In[ ]:=
```
cancelFactors[expr_] :=
  expr //. {dot1 : d1_^(n_.) * (c1_. ϵ + dot2 : d2_ + d3___)^(m_) /; d1 == d2 + d3 →
     If[Abs[n] < Abs[m], (c1 ϵ + d1)^(m + n), d1^(m + n)]}
```

In[∘]:=
```
wedgeToDot[expr_] :=
  expr /. {HoldPattern[Wedge[l1, c_]] :> l ⊙ c, HoldPattern[Wedge[c_, l1]] :> -l ⊙ c}
```

In[∘]:=
```
extractLog[expr_, expnt_] := Coefficient[factorRho[
    simplifyTerm[Expand[simplifiedForm[onShellP[expr]]]] /. {l → ρ l, ϵ → ρ ϵ}], ρ, expnt]
```

In[∘]:=
```
delx := (D[#, {x1, 1}] - D[#, {x2, 1}]) &;
```

In[∘]:=
```
L[1] = 1 / ((p1 ⊙ l + ⅈ ϵ) (p2 ⊙ l - ⅈ ϵ));
L[2] = 1 / ((p1 ⊙ l + ⅈ ϵ) (p2 ⊙ (q - l) - ⅈ ϵ));
L[3] = 1 / ((p1 ⊙ (q - l) + ⅈ ϵ) (p2 ⊙ (q - l) - ⅈ ϵ));
L[4] = 1 / ((p1 ⊙ (q - l) + ⅈ ϵ) (p2 ⊙ l - ⅈ ϵ));
```

In[∘]:=
```
Cf[1] = (1/2) (2 γ + ℏ (p2 - p1) ⊙ l - (ℏ * γ l ⊙ l)/(p1 ⊙ l + ⅈ ϵ) + (ℏ * γ l ⊙ l)/(p2 ⊙ l - ⅈ ϵ));

Cf[2] = (1/2) (2 γ + ℏ (p2 + p1) ⊙ l - 2 ℏ * p1 ⊙ q - (ℏ * γ l ⊙ l)/(p1 ⊙ l + ⅈ ϵ) + (ℏ * γ (q - l) ⊙ (q - l))/(p2 ⊙ (q - l) - ⅈ ϵ));

Cf[3] = (1/2) (2 γ + ℏ (p2 - p1) ⊙ (2 q - l) - (ℏ * γ (q - l) ⊙ (q - l))/(p1 ⊙ (q - l) + ⅈ ϵ) + (ℏ * γ (q - l) ⊙ (q - l))/(p2 ⊙ (q - l) - ⅈ ϵ));

Cf[4] = (1/2) (2 γ - ℏ (p2 + p1) ⊙ l + 2 ℏ * p2 ⊙ q - (ℏ * γ (q - l) ⊙ (q - l))/(p1 ⊙ (q - l) + ⅈ ϵ) + (ℏ * γ l ⊙ l)/(p2 ⊙ l - ⅈ ϵ));
```

In[∘]:=
```
A0[1] = ⅈ ((2 p1 + ℏ (q + ρ * l)) ⊙ (2 p2 - ℏ (q + ρ * l)))/((q - ρ * l) ⊙ (q - ρ * l));

A0[2] = ⅈ ((2 p1 + ℏ (q + ρ * l)) ⊙ (2 p2 - ℏ (q - ρ * l)))/((q - ρ * l) ⊙ (q - ρ * l));

A0[3] = ⅈ ((2 p1 + ℏ (q - ρ * l)) ⊙ (2 p2 - ℏ (q - ρ * l)))/((q - ρ * l) ⊙ (q - ρ * l));

A0[4] = ⅈ ((2 p1 + ℏ (q - ρ * l)) ⊙ (2 p2 - ℏ (q + ρ * l)))/((q - ρ * l) ⊙ (q - ρ * l));
```

In[∘]:=
```
Do[Do[Cfhbar[i][n] = Coefficient[Normal[Series[Cf[i], {ℏ, 0, n}]], ℏ, n];, {i, 1, 4}],
  {n, 0, 2}];
```

In[∘]:=
```
Do[Do[A0hbar[i][n] = Coefficient[Normal[Series[A0[i], {ℏ, 0, n}]], ℏ, n];, {i, 1, 4}],
  {n, 0, 1}];
```

In[∘]:=
```
Do[Do[ Do[A0hbarl[i][n, m] = Coefficient[Normal[Series[A0hbar[i][n], {ρ, 0, m}]], ρ, m],
    {i, 1, 4}];, {m, 0, 3 }], {n, 0, 1}];
```

In[ ]:=
```
D[p1 ⊙ q, x1]
```
Out[ ]=

$$-\frac{m2^2\ p1 \odot p1}{S} + \frac{\gamma\ p1 \odot p2}{S}$$

In[ ]:=
```
a1 = aWedgeDb[A0[1] /. {ρ → 0}, l1, p2] /.
    {HoldPattern[Wedge[l1, c_]] :→ l ⊙ c, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c};

a2 = aWedgeDb[aWedgeDb[A0[1] /. {ρ → 0}, l1, p1] /.
     {HoldPattern[Wedge[l1, c_]] :→ l ⊙ c, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c}, p1, p1];

a3 = aWedgeDb[aWedgeDb[A0[1] /. {ρ → 0}, l1, p2] /.
     {HoldPattern[Wedge[l1, c_]] :→ l ⊙ c, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c}, p1, p1];

b1 = D[Wedge[p1, q] * (aWedgeDb[A0[1] /. {ρ → 0}, l1, p1] /.
        {HoldPattern[Wedge[l1, c_]] :→ l ⊙ c, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c}), x1];

b2 = D[Wedge[p1, q] * (aWedgeDb[A0[1] /. {ρ → 0}, l1, p2] /.
        {HoldPattern[Wedge[l1, c_]] :→ l ⊙ c, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c}), x1];

a1 = simplifiedForm@onShellP@a1;
a2 = simplifiedForm@onShellP@a2;
a3 = simplifiedForm@onShellP@a3;
b1 = simplifiedForm@onShellP@b1;
b2 = simplifiedForm@onShellP@b2;
```
In[ ]:=
```
sum = 0;
Do[sum += L[i] * Cf[i], {i, {1, 2, 3, 4}}];
```
In[ ]:=
```
ClearAll[a1, a2, a3, a4, a5, a6]
```

In[∘]:=
```
a1 = Coefficient[extractLog[
    sum * (aWedgeDb[A0[1] /. {ρ → 0}, p1, p1] - D[Wedge[p1, q] * (A0[1] /. {ρ → 0}), x1]), -2], ℏ, 1]
```

Out[∘]=

$$\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{4\,i\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[∘]:=
```
a2 = Coefficient[
   extractLog[(aWedgeDb[sum /. {γ → p1 ⊙ p2}, p1, p1] - Wedge[p1, q] * D[sum, x1]) *
     (A0[1] /. {ρ → 0}), -2], ℏ, 1]
```

Out[∘]=

$$\frac{8\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{8\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma^3\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma^3\,p1\wedge q}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[ ]:=
```
a3 = Coefficient[
  extractLog[-(aWedgeDb[sum /. {γ → p1 ⊙ p2}, p1, p1] - Wedge[p1, q] * D[sum, x1]) *
    (wedgeToDot[aWedgeDb[A0[1] /. ρ → 0, l1, q]]), -2], ℏ, 1]
```

Out[ ]=

$$-\frac{8\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{4\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{8\,i\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{4\,i\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[ ]:=
```
a4 = Coefficient[
  extractLog[-sum * (aWedgeDb[wedgeToDot[aWedgeDb[A0[1] /. ρ → 0, l1, p1]], p1, p1] -
      D[Wedge[p1, q] * wedgeToDot[aWedgeDb[A0[1] /. ρ → 0, l1, p1]], x1]), -2], ℏ, 1]
```

Out[ ]=

$$-\frac{2\,i\,\gamma^2\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{2\,i\,\gamma^2\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
a2 + a3 + a4
```

Out[ ]=

$$-\frac{2\,i\,\gamma^2\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{2\,i\,\gamma^2\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{4\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma^3\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{4\,i\,\gamma^3\,p1\wedge q}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[ ]:=
```
sum = 0;
Do[sum += L[i] * Cf[i], {i, {1, 2, 3, 4}}];
```

In[ ]:=
```
b1 = extractLog[D[sum * q ⊙ q * aWedgeDb[A0[1] /. ρ → 0, p1, p1], x1] -
    D[sum * q ⊙ q * aWedgeDb[A0[1] /. ρ → 0, p1, p1], x2], -2];
```

In[ ]:=
```
b2 = extractLog[D[(A0[1] /. ρ → 0) * q ⊙ q * aWedgeDb[sum, p1, p1], x1] -
    D[(A0[1] /. ρ → 0) * q ⊙ q * aWedgeDb[sum, p1, p1], x2], -2];
```

In[ ]:=
```
b3 = -extractLog[
    D[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]] * q ⊙ q * aWedgeDb[sum, p1, p1], x1] -
     D[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]] *
       q ⊙ q * aWedgeDb[sum, p1, p1], x2], -2];
```

In[ ]:=
```
b4 = -extractLog[
   D[sum * q ⊙ q * aWedgeDb[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], p1, p1], x1] -
    D[sum * q ⊙ q * aWedgeDb[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], p1, p1],
     x2], -2];
```

In[ ]:=
```
b5 = 1/2 extractLog[
   D[wedgeToDot[aWedgeDb[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], l1, q]] *
      q ⊙ q * aWedgeDb[sum, p1, p1], x1] -
    D[wedgeToDot[aWedgeDb[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], l1, q]] *
      q ⊙ q * aWedgeDb[sum, p1, p1], x2], -2];
```

In[ ]:=
```
c1 = extractLog[D[D[sum * Wedge[p1, q] * (A0[1] /. ρ → 0), x1] -
    D[sum * Wedge[p1, q] * (A0[1] /. ρ → 0), x2], x1], -2];
```

In[ ]:=
```
c2 = -extractLog[
   D[D[sum * Wedge[p1, q] * q ⊙ q * wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], x1] - D[sum *
       Wedge[p1, q] * q ⊙ q * wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], x2], x1], -2];
```

In[ ]:=
```
c3 =
  1/2 extractLog[D[D[sum * Wedge[p1, q] * q ⊙ q * wedgeToDot[aWedgeDb[wedgeToDot[aWedgeDb[
           (A0[1] /. ρ → 0), l1, q]], l1, q]], x1] - D[sum * Wedge[p1, q] * q ⊙ q * wedgeToDot[
        aWedgeDb[wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]], l1, q]], x2], x1], -2];
```

In[ ]:=
```
Coefficient[Expand[b1 + b2 + b3 + b4 + b5], ℏ, 0]
```

In[ ]:=
```
Coefficient[Expand[c1 + c2 + c3], ℏ, 0] - Coefficient[Expand[b1 + b2 + b3 + b4 + b5], ℏ, 0]
```

In[ ]:=
```
wedgeToDot[aWedgeDb[(A0[1] /. ρ → 0), l1, q]]
```

Out[ ]=

$$\frac{i\left(-2\,\hbar\,l\odot p1+2\,\hbar\,l\odot p2-2\,\hbar^2\,l\odot q\right)}{q\odot q}-\frac{2\,i\,l\odot q\left(4\,p1\odot p2-2\,\hbar\,p1\odot q+2\,\hbar\,p2\odot q-\hbar^2\,q\odot q\right)}{(q\odot q)^2}$$

In[ ]:= **Coefficient[Expand[b3], ℏ, 0]**

Out[ ]=

$$-\frac{16 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)\, q\odot q}-\frac{8 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2\, q\odot q}+$$
$$\frac{8 i \gamma^2 l\odot q\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2\, q\odot q}+\frac{16 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)\, q\odot q}-$$
$$\frac{8 i\, m1^2 \gamma^2 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)\, q\odot q}-\frac{8 i \gamma^3 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)\, q\odot q}+$$
$$\frac{8 i\, m1^2 \gamma^2 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)\, q\odot q}+\frac{8 i \gamma^3 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)\, q\odot q}+$$
$$\frac{8 i\, m2^2 \gamma^2 p1\wedge q}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}+\frac{8 i \gamma^3 p1\wedge q}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-$$
$$\frac{8 i\, m2^2 \gamma^2 p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}-\frac{8 i \gamma^3 p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}$$

In[ ]:= **extractLog[simplifyTerm[simplifiedForm[onShellP[Expand[sum]]]], -2]**

Out[ ]=

$$-\frac{\gamma}{(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{\gamma}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}-\frac{\gamma}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}+\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{\gamma\hbar\, l\odot q}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}$$

In[•]:=
```
extractLog[Total[Select[
    List @@ simplifyTerm[simplifiedForm[Expand[onShellP[aWedgeDb[sum, p1, p1]]]]],
    ContainsAll[List @@ Numerator[#], {p1 ∧ q} &]]] -
  simplifyTerm[Expand[simplifiedForm[onShellP[p1 ∧ q D[sum, x1]]]]], -2]
```

Out[•]=

$$\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{2\left(-i\epsilon+l\odot p1\right)^2\left(-i\epsilon+l\odot p2\right)^2}+\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{\left(-i\epsilon+l\odot p1\right)^3\left(-i\epsilon+l\odot p2\right)}-\frac{\hbar\, p1\wedge q}{2\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right)}+\frac{m2^2\gamma\hbar\, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right)}+\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{2\left(-i\epsilon+l\odot p1\right)^2\left(i\epsilon+l\odot p2\right)^2}-\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{\left(-i\epsilon+l\odot p1\right)^3\left(i\epsilon+l\odot p2\right)}+\frac{\hbar\, p1\wedge q}{2\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}-\frac{m2^2\gamma\hbar\, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}-\frac{\gamma^2\hbar\, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}-\frac{\hbar\, p1\wedge q}{\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}+\frac{\gamma^2\hbar\, p1\wedge q}{S\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}$$

In[•]:=
```
ClearAll[sum];
sum = 0;
Do[sum += L[i] * Cf[i] /. {γ → p1 ⊙ p2}, {i, {1, 2, 3, 4}}];
```

In[•]:=
```
extractLog[delx[(aWedgeDb[sum /. {γ → p1 ⊙ p2}, p1, p1] - Wedge[p1, q] * D[sum, x1])], -3]
```
Out[•]=

$$-\frac{2\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)}-\frac{\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}+\frac{\gamma\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}+\frac{2\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)}+\frac{6\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^4(-i\epsilon+l\odot p2)}-\frac{2\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^3}+\frac{2\gamma\hbar\, l\odot q\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^3}+\frac{4\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)^2}-\frac{6\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^4(i\epsilon+l\odot p2)}-\frac{p1\wedge p2}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}-\frac{p1\wedge p2}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}+\frac{p1\wedge p2}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}+\frac{p1\wedge p2}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}+\frac{2\hbar\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)}-\frac{2\hbar\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^3}+\frac{2\hbar\, l\odot q\, p1\wedge p2}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^3}+\frac{2\hbar\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}-\frac{2\hbar\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)}+\frac{m2^2\gamma\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}-\frac{\gamma^2\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+\frac{m2^2\gamma\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}+\frac{\gamma^2\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}+\frac{m2^2\gamma\hbar\, p1\wedge q}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{\gamma^2\hbar\, p1\wedge q}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{m2^2\gamma\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}-\frac{\gamma^2\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}$$

In[•]:=
```
extractLog[simplifiedForm[onShellP[delx[sum]]], -5]
```
Out[•]=

0

In[•]:=
```
simplifyTerm[Expand[extractLog[
   simplifiedForm[onShellP[aWedgeDb[sum, p1, p1] - Wedge[p1, q] * D[sum, x1]]], -2]]]
```
Out[•]=

$$-\frac{\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+\frac{\gamma\, l\wedge p1}{(i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+\frac{2\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)}-\frac{p1\wedge p2}{(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{p1\wedge p2}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{\hbar\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}-\frac{\gamma^2\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2}+\frac{m2^2\gamma\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}$$

In[ ]:=
```
b1 = simplifyTerm[Expand[extractLog[
    simplifiedForm[onShellP[aWedgeDb[sum12, p1, p1] - Wedge[p1, q] * D[sum12, x1]]], -3]]]
```

Out[ ]=

$$\frac{\gamma\,\hbar\,q\odot q\;l\wedge p1}{2\left(i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}+\frac{\hbar\,q\odot q\;p1\wedge p2}{2\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}$$

In[ ]:=
```
b2 = simplifyTerm[Expand[extractLog[
    simplifiedForm[onShellP[aWedgeDb[sum14, p1, p1] - Wedge[p1, q] * D[sum14, x1]]], -3]]]
```

Out[ ]=

$$-\frac{\gamma\,\hbar\,q\odot q\;l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^3\left(-i\,\epsilon+l\odot p2\right)}-\frac{\hbar\,q\odot q\;p1\wedge p2}{2\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}$$

In[ ]:=
```
ClearAll[b3];
b3 = extractLog[simplifiedForm[onShellP[sum]], -3]
```

Out[ ]=

$$-\frac{\gamma\,\hbar\,q\odot q}{2\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}-\frac{\gamma\,\hbar\,q\odot q}{2\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+$$
$$\frac{\gamma\,\hbar\,q\odot q}{2\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+\frac{\gamma\,\hbar\,q\odot q}{2\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)}$$

In[ ]:=
```
Coefficient[simplifyTerm[
   Expand[onShellP[(aWedgeDb[wedgeToDot[aWedgeDb[A0[1] /. {ρ → 0}, l1, q]], p1, p1] -
        D[p1 ∧ q * wedgeToDot[aWedgeDb[A0[1] /. {ρ → 0}, l1, q]], x1]) * b3]]], ℏ, 1]
```

Out[ ]=

$$\frac{4\,i\,\gamma\;l\odot q\;p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)q\odot q}-\frac{4\,i\,\gamma^3\;l\odot q\;p1\wedge p2}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)q\odot q}+$$
$$\frac{4\,i\,\gamma\;l\odot q\;p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2 q\odot q}-\frac{4\,i\,\gamma^3\;l\odot q\;p1\wedge p2}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2 q\odot q}-$$
$$\frac{4\,i\,\gamma\;l\odot q\;p1\wedge p2}{\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2 q\odot q}+\frac{4\,i\,\gamma^3\;l\odot q\;p1\wedge p2}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2 q\odot q}-$$
$$\frac{4\,i\,\gamma\;l\odot q\;p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)q\odot q}+\frac{4\,i\,\gamma^3\;l\odot q\;p1\wedge p2}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)q\odot q}+$$
$$\frac{4\,i\,m2^2\,\gamma^2\;p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)q\odot q}-\frac{4\,i\,m2^2\,\gamma^2\;p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)q\odot q}-$$
$$\frac{4\,i\,\gamma^3\;p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)q\odot q}+\frac{4\,i\,\gamma^3\;p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)q\odot q}$$

In[ ]:=
```
b3 = Total[Select[List @@ b3, ContainsAll[List @@ Numerator[#], {l ∧ p1}] &]]
```
Out[ ]=

$$-\frac{\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+\frac{\gamma\, l\wedge p1}{(i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}-\frac{\gamma\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}+\frac{2\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}-\frac{\gamma\hbar\, l\odot q\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}-\frac{2\gamma\hbar\, l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)}$$

In[ ]:=
```
Do[If[ContainsAll[List @@ Numerator[b3[[i]]], {l ⊙ q, l ∧ p1}], b3[[i]] = K4[b3[[i]]]],
  {i, 1, Length[b3]}]
```

In[ ]:=
```
simplifyTerm[Expand[b3 /. {HoldPattern[Wedge[l, c_]] :>
    1/S (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] + Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])}]]
```
Out[ ]=

$$\frac{\gamma^2\, p1\wedge p2}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\gamma^2\, p1\wedge p2}{S(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\gamma^2\, p1\wedge p2}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}+$$
$$\frac{\gamma^2\, p1\wedge p2}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}-\frac{2\,m1^2\gamma\hbar\, l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^3}+\frac{\gamma^2\hbar\, l\odot q\, p1\wedge p2}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}+$$
$$\frac{2\gamma^2\hbar\, l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}-\frac{m1^2\gamma\hbar\, l\odot q\, p1\wedge p2}{S(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}+\frac{2\gamma^2\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)^2}+\frac{m1^2\gamma\hbar\, p1\wedge q}{2S(i\epsilon+l\odot p1)^2}-$$
$$\frac{m1^2\gamma\hbar\, l\odot p2\, p1\wedge q}{S(-i\epsilon+l\odot p1)^3}-\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{S(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)}-\frac{m2^2\gamma\hbar\, p1\wedge q}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+$$
$$\frac{m2^2\gamma\hbar\, p1\wedge q}{2S(i\epsilon+l\odot p2)^2}+\frac{\gamma\hbar\, l\odot l\, p1\wedge q}{2S(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2}-\frac{\gamma^2\hbar\, p1\wedge q}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}$$

In[ ]:=
```
extractLog[simplifyTerm[Expand[simplifiedForm[onShellP[sum]]]], -2]
```
Out[ ]=

$$-\frac{\gamma}{(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{\gamma}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}-\frac{\gamma}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}+\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{\gamma\hbar\, l\odot q}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2}-\frac{\gamma\hbar\, l\odot q}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)}$$

In[ ]:=
```
simplifiedForm[onShellP[sum12]]
```

Out[ ]=

$$\frac{2\,\gamma-\frac{\gamma\,\hbar\,l\odot l}{i\,\epsilon+l\odot p1}+\frac{\gamma\,\hbar\,l\odot l}{-i\,\epsilon+l\odot p2}+\hbar\,(-l\odot p1+l\odot p2)}{2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{2\,\gamma-\frac{\gamma\,\hbar\,l\odot l}{i\,\epsilon+l\odot p1}+\hbar\,(l\odot p1+l\odot p2)-\frac{\gamma\,\hbar\,(l\odot l-2\,l\odot q+q\odot q)}{i\,\epsilon+l\odot p2}}{2\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
a =
  extractLog[simplifiedForm[onShellP[aWedgeDb[sum, p1, p1] - Wedge[p1, q] * D[sum, x1]]],
    -2] /. {HoldPattern[Wedge[l, c_]] :>
    1/S (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] + Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])};
```

In[ ]:=
```
simplifyTerm[
 Expand[Total[Select[List @@ a, ContainsAll[List @@ Numerator[#], {p1∧p2, l⊙q}]
      (*&&ContainsNone[List@@Numerator[#],{l⊙q}]*)(*&&
       ContainsAll[List@@Denominator[#],{S^2}]*) &]] /. {HoldPattern[Wedge[l, c_]] :>
    1/S (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] + Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])}]]
```

Out[ ]=

$$\frac{\hbar\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{2\,\gamma^2\,\hbar\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+$$
$$\frac{\hbar\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}-\frac{\gamma^2\,\hbar\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}-$$
$$\frac{\hbar\,l\odot q\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{\gamma^2\,\hbar\,l\odot q\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}-\frac{\hbar\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}+$$
$$\frac{m1^2\,\gamma\,\hbar\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}+\frac{2\,\gamma^2\,\hbar\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}-\frac{m1^2\,\gamma\,\hbar\,l\odot q\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
K4[expr_] := simplifyTerm[Expand[1/(2 S) (expr /. {l⊙q l∧p1 → -p1∧q})
     (m2^2 l⊙p1 l⊙p1 + m1^2 l⊙p2 l⊙p2 + l⊙l - 2 γ l⊙p1 l⊙p2)]];
```

In[ ]:=

$$K4\left[\frac{2\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}\right]$$

Out[ ]=

$$\frac{2\,\gamma^2\,\hbar\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)^2}-\frac{m1^2\,\gamma\,\hbar\,l\odot p2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)^3}-$$
$$\frac{\gamma\,\hbar\,l\odot l\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}-\frac{m2^2\,\gamma\,\hbar\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
b = extractLog[simplifiedForm[onShellP[wsp]], -2];
```

In[ ]:=
```
extractLog[simplifiedForm[onShellP[delx[sum]]], -2]
```

Out[ ]=

$$-\frac{\gamma \hbar\, l\odot l}{2\left(-i\epsilon+l\odot p1\right)^2\left(-i\epsilon+l\odot p2\right)^2}-\frac{\gamma \hbar\, l\odot l}{\left(-i\epsilon+l\odot p1\right)^3\left(-i\epsilon+l\odot p2\right)}+$$
$$\frac{3\hbar}{2\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right)}-\frac{m2^2\gamma\hbar}{S\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right)}-\frac{\gamma^2\hbar}{S\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right)}+$$
$$\frac{\gamma \hbar\, l\odot l}{\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)^3}-\frac{\gamma \hbar\, l\odot l}{\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)^3}-\frac{\gamma \hbar\, l\odot l}{\left(-i\epsilon+l\odot p1\right)^2\left(i\epsilon+l\odot p2\right)^2}-$$
$$\frac{\gamma \hbar\, l\odot l}{2\left(i\epsilon+l\odot p1\right)^2\left(i\epsilon+l\odot p2\right)^2}+\frac{\gamma \hbar\, l\odot l}{\left(-i\epsilon+l\odot p1\right)^3\left(i\epsilon+l\odot p2\right)}-\frac{\hbar}{\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}+$$
$$\frac{m1^2\gamma\hbar}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}+\frac{m2^2\gamma\hbar}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}+\frac{2\gamma^2\hbar}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}+$$
$$\frac{3\hbar}{2\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}-\frac{m1^2\gamma\hbar}{S\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}-\frac{\gamma^2\hbar}{S\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)}$$

In[ ]:=
```
sum = 0;
Do[sum += L[i] * Cf[i] /. {γ → p1 ⊙ p2}, {i, {1, 2}}];

Expand[
 simplifiedForm@Coefficient[factorRho[simplifyTerm@Expand[onShellP[aWedgeDb[
        simplifiedForm@sum, l1, q] /. {Wedge[l1, c_] → (γ p2 - m2^2 p1) ⊙ c / S,
        Wedge[c_, l1] → -(γ p2 - m2^2 p1) ⊙ c / S}] /. {l → ρ l, ϵ → ρ ϵ}]], ρ, -3]]
```

Out[ ]=

```
$Aborted
```

In[ ]:=
```
aWedgeDb[Expand[
  L[i] * Cf[i] * (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] + ℏ A0hbarl[i][1, 0] +
      ℏ A0hbarl[i][1, 1] + ℏ A0hbarl[i][1, 2]) /. {i → 1}]
 , p1, p1]
```

In[ ]:=
```
ClearAll[sum10, sum11, sum20, sum21, sum]
```

```
In[◦]:= sum10 = 0;
Do[term10 =
   L[i] * Cf[i] * (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] + ħ A0hbarl[i][1, 0] +
        ħ A0hbarl[i][1, 1] + ħ A0hbarl[i][1, 2]) /. {γ → p1 ⊙ p2};

  sum10 += simplifyTerm[Expand[
     Coefficient[factorRho[simplifiedForm[onShellP[aWedgeDb[term10, p1, p1]]] /.
        {l → ρ l, ϵ → ρ ϵ}], ρ, -2]]], {i, 1, 4}];

In[◦]:= sum11 = 0;
Do[term11 = q ⊙ q * L[i] * Cf[i] * (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] +
        ħ A0hbarl[i][1, 0] + ħ A0hbarl[i][1, 1] + ħ A0hbarl[i][1, 2]) /. {γ → p1 ⊙ p2};

  sum11 += simplifyTerm@Expand[Coefficient[
      factorRho[simplifiedForm@onShellP[D[aWedgeDb[term11, p1, p1], x1] -
           D[aWedgeDb[term11, p1, p1], x2]] /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]], {i, 1, 4}];

In[◦]:= sum20 = 0;
Do[
  term20 = Wedge[p1, q] * L[i] * Cf[i] * (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] +
        ħ A0hbarl[i][1, 0] + ħ A0hbarl[i][1, 1] + ħ A0hbarl[i][1, 2]) /. {γ → p1 ⊙ p2};

  sum20 += simplifyTerm[
    Expand[Coefficient[factorRho[simplifiedForm@onShellP[D[term20, x1]] /.
        {l → ρ l, ϵ → ρ ϵ}], ρ, -2]]], {i, 1, 4}];

In[◦]:= sum21 = 0;
Do[term21 =
   q ⊙ q * Wedge[p1, q] * L[i] * Cf[i] * (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] +
        ħ A0hbarl[i][1, 0] + ħ A0hbarl[i][1, 1] + ħ A0hbarl[i][1, 2]) /. {γ → p1 ⊙ p2};

  sum21 += simplifyTerm@Expand[Coefficient[
      factorRho[simplifiedForm@onShellP[D[D[term21, x1], x1] - D[D[term21, x2], x1]] /.
        {l → ρ l, ϵ → ρ ϵ}], ρ, -2]], {i, 1, 4}];

In[◦]:= simplifyTerm@Expand[((sum10 - sum20) / ħ - (sum11 - sum21) / 2 /. {(l ⊙ q)^2 → l ⊙ l * q ⊙ q} /.
       {HoldPattern[Wedge[l, c_]] :> 1/s (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] +
            Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])}) /.
     {l ⊙ q → 0}] /. {Power[ħ, -1] → 0, Power[ħ, 1] → 0}
```

In[ ]:= **Coefficient[simplifyTerm[Expand[sum10 / ℏ]], ℏ, 0]**

Out[ ]=

$$-\frac{2\,i\,\gamma^2\,l\odot l\;p1\wedge q}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{6\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{6\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[ ]:= **Coefficient[simplifyTerm@Expand[(sum11 - sum21)], ℏ, 0]**

Out[ ]=

$$-\frac{16\,i\,\gamma^2\,l\odot q\;l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,i\,\gamma^2\,l\odot q\;l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{8\,i\,\gamma^2\,l\odot q\;l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{16\,i\,\gamma^2\,l\odot q\;l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)\,q\odot q}-$$
$$\frac{16\,i\,\gamma\,l\odot q\;p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{8\,i\,\gamma^3\,l\odot q\;p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{16\,i\,\gamma\,l\odot q\;p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{8\,i\,\gamma^3\,l\odot q\;p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+$$
$$\frac{16\,i\,\gamma\,l\odot q\;p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{8\,i\,\gamma^3\,l\odot q\;p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{16\,i\,\gamma\,l\odot q\;p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,i\,\gamma^3\,l\odot q\;p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}-$$
$$\frac{8\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{8\,i\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{8\,i\,\gamma^3\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,i\,\gamma^3\,p1\wedge q}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}$$

In[ ]:= **b = simplifyTerm@Expand[((sum10 - sum20) / ℏ /. {(l ⊙ q)^2 → l ⊙ l * q ⊙ q} /. {HoldPattern[Wedge[l, c_]] :→ 1/S (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] + Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])}) /. {l ⊙ q → 0}]**

In[ ]:=
$$a1 = i\,\gamma\,\text{Wedge[p1, l]}\times\delta[\text{p2}\odot\text{l}]\,(\text{A0[1] /. }\{\rho\to 0\})\left(\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)^2}-\frac{1}{(\text{p1}\odot\text{l}+i\,\epsilon)^2}\right);$$

$$a2 = \hbar\,\gamma\,\text{l}\odot\text{q}\,\text{Wedge[p1, l]}\,(\text{A0[1] /. }\{\rho\to 0\})\left(\frac{-2\,i\,\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}-\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}+\frac{1}{(\text{p1}\odot\text{l}+i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}\right);$$

$$a3 = -\hbar\,\gamma\,\text{q}\odot\text{q}\,\text{Wedge[p1, l]}\left(i\,\frac{\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}+\frac{1}{2(\text{p1}\odot\text{l}-i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}-\frac{1}{2(\text{p1}\odot\text{l}+i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}\right)$$
```
onShellP[aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /.
  {HoldPattern[Wedge[l1, c_]] :→ l⊙c, HoldPattern[Wedge[c_, l1]] :→ -l⊙c}];
```

$$a4 = -\left(\hbar\,\gamma\,\text{l}\odot\text{q}\,\text{Wedge[p1, q]}\left(\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}+\frac{2\,i\,\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}\right)-i\,\gamma\,\text{Wedge[p1, q]}\,\frac{\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^2}\right)\text{onShellP[aWedgeDb[A0[1] /. }\{\rho\to 0\}\text{, l1, q] /.}$$
```
  {HoldPattern[Wedge[l1, c_]] :→ l⊙c, HoldPattern[Wedge[c_, l1]] :→ -l⊙c}];
```

$$a5 = \left(\frac{-i\,\gamma\,\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^2}+\hbar\,\gamma\,\text{l}\odot\text{q}\left(\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)^2(\text{p2}\odot\text{l}+i\,\epsilon)^2}+\frac{2\,i\,\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}\right)\right)$$
```
Wedge[p1, q] × onShellP[aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /.
  {HoldPattern[Wedge[l1, c_]] :→ l⊙c, HoldPattern[Wedge[c_, l1]] :→ -l⊙c}];
```

$$a6 = i\,\hbar\,\gamma\,\frac{\text{q}\odot\text{q}}{2}\left(\frac{\delta[\text{p1}\odot\text{l}]}{(\text{p2}\odot\text{l}+i\,\epsilon)^2}+\frac{\delta[\text{p2}\odot\text{l}]}{(\text{p1}\odot\text{l}-i\,\epsilon)^2}\right)$$
```
onShellP[aWedgeDb[(aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /.
      {HoldPattern[Wedge[l1, c_]] :→ l⊙c, HoldPattern[Wedge[c_, l1]] :→ -l⊙c}),
    p1, p1] - D[Wedge[p1, q] (aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /.
       {HoldPattern[Wedge[l1, c_]] :→ l⊙c, HoldPattern[Wedge[c_, l1]] :→ -l⊙c}), x1]];
```

In[ ]:=
```
Expand[Coefficient[simplifyTerm[Expand[onShellP[a1 + a2 + a3 + a4 + a5 + a6] / ħ]] /.
    {(l⊙p1)^n_. δ[l⊙p1] → 0, (l⊙p2)^m_. δ[l⊙p2] → 0}, ħ, 0] /.
```
$$\left\{\delta[\text{l}\odot\text{p2}]\to\frac{i}{(\text{p2}\odot\text{l}+i\,\epsilon)}-\frac{i}{(\text{p2}\odot\text{l}-i\,\epsilon)},\ \delta[\text{l}\odot\text{p1}]\to\frac{i}{(\text{p1}\odot\text{l}+i\,\epsilon)}-\frac{i}{(\text{p1}\odot\text{l}-i\,\epsilon)}\right\}]$$

In[ ]:=
$$a = \text{simplifyTerm}\Big[\text{Expand}\Big[\text{onShellP[a1 + a2 + a3 + a4 + a5]} / \hbar\ \text{/. }\Big\{\text{HoldPattern[Wedge[l, c\_]]} :\to \frac{1}{s}\big(\text{Wedge[p1, c]} * \text{holdDot}[\text{l}, \gamma * \text{p2} - \text{m2}^2\,\text{p1}] + \text{Wedge[p2, c]} * \text{holdDot}[\text{l}, \gamma\,\text{p1} - \text{m1}^2\,\text{p2}]\big)\Big\}\Big]\Big]$$

In[ ]:=

$$\text{Expand}\Big[a \mathbin{/.} \big\{(l\odot p1)^{\wedge} n\_.\ \delta[l\odot p1] \to 0,\ (l\odot p2)^{\wedge} m\_.\ \delta[l\odot p2] \to 0\big\} \mathbin{/.} \{l\odot q \to 0\} \mathbin{/.} \Big\{\delta[l\odot p2] \to \frac{i}{(p2\odot l + i\,\epsilon)} - \frac{i}{(p2\odot l - i\,\epsilon)},\ \delta[l\odot p1] \to \frac{i}{(p1\odot l + i\,\epsilon)} - \frac{i}{(p1\odot l - i\,\epsilon)}\Big\}\Big]$$

Out[ ]=

$$\frac{i\,m1^2\,\gamma\,\hbar\,p1\wedge p2}{S\,(-i\,\epsilon + l\odot p1)^2} - \frac{i\,m1^2\,\gamma\,\hbar\,p1\wedge p2}{S\,(i\,\epsilon + l\odot p1)^2} + \frac{i\,\gamma^2\,\hbar\,p1\wedge p2}{S\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{i\,\gamma^2\,\hbar\,p1\wedge p2}{S\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} -$$

$$\frac{i\,m1^2\,\gamma\,\hbar\,p1\wedge p2}{S\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{2\,i\,\gamma^2\,\hbar\,p1\wedge p2}{S\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} + \frac{i\,m1^2\,\gamma\,\hbar\,p1\wedge p2}{S\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} +$$

$$\frac{4\,i\,\gamma^3\,p1\wedge p2}{S\,\hbar\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)\,q\odot q} - \frac{4\,i\,\gamma^3\,p1\wedge p2}{S\,\hbar\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)\,q\odot q} -$$

$$\frac{4\,i\,\gamma^3\,p1\wedge p2}{S\,\hbar\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)\,q\odot q} + \frac{4\,i\,\gamma^3\,p1\wedge p2}{S\,\hbar\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)\,q\odot q}$$

In[•]:=
```
a = simplifyTerm[Expand[(simplifyTerm@Expand[-γ * q ⊙ q * Wedge[p1, l]
      (𝕚 δ[p2 ⊙ l]/(p1 ⊙ l - 𝕚 ϵ)^3 + 1/(2 (p1 ⊙ l - 𝕚 ϵ)^2 (p2 ⊙ l + 𝕚 ϵ)^2) - 1/(2 (p1 ⊙ l + 𝕚 ϵ)^2 (p2 ⊙ l + 𝕚 ϵ)^2)) *
      onShellP[aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /. {HoldPattern[
          Wedge[l1, c_]] :→ l ⊙ c / S, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c / S}]] +
    simplifyTerm@Expand[𝕚 γ (q ⊙ q)/2 (δ[p1 ⊙ l]/(p2 ⊙ l + 𝕚 ϵ)^2 + δ[p2 ⊙ l]/(p1 ⊙ l - 𝕚 ϵ)^2) * onShellP[
        aWedgeDb[aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /. {HoldPattern[Wedge[l1, c_]] :→
            l ⊙ c / S, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c / S}, p1, p1] -
         D[Wedge[p1, q] * (aWedgeDb[A0[1] /. {ρ → 0}, l1, q] /. {HoldPattern[Wedge[l1,
                c_]] :→ l ⊙ c / S, HoldPattern[Wedge[c_, l1]] :→ -l ⊙ c / S}), x1]]]) /.
   {HoldPattern[Wedge[l, c_]] :→ 1/S (Wedge[p1, c] * holdDot[l, γ * p2 - m2^2 p1] +
         Wedge[p2, c] * holdDot[l, γ p1 - m1^2 p2])}]] /.
  {l ⊙ q → 0} /. {(l ⊙ p1) ^ n_. δ[l ⊙ p1] → 0, (l ⊙ p2) ^ m_.
    δ[
     l ⊙ p2] → 0}
```

Out[•]=

$$\frac{i\, m1^2\, \gamma\, \hbar\, p1\wedge p2}{S^2 \left(-i\,\epsilon + l\odot p1\right)^2} - \frac{i\, m1^2\, \gamma\, \hbar\, p1\wedge p2}{S^2 \left(i\,\epsilon + l\odot p1\right)^2} - \frac{i\, m1^2\, \gamma\, \hbar\, p1\wedge p2}{S^2 \left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} - \frac{i\, \gamma^2\, \hbar\, p1\wedge p2}{S^2 \left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} + \frac{i\, m1^2\, \gamma\, \hbar\, p1\wedge p2}{S^2 \left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} + \frac{i\, \gamma^2\, \hbar\, p1\wedge p2}{S^2 \left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} - \frac{m1^2\, \gamma\, \hbar\, p1\wedge p2\, \delta[l\odot p1]}{S^2 \left(i\,\epsilon + l\odot p2\right)} + \frac{\gamma^2\, \hbar\, p1\wedge p2\, \delta[l\odot p1]}{S^2 \left(i\,\epsilon + l\odot p2\right)} - \frac{4\, \gamma^3\, p1\wedge q\, \delta[l\odot p1]}{S^2 \left(i\,\epsilon + l\odot p2\right) q\odot q} - \frac{2\, \gamma^2\, \hbar\, p1\wedge p2\, \delta[l\odot p2]}{S^2 \left(-i\,\epsilon + l\odot p1\right)} + \frac{4\, m2^2\, \gamma^2\, p1\wedge q\, \delta[l\odot p2]}{S^2 \left(-i\,\epsilon + l\odot p1\right) q\odot q}$$

In[•]:=
```
Expand[a /. {δ[l ⊙ p2] → 𝕚/(p2 ⊙ l + 𝕚 ϵ) - 𝕚/(p2 ⊙ l - 𝕚 ϵ), δ[l ⊙ p1] → 𝕚/(p1 ⊙ l + 𝕚 ϵ) - 𝕚/(p1 ⊙ l - 𝕚 ϵ)}] /.
  {ℏ → 0}
```

Out[•]=

$$-\frac{4\, i\, m2^2\, \gamma^2\, p1\wedge q}{S^2 \left(-i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right) q\odot q} + \frac{4\, i\, m2^2\, \gamma^2\, p1\wedge q}{S^2 \left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right) q\odot q} + \frac{4\, i\, \gamma^3\, p1\wedge q}{S^2 \left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right) q\odot q} - \frac{4\, i\, \gamma^3\, p1\wedge q}{S^2 \left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right) q\odot q}$$

In[∘]:=
```
Dg =
  Simplify[Expand[Solve[A*(m1^2 m2^2 + γ^2) + B*m1^2 γ + C*γ*m2^2 + D*γ == I12 && 2 A γ m1^2 +
          B m1^4 + C γ^2 + D m1^2 == I11 && 2 A  m2^2 γ + B γ^2 + C m2^4 + D m2^2 == I22 &&
        2 A γ + B m1^2 + C m2^2 + 4 D == I00, {A, B, C, D}, Reals][[1]][[4]][[2]] /.
     {2 m1^4 m2^4 - 4 m1^2 m2^2 γ^2 + 2 γ^4 → 2 S^2}], γ^2 - m1^2 m2^2 == S]
```

Out[∘]=

$$\frac{\text{I22 m1}^2+\text{I11 m2}^2+\text{I00 S}-2\,\text{I12}\,\gamma}{2\,\text{S}}$$

In[∘]:=

$$\text{I1 = Expand}\Big[\text{Dg /. }\Big\{\text{I00}\to\frac{\text{l}\odot\text{l}}{(\text{p1}\odot\text{l}+i\,\epsilon)^2\,(\text{p2}\odot\text{l}+i\,\epsilon)^2},\ \text{I12}\to\frac{1}{(\text{p1}\odot\text{l}+i\,\epsilon)\,(\text{p2}\odot\text{l}+i\,\epsilon)},\ \text{I11}\to\frac{1}{(\text{p2}\odot\text{l}+i\,\epsilon)^2},\ \text{I22}\to\frac{1}{(\text{p1}\odot\text{l}+i\,\epsilon)^2}\Big\}\Big];$$

In[∘]:=

$$\text{I2 = Expand}\Big[\text{Dg /. }\Big\{\text{I00}\to-\frac{\text{l}\odot\text{l}}{(\text{p1}\odot\text{l}-i\,\epsilon)^2\,(\text{p2}\odot\text{l}+i\,\epsilon)^2},\ \text{I12}\to-\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)\,(\text{p2}\odot\text{l}+i\,\epsilon)},\ \text{I11}\to-\frac{1}{(\text{p2}\odot\text{l}+i\,\epsilon)^2},\ \text{I22}\to-\frac{1}{(\text{p1}\odot\text{l}-i\,\epsilon)^2}\Big\}\Big];$$

In[∘]:=

$$\text{I3 = Expand}\Big[\text{Dg /. }\Big\{\text{I00}\to\frac{2\,\text{l}\odot\text{l}}{(\text{p1}\odot\text{l}-i\,\epsilon)^3\,(\text{p2}\odot\text{l}+i\,\epsilon)},\ \text{I12}\to\frac{2}{(\text{p1}\odot\text{l}-i\,\epsilon)^2},\ \text{I11}\to\frac{2}{(\text{p1}\odot\text{l}-i\,\epsilon)\,(\text{p2}\odot\text{l}+i\,\epsilon)},\ \text{I22}\to\frac{2\,\text{p2}\odot\text{l}}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}\Big\}\Big];$$

In[∘]:=

$$\text{I4 = Expand}\Big[\text{Dg /. }\Big\{\text{I00}\to-\frac{2\,\text{l}\odot\text{l}}{(\text{p1}\odot\text{l}-i\,\epsilon)^3\,(\text{p2}\odot\text{l}-i\,\epsilon)},\ \text{I12}\to-\frac{2}{(\text{p1}\odot\text{l}-i\,\epsilon)^2},\ \text{I11}\to-\frac{2}{(\text{p1}\odot\text{l}-i\,\epsilon)\,(\text{p2}\odot\text{l}-i\,\epsilon)},\ \text{I22}\to-\frac{2\,\text{p2}\odot\text{l}}{(\text{p1}\odot\text{l}-i\,\epsilon)^3}\Big\}\Big];$$

In[ ]:= I1 + I2 + I3 + I4

Out[ ]=

$$-\frac{m1^2}{2\,S\left(-i\,\epsilon+l\odot p1\right)^2}+\frac{m1^2}{2\,S\left(i\,\epsilon+l\odot p1\right)^2}-\frac{l\odot l}{\left(-i\,\epsilon+l\odot p1\right)^3\left(-i\,\epsilon+l\odot p2\right)}-$$
$$\frac{m2^2}{S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)}-\frac{l\odot l}{2\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}+$$
$$\frac{l\odot l}{2\left(i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}+\frac{l\odot l}{\left(-i\,\epsilon+l\odot p1\right)^3\left(i\,\epsilon+l\odot p2\right)}+$$
$$\frac{m2^2}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)}+\frac{\gamma}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)}-\frac{\gamma}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)}$$

```
In[ ]:= ClearAll[a1, a2, a3, b1, b2, b3, c, d];

a1 = Expand[
   aWedgeDb[aWedgeDb[A0hbar[1][0] /. ρ → 0, l, p1] /. HoldPattern[Wedge[l, c_]] :> l ⊙ c,
     l1, q] /. {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
     HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S}];
a2 = Expand[
   aWedgeDb[aWedgeDb[A0hbar[1][0] /. ρ → 0, l, p2] /. HoldPattern[Wedge[l, c_]] :> l ⊙ c,
     l1, q] /. {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
     HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S}];
a3 = Expand[
   aWedgeDb[aWedgeDb[A0hbar[1][0] /. ρ → 0, l, q] /. HoldPattern[Wedge[l, c_]] :> l ⊙ c,
     l1, q] //. {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
     HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S}];

b1 = aWedgeDb[L[1] * Cf[1] + L[2] * Cf[2], l1, q] /.
   {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
    HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S};
b2 = aWedgeDb[L[1] * Cf[1] + L[4] * Cf[4], l1, q] /.
   {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
    HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S};
b3 = aWedgeDb[L[1] * Cf[1] + L[2] * Cf[2] + L[3] * Cf[3] + L[4] * Cf[4], l1, q] /.
   {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
    HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S};

c = 0;
Do[c += L[i] * Cf[i], {i, 1, 4}];
c = simplifyTerm[simplifiedForm[c]];
c = aWedgeDb[c, l1, q] /. {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
    HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S};

d = aWedgeDb[aWedgeDb[A0hbar[1][0] /. ρ → 0, l, q] /. HoldPattern[Wedge[l, c_]] :> l ⊙ c,
    l1, q] /. {HoldPattern[Wedge[l1, c_]] :> (γ p2 - m2^2 p1) ⊙ c / S,
    HoldPattern[Wedge[c_, l1]] :> -(γ p2 - m2^2 p1) ⊙ c / S};
```

In[ ]:=
```
a1 = onShellP@a1;
a2 = onShellP@a2;
a3 = onShellP@a3;
c = simplifyTerm[Expand[simplifiedForm[onShellP[c]]]];
d = onShellP@d;
b1 = simplifyTerm@Expand[simplifiedForm@onShellP@b1];
b2 = simplifyTerm@Expand[simplifiedForm@onShellP@b2];
b3 = simplifyTerm@Expand[simplifiedForm[onShellP[b3]]];
```

In[ ]:=
```
simplifyTerm@Expand[onShellP[c] /. {-m1^2 m2^2 + γ^2 → S, m1^2 m2^2 - γ^2 → -S}]
```

In[ ]:=
```
Coefficient[
  factorRho[simplifyTerm@Expand[onShellP[c] /. {-m1^2 m2^2 + γ^2 → S, m1^2 m2^2 - γ^2 → -S}] /.
    {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

In[ ]:=
```
sum = Coefficient[
   factorRho[simplifyTerm[Expand[-ℏ * a3 * b3 - c * d]] /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

In[ ]:=
```
(*ClearAll[holdDot]
   SetOptions[D, NonConstants→{holdDot}];*)
```

In[ ]:=
```
(*Product rule when holdDot is inside product*)
(*holdDot/:D[expr_Times,z_]/;MemberQ[expr,_holdDot,{0,Infinity}]:=
   Module[{factors=List@@expr},
    Total[Table[D[factors[[i]],z]*Times@@Delete[factors,i],{i,Length[factors]}]]];*)
```

In[ ]:=
```
T = 0;

Do[T += L[i] * D[A0hbar[i][0], {x1, 2}], {i, 1, 4}]

cancelFactors@simplifiedForm@Expand@onShellP@T /. {ρ → 1} /.
 {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}
```

Out[ ]=

$$\frac{8\,i\,m1^2\,m2^4\,\gamma}{qml2^2\,S^2\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{8\,i\,m2^2\,\gamma^3}{qml2^2\,S^2\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} -$$
$$\frac{8\,i\,m1^2\,m2^4\,\gamma}{qml2^2\,S^2\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{8\,i\,m2^2\,\gamma^3}{qml2^2\,S^2\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} -$$
$$\frac{8\,i\,m1^2\,m2^4\,\gamma}{qml2^2\,S^2\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} + \frac{8\,i\,m2^2\,\gamma^3}{qml2^2\,S^2\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} +$$
$$\frac{8\,i\,m1^2\,m2^4\,\gamma}{qml2^2\,S^2\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{8\,i\,m2^2\,\gamma^3}{qml2^2\,S^2\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)}$$

In[•]:= onShellP@Expand@D[A0[1] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}, x1]

Out[•]=

$$\frac{2 i \, m1^2 \, m2^2 \, \hbar}{qml2 \, S} - \frac{2 i \gamma^2 \hbar}{qml2 \, S} + \frac{2 i \, m2^2 \, \hbar^2 \, l \odot p1}{qml2 \, S} - \frac{2 i \gamma \hbar^2 \, l \odot p2}{qml2 \, S}$$

In[•]:= Expand[A0[1]] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}

Out[•]=

$$-\frac{i \hbar^2 \, l \odot l}{qml2} - \frac{2 i \hbar \, l \odot p1}{qml2} + \frac{2 i \hbar \, l \odot p2}{qml2} - \frac{2 i \hbar^2 \, l \odot q}{qml2} + \frac{4 i \, p1 \odot p2}{qml2} - \frac{2 i \hbar \, p1 \odot q}{qml2} + \frac{2 i \hbar \, p2 \odot q}{qml2} - \frac{i \hbar^2 \, q \odot q}{qml2}$$

In[•]:= onShellP@Expand@D[A0[2] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}, x1]

Out[•]=

$$\frac{2 i \, m1^2 \, m2^2 \, \hbar}{qml2 \, S} - \frac{2 i \gamma^2 \hbar}{qml2 \, S}$$

In[•]:= onShellP@Expand@D[A0[3] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}, x1]

Out[•]=

$$\frac{2 i \, m1^2 \, m2^2 \, \hbar}{qml2 \, S} - \frac{2 i \gamma^2 \hbar}{qml2 \, S} - \frac{2 i \, m2^2 \, \hbar^2 \, l \odot p1}{qml2 \, S} + \frac{2 i \gamma \hbar^2 \, l \odot p2}{qml2 \, S}$$

In[•]:= onShellP@Expand@D[A0[4] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}, x1]

Out[•]=

$$\frac{2 i \, m1^2 \, m2^2 \, \hbar}{qml2 \, S} - \frac{2 i \gamma^2 \hbar}{qml2 \, S}$$

In[•]:= Expand[A0[1] - A0[3] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}]

Out[•]=

$$-\frac{4 i \hbar \, l \odot p1}{qml2} + \frac{4 i \hbar \, l \odot p2}{qml2} - \frac{4 i \hbar^2 \, l \odot q}{qml2}$$

In[•]:= Expand[A0hbarl[1][1, 1] - A0hbarl[3][1, 1]]

Out[•]=

$$-\frac{4 i \, l \odot p1}{q \odot q} + \frac{4 i \, l \odot p2}{q \odot q}$$

In[•]:= Expand[A0[2] + A0[4] /. {ρ → 1} /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2}]

Out[•]=

$$\frac{2 i \hbar^2 \, l \odot l}{qml2} + \frac{8 i \, p1 \odot p2}{qml2} - \frac{4 i \hbar \, p1 \odot q}{qml2} + \frac{4 i \hbar \, p2 \odot q}{qml2} - \frac{2 i \hbar^2 \, q \odot q}{qml2}$$

In[ ]:=
```
Expand@simplifiedForm@onShellP@D[A0hbar[1][1], x1]
```
Out[ ]=
$$\frac{4\,i\,m2^2\,\rho^2\,(l\odot p1)^2}{S\left(\rho^2\,l\odot l-2\,\rho\,l\odot q+q\odot q\right)^2}-\frac{4\,i\,m2^2\,\rho^2\,l\odot p1\,l\odot p2}{S\left(\rho^2\,l\odot l-2\,\rho\,l\odot q+q\odot q\right)^2}-\frac{4\,i\,\gamma\,\rho^2\,l\odot p1\,l\odot p2}{S\left(\rho^2\,l\odot l-2\,\rho\,l\odot q+q\odot q\right)^2}+\frac{4\,i\,\gamma\,\rho^2\,(l\odot p2)^2}{S\left(\rho^2\,l\odot l-2\,\rho\,l\odot q+q\odot q\right)^2}-\frac{2\,i}{\rho^2\,l\odot l-2\,\rho\,l\odot q+q\odot q}$$

In[ ]:=

In[ ]:=
```
a = D[p1⊙q, x1]
b = D[p1⊙q, x2]
```
Out[ ]=
$$-\frac{m2^2\,p1\odot p1}{S}+\frac{\gamma\,p1\odot p2}{S}$$
Out[ ]=
$$\frac{\gamma\,p1\odot p1}{S}-\frac{m1^2\,p1\odot p2}{S}$$

In[ ]:=
```
A0hbarl[1][0, 0]
```
Out[ ]=
$$\frac{4\,i\,p1\odot p2}{q\odot q}$$

One Loop: Calculation 1

In[ ]:=
```
MaTeX["\\begin{aligned} R_2 = -\\partial_{x_1}(p_1\\wedge
    q\\,A_{1,1})+\\frac{1}{2}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2})(q^2\\,
    p_1\\wedge q\\,A_{1,0}))\\\\=-\\sum_i
    L_i[C_{i,0}\\partial_{x_1}(p_1\\wedge
    q\\,_i\\tilde{A}_{0,1})+C_{i,1}\\partial_{x_1}(p_1\\wedge
    q\\,_i\\tilde{A}_{0,0})]+\\frac{1}{2}\\sum_iL_iC_{i,0}(\\partial_{x_i}^2-\\
    partial_{x_1}\\partial_{x_2})(p_1\\wedge
    q\\,q^2\\,_i\\tilde{A}_{0,0})\\\\-\\,p_1\\wedge
    q\\sum_i(\\,_i\\tilde{A}_{0,1}\\partial_{x_1}L_iC_{i,0}+\\,_i\\tilde{A}_{0,0}\\
    partial_{x_1}L_iC_{i,1})+\\frac{q^2}{2}p_1\\wedge
    q\\sum_i\\,_i\\tilde{A}_{0,0}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2})
    L_iC_{i,0}\\\\+\\sum_i\\partial_{x_1}(L_iC_{i,0})\\partial_{x_1}(p_1\\wedge
    q\\,q^2\\,_i\\tilde{A}_{0,0})-\\frac{1}{2}\\sum_i[\\partial_{x_1}(L_iC_{i,0})\\
    partial_{x_2}(p_1\\wedge
    q\\,q^2\\,_i\\tilde{A}_{0,0})+\\partial_{x_2}(L_iC_{i,0})\\partial_{x_1}(p_1\\
    wedge q\\,q^2\\,_i\\tilde{A}_{0,0})]\\end{aligned}",
  "DisplayStyle" → True]
```

Out[ ]=

$$\begin{aligned} R_2 &= -\partial_{x_1}(p_1\wedge q\,A_{1,1})+\frac{1}{2}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})(q^2\,p_1\wedge q\,A_{1,0}))\\ &=-\sum_i L_i[C_{i,0}\partial_{x_1}(p_1\wedge q\,_i\tilde{A}_{0,1})+C_{i,1}\partial_{x_1}(p_1\wedge q\,_i\tilde{A}_{0,0})]+\frac{1}{2}\sum_iL_iC_{i,0}(\partial_{x_i}^2-\partial_{x_1}\partial_{x_2})(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})\\ &-\,p_1\wedge q\sum_i(\,_i\tilde{A}_{0,1}\partial_{x_1}L_iC_{i,0}+\,_i\tilde{A}_{0,0}\partial_{x_1}L_iC_{i,1})+\frac{q^2}{2}p_1\wedge q\sum_i\,_i\tilde{A}_{0,0}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})L_iC_{i,0}\\ &+\sum_i\partial_{x_1}(L_iC_{i,0})\partial_{x_1}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})-\frac{1}{2}\sum_i[\partial_{x_1}(L_iC_{i,0})\partial_{x_2}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})+\partial_{x_2}(L_iC_{i,0})\partial_{x_1}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})]\end{aligned}$$

In[ ]:=
```
ol = 1;
fromDiag = 1;
toDiag = 4;
```

In[ ]:=
```
MaTeX["\\begin{aligned}X1\\cong\\sum_i L_iC_{i,0}\\partial_{x_1}(p_1\\wedge
    q\\,_i\\tilde{A}_{0,1})\\\\=\\partial_{x_1}(p_1\\wedge
    q)\\sum_i L_iC_{i,0}\\,_i\\tilde{A}_{0,1}+(p_1\\wedge q)\\sum_i
    L_iC_{i,0}\\,\\partial_{x_1}\\,_i\\tilde{A}_{0,1}\\end{aligned}"]
```

Out[ ]=

```
$Aborted
```

In[ ]:=
```
X1 = 0;

Do[X1 += -D[Wedge[p1, q] * A0hbarl[i][1, ol], x1] × L[i] × Cfhbar[i][0],
  {i, fromDiag, toDiag}];

X1 = simplifiedForm@onShellP[X1];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X1 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```
Out[ ]=
```
0
```

In[ ]:=
```
MaTeX["\\begin{aligned}X2\\cong\\sum_i L_iC_{i,1}\\partial_{x_1}(p_1\\wedge
    q\\,_i\\tilde{A}_{0,0})\\\\=\\partial_{x_1}(p_1\\wedge
    q)\\sum_i L_iC_{i,1}\\,_i\\tilde{A}_{0,0}+p_1\\wedge q\\sum_i
    L_iC_{i,1}\\,\\partial_{x_1}\\,_i\\tilde{A}_{0,0}\\end{aligned}"]
```
Out[ ]=

$$\begin{aligned}X2\cong\sum_i L_iC_{i,1}\partial_{x_1}(p_1\wedge q\,_i\tilde{A}_{0,0})\\=\partial_{x_1}(p_1\wedge q)\sum_i L_iC_{i,1}\,_i\tilde{A}_{0,0}+p_1\wedge q\sum_i L_iC_{i,1}\,\partial_{x_1}\,_i\tilde{A}_{0,0}\end{aligned}$$

In[ ]:=
```
X2 = 0;

Do[X2 += -D[Wedge[p1, q] * A0hbarl[i][0, ol], x1] × L[i] × Cfhbar[i][1],
  {i, fromDiag, toDiag}];

X2 = simplifiedForm@onShellP[X2];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X2 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```
Out[ ]=

$$\frac{4 i \gamma^3 \, l\odot q \, p1\wedge p2}{S\left(-i\epsilon+l\odot p1\right)^2\left(-i\epsilon+l\odot p2\right) q\odot q}+\frac{4 i \gamma^3 \, l\odot q \, p1\wedge p2}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)^2 q\odot q}-$$
$$\frac{4 i \gamma^3 \, l\odot q \, p1\wedge p2}{S\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right)^2 q\odot q}-\frac{4 i \gamma^3 \, l\odot q \, p1\wedge p2}{S\left(-i\epsilon+l\odot p1\right)^2\left(i\epsilon+l\odot p2\right) q\odot q}-$$
$$\frac{4 i \, m2^2 \gamma^2 \, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(-i\epsilon+l\odot p2\right) q\odot q}+\frac{4 i \, m2^2 \gamma^2 \, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right) q\odot q}+$$
$$\frac{4 i \gamma^3 \, p1\wedge q}{S\left(-i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right) q\odot q}-\frac{4 i \gamma^3 \, p1\wedge q}{S\left(i\epsilon+l\odot p1\right)\left(i\epsilon+l\odot p2\right) q\odot q}$$

In[ ]:=
```
MaTeX["\\begin{aligned}X3\\cong-\\frac{1}{2}\\sum_iL_iC_{i,0}(\\partial_{x_1}^2-\\
partial_{x_1}\\partial_{x_2})(p_1\\wedge
q\\,q^2\\,_i\\tilde{A}_{0,0})\\\\=-\\frac{1}{2}\\partial_{x_1}^2(p_1\\wedge
q)\\sum_iL_iC_{i,0}\\,q^2\\,_i\\tilde{A}_{0,0}-\\partial_{x_1}(p_1\\wedge
q)\\sum_iL_iC_{i,0}\\,\\partial_{x_1}(q^2\\,_i\\tilde{A}_{0,0})-\\frac{1}{2}(p_1\\
wedge
q)\\sum_iL_iC_{i,0}\\,\\partial_{x_1}^2(q^2\\,_i\\tilde{A}_{0,0})\\\\-\\frac{1}{2}
\\partial_{x_1}\\partial_{x_2}(p_1\\wedge
q)\\sum_iL_iC_{i,0}\\,\\,_i\\tilde{A}_{0,0}-\\frac{1}{2}\\partial_{x_1}(p_1\\
wedge
q)\\sum_iL_iC_{i,0}\\,\\partial_{x_2}(q^2\\,_i\\tilde{A}_{0,0})-\\frac{1}{2}\\
partial_{x_2}(p_1\\wedge
q)\\sum_iL_iC_{i,0}\\,\\partial_{x_1}(q^2\\,_i\\tilde{A}_{0,0})-\\frac{1}{2}(p_1\\
wedge
q)\\sum_iL_iC_{i,0}\\,\\partial_{x_1}\\partial_{x_2}(q^2\\,_i\\tilde{A}_{0,0})\\
end{aligned}"]
```

Out[ ]=

$$X3 \cong -\frac{1}{2}\sum_i L_i C_{i,0}(\partial_{x_1}^2 -$$

$$= -\frac{1}{2}\partial_{x_1}^2(p_1 \wedge q)\sum_i L_i C_{i,0}\, q^2\, _i\tilde{A}_{0,0} - \partial_{x_1}(p_1 \wedge q)\sum_i L_i C_{i,0}\,\partial_{x_1}(q^2\, _i\tilde{A}_{0,0}) - \frac{1}{2}(p_1 \wedge q)$$

$$-\frac{1}{2}\partial_{x_1}\partial_{x_2}(p_1 \wedge q)\sum_i L_i C_{i,0}\, _i\tilde{A}_{0,0} - \frac{1}{2}\partial_{x_1}(p_1 \wedge q)\sum_i L_i C_{i,0}\,\partial_{x_2}(q^2\, _i\tilde{A}_{0,0}) - \frac{1}{2}\partial_{x_2}(p_1 \wedge q)\sum_i L_i C_{i,0}\,\partial_{x_1}(q^2\, _i\tilde{A}_{0,0}) - \frac{1}{2}(p_1 \wedge q)\sum_i$$

In[ ]:=
```
Do[X306[n] = 0, {n, 0, 6}];

Do[Do[X306[n] += (-Binomial[2, n])/2 D[q ⊙ q × ToExpression["A0" <> ToString[i] <> "hbar"][0],
    {x1, n}] × ToExpression["L" <> ToString[i]] ×
   ToExpression["C" <> ToString[i] <> "hbar"][0], {i, 1, 2}], {n, 0, 2}];
Do[Do[X306[2 n + m + 3] +=
   (-1)/2 D[q ⊙ q × ToExpression["A0" <> ToString[i] <> "hbar"][0], {x1, n}, {x2, m}] ×
    ToExpression["L" <> ToString[i]] ×
    ToExpression["C" <> ToString[i] <> "hbar"][0], {i, 1, 2}], {n, 0, 1}, {m, 0, 1}]
```

In[ ]:=
```
(*X3[0] and X3[3] are zero*)
X306[0] = 0;
X306[3] = 0;
```

In[ ]:=
```
Do[X306[n] = onShellP[X306[n]], {n, 0, 6}]
```

```
X3 = -(γ Wedge[p1, p2]/s) X306[1] - Wedge[p1, q] × X306[2] -
   (γ Wedge[p1, p2]/s) X306[4] + (m1^2 Wedge[p1, p2]/s) X306[5] - Wedge[p1, q] × X306[6];
```

In[∘]:=
```
X3 = 0;

Do[X3 += 1/2 L[i] × Cfhbar[i][0] * (D[D[Wedge[p1, q] * q ⊙ q * A0hbarl[i][0, ol], x1], x1] -
      D[D[Wedge[p1, q] * q ⊙ q * A0hbarl[i][0, ol], x2], x1]), {i, fromDiag, toDiag}];

X3 = simplifiedForm@onShellP@X3;
```

In[∘]:=
```
cancelFactors@Coefficient[Expand@factorRho[X3 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[∘]=

0

In[∘]:=
```
MaTeX[
 "X4\\cong\\,p_1\\wedge q\\sum_i\\,_i\\tilde{A}_{0,1}\\partial_{x_1}L_iC_{i,0}"]
```

Out[∘]=

$$X4 \cong \, p_1 \wedge q \sum_i \,_i\tilde{A}_{0,1}\partial_{x_1}L_iC_{i,0}$$

In[∘]:=
```
X4 = 0;

Do[X4 += -Wedge[p1, q] * A0hbarl[i][1, ol] × D[L[i] × Cfhbar[i][0], x1],
  {i, fromDiag, toDiag}];

X4 = simplifiedForm@onShellP[X4];
```

In[∘]:=
```
-simplifiedForm[onShellP[Wedge[p1, q] * A0hbarl[4][1, 1] × D[L[4] × Cfhbar[4][0], x1]]]
```

Out[∘]=

$$-\frac{2\, i\, \gamma\, (l \odot p1 + l \odot p2)\, p1 \wedge q}{(-i\,\epsilon + l \odot p1)^2\, (-i\,\epsilon + l \odot p2)\, q \odot q}$$

In[∘]:=
```
D[L[4] × Cfhbar[4][0], x1]
```

Out[∘]=

$$-\frac{\gamma\left(-\frac{m2^2\, p1\odot p1}{s} + \frac{\gamma\, p1\odot p2}{s}\right)}{(-i\,\epsilon + l \odot p2)\,(i\,\epsilon - l \odot p1 + p1 \odot q)^2}$$

In[∘]:=
```
Cfhbar[4][0]
```

Out[∘]=

γ

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X4 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```
Out[ ]=

$$-\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}$$

```
MaTeX[
 "X5\\cong\\,p_1\\wedge q\\sum_i\\,_i\\tilde{A}_{0,0}\\partial_{x_1}L_iC_{i,1}"]
```
Out[ ]=

$$X5 \cong\, p_1 \wedge q \sum_i \,_i\tilde{A}_{0,0}\partial_{x_1}L_iC_{i,1}$$

In[ ]:=
```
s = 0;
Do[s += aWedgeDb[L[i] * Cf[i], p1, p1], {i, 1, 4}];
```

In[ ]:=
```
cancelFactors@Coefficient[
  Expand@factorRho[simplifiedForm[onShellP[s]] /. {l → ρ l, ϵ → ρ ϵ}], ρ, -3]
```

$$-\frac{\gamma\,\hbar\,q\odot q\,l\wedge p1}{2\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}+\frac{\gamma\,\hbar\,q\odot q\,l\wedge p1}{2\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}-$$
$$\frac{\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+\frac{\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}$$
$$\frac{\gamma\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+\frac{\gamma\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}+$$
$$\frac{\hbar\,p1\wedge q}{2\,(-i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)}-\frac{\hbar\,p1\wedge q}{2\,(-i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)}+\frac{\hbar\,p1\wedge q}{(i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
X5 = 0;

Do[X5 += -Wedge[p1, q] × A0hbarl[i][0, ol] × D[L[i] × Cfhbar[i][1], x1],
  {i, fromDiag, toDiag}];

X5 = simplifiedForm@onShellP[X5];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X5 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

$$\frac{2 i \gamma^2 l\odot l\, p1\wedge q}{(-i\epsilon + l\odot p1)^2 (-i\epsilon + l\odot p2)^2\, q\odot q} + \frac{4 i \gamma^2 l\odot l\, p1\wedge q}{(-i\epsilon + l\odot p1)^3 (-i\epsilon + l\odot p2)\, q\odot q} - \frac{2 i \gamma\, p1\wedge q}{(-i\epsilon + l\odot p1)(-i\epsilon + l\odot p2)\, q\odot q} + \frac{4 i\, m2^2 \gamma^2\, p1\wedge q}{S(-i\epsilon + l\odot p1)(-i\epsilon + l\odot p2)\, q\odot q} + \frac{2 i \gamma^2 l\odot l\, p1\wedge q}{(-i\epsilon + l\odot p1)^2 (i\epsilon + l\odot p2)^2\, q\odot q} - \frac{4 i \gamma^2 l\odot l\, p1\wedge q}{(-i\epsilon + l\odot p1)^3 (i\epsilon + l\odot p2)\, q\odot q} + \frac{2 i \gamma\, p1\wedge q}{(-i\epsilon + l\odot p1)(i\epsilon + l\odot p2)\, q\odot q} - \frac{4 i\, m2^2 \gamma^2\, p1\wedge q}{S(-i\epsilon + l\odot p1)(i\epsilon + l\odot p2)\, q\odot q} - \frac{4 i \gamma^3\, p1\wedge q}{S(-i\epsilon + l\odot p1)(i\epsilon + l\odot p2)\, q\odot q} - \frac{4 i \gamma\, p1\wedge q}{(i\epsilon + l\odot p1)(i\epsilon + l\odot p2)\, q\odot q} + \frac{4 i \gamma^3\, p1\wedge q}{S(i\epsilon + l\odot p1)(i\epsilon + l\odot p2)\, q\odot q}$$

In[ ]:=
```
MaTeX["X6\\cong-\\frac{1}{2}p_1\\wedge
  q\\sum_iq^2\\,_i\\tilde{A}_{0,0}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2
  })L_iC_{i,0}"]
```

Out[ ]=

$$X6 \cong -\frac{1}{2}p_1\wedge q\sum_i q^2\,_i\tilde{A}_{0,0}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})L_iC_{i,0}$$

In[ ]:=
```
X6 = 0;

Do[X6 += (Wedge[p1, q] × q ⊙ q)/2 A0hbarl[i][0, ol] × (D[D[L[i] × Cfhbar[i][0], x1], x1] -
      D[D[L[i] × Cfhbar[i][0], x2], x1]), {i, fromDiag, toDiag}];

X6 = simplifiedForm@onShellP[X6];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X6 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

0

In[ ]:=
```
MaTeX[
 "\\begin{aligned}X7\\cong-\\sum_i\\partial_{x_1}(L_iC_{i,0})\\partial_{x_1}(p_1\\
   wedge q\\,q^2\\,_i\\tilde{A}_{0,0})\\\\=-\\partial_{x_1}(p_1\\wedge
   q)\\sum_iq^2\\,_i\\tilde{A}_{0,0}\\partial_{x_1}(L_iC_{i,0})-p_1\\wedge
   q\\sum_i\\partial_{x_1}(L_iC_{i,0})\\partial_{x_1}(q^2\\,_i\\tilde{A}_{0,0})\\end{
   aligned}"]
```

Out[ ]=

$$\begin{aligned}X7\cong-\sum_i\partial_{x_1}(L_iC_{i,0})\partial_{x_1}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})\\=-\partial_{x_1}(p_1\wedge q)\sum_iq^2\,_i\tilde{A}_{0,0}\partial_{x_1}(L_iC_{i,0})-p_1\wedge q\sum_i\partial_{x_1}(L_iC_{i,0})\partial_{x_1}(q^2\,_i\tilde{A}_{0,0})\end{aligned}$$

In[ ]:=
```
X7 = 0;

Do[X7 += D[Wedge[p1, q] × q ⊙ q × A0hbarl[i][0, ol], x1] × D[L[i] × Cfhbar[i][0], x1],
  {i, fromDiag, toDiag}];

X7 = simplifiedForm@onShellP[X7];
```

In[ ]:=
```
X7 = 0;

Do[X7 += Wedge[p1, q] × D[q ⊙ q × A0[i] /. {ρ → 1}, x1] × D[L[i] × Cf[i], x1], {i, 1, 4}];

X7 = simplifiedForm@onShellP[X7];
```

In[ ]:=
```
a = Total@Select[List @@ Expand[X7 /. l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2], Exponent[#, ℏ] ≤ 1 &];
```

In[ ]:=
```
b = {};
Do[AppendTo[b, simplifiedForm[a[[i]]]], {i, 1, Length[a]}];
ClearAll[a];
a = Total[b];
ClearAll[b];
```

In[ ]:=
```
b = {};
Do[AppendTo[b, simplifyTerm[a[[i]]]], {i, 1, Length[a]}];
ClearAll[a];
a = Total[b];
ClearAll[b];

Expand[Series[Coefficient[factorRho[a /. {l → ρ l, ϵ → ρ ϵ}], ρ, -3] /. {qml2 →
     1 / (Normal[Series[1 / (ρ^2 l ⊙ l + q ⊙ q - 2 ρ l ⊙ q), {ρ, 0, 1}]] /. {ρ → 1})}, {ρ, 0, 1}]]

Expand[Series[Coefficient[factorRho[a /. {l → ρ l, ϵ → ρ ϵ}], ρ, -3] /. {qml2 →
     1 / (Normal[Series[1 / (ρ^2 l ⊙ l + q ⊙ q - 2 ρ l ⊙ q), {ρ, 0, 1}]] /. {ρ → 1})}, {ρ, 0, 1}]]
```

Out[ ]=

0

In[ ]:=
```
simplifyTerm[
  Expand[simplifiedForm@Normal[Series[X7 /. l⊙l - 2 l⊙q + q⊙q → qml2, {ℏ, 0, 1}]]]]
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X7 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=
```
0
```

In[ ]:=
```
MaTeX[
  "\\begin{aligned}X8\\cong\\frac{1}{2}\\sum_i\\partial_{x_1}(L_iC_{i,0})\\partial_{x_
    2}(p_1\\wedge
    q\\,q^2\\,_i\\tilde{A}_{0,0})\\\\=\\frac{1}{2}\\partial_{x_2}(p_1\\wedge
    q)\\sum_iq^2\\,_i\\tilde{A}_{0,0}\\partial_{x_1}(L_iC_{i,0})+\\frac{1}{2}p_1\\
    wedge
    q\\sum_i\\partial_{x_1}(L_iC_{i,0})\\partial_{x_2}(q^2\\,_i\\tilde{A}_{0,0})\\end{
    aligned}"]
```

Out[ ]=

$$\begin{aligned}X8&\cong\frac{1}{2}\sum_i\partial_{x_1}(L_iC_{i,0})\partial_{x_2}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})\\&=\frac{1}{2}\partial_{x_2}(p_1\wedge q)\sum_iq^2\,_i\tilde{A}_{0,0}\partial_{x_1}(L_iC_{i,0})+\frac{1}{2}p_1\wedge q\sum_i\partial_{x_1}(L_iC_{i,0})\partial_{x_2}(q^2\,_i\tilde{A}_{0,0})\end{aligned}$$

In[ ]:=
```
X8 = 0;

Do[X8 += -1/2 D[Wedge[p1, q] × q⊙q × A0hbarl[i][0, ol], x2] × D[L[i] × Cfhbar[i][0], x1],
  {i, fromDiag, toDiag}];

X8 = simplifiedForm@onShellP[X8];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X8 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=
```
0
```

In[ ]:=
```
X8 = 0;

Do[X8 += -1/2 D[Wedge[p1, q] × q⊙q × (A0hbarl[i][0, ol] + ℏ * A0hbarl[i][1, ol]), x2] ×
    D[L[i] × (Cfhbar[i][0] + ℏ * Cfhbar[i][1]), x1], {i, fromDiag, toDiag}];

X8 = simplifiedForm@onShellP[X8];
```

In[ ]:=
```
X8 = 0;

Do[X8 += -1/2 D[Wedge[p1, q] × q ⊙ q × A0[i], x2] × D[L[i] × Cf[i], x1], {i, 1, 4}];

X8 = simplifiedForm@onShellP[X8];
```

In[ ]:=
```
a = Total@Select[
    List @@ Expand[X8 /. {ρ → 1} /. l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2], Exponent[#, ℏ] ≤ 1 &];
```

In[ ]:=
```
b = {};
Do[AppendTo[b, simplifiedForm[a[[i]]]], {i, 1, Length[a]}];
ClearAll[a];
a = Total[b];
ClearAll[b];
```

In[ ]:=
```
b = {};
Do[AppendTo[b, simplifyTerm[a[[i]]]], {i, 1, Length[a]}];
ClearAll[a];
a = Total[b];
ClearAll[b];
```

In[ ]:=
```
Coefficient[factorRho[a /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

$$-\frac{i\, m1^2\, \gamma^2\, \hbar\, l\odot l\; q\odot q\; p1\wedge p2}{qml2\; S\left(-i\,\epsilon + l\odot p1\right)^2\left(-i\,\epsilon + l\odot p2\right)^2} + \frac{2\, i\, m1^2\, \gamma\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S\left(-i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right)} - \frac{2\, i\, m1^2\, m2^2\, \gamma^2\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S^2\left(-i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right)} +$$
$$\frac{2\, i\, m1^2\, m2^2\, \gamma^2\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S^2\left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} + \frac{2\, i\, m1^2\, \gamma^3\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S^2\left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} +$$
$$\frac{2\, i\, m1^2\, \gamma\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S\left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} - \frac{2\, i\, m1^2\, \gamma^3\, \hbar\, q\odot q\; p1\wedge p2}{qml2\; S^2\left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)} +$$
$$\frac{4\, i\, \gamma^3\, q\odot q\; p1\wedge q}{qml2^2\; S\left(-i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right)} - \frac{4\, i\, \gamma^3\, q\odot q\; p1\wedge q}{qml2^2\; S\left(-i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)}$$

In[ ]:=
```
MaTeX[
 "\\begin{aligned}X9\\cong\\frac{1}{2}\\sum_i\\partial_{x_2}(L_iC_{i,0})\\partial_{x_1}(p_1\\wedge q\\,q^2\\,_i\\tilde{A}_{0,0})\\\\=\\frac{1}{2}\\partial_{x_1}(p_1\\wedge q)\\sum_iq^2\\,_i\\tilde{A}_{0,0}\\partial_{x_2}(L_iC_{i,0})+\\frac{1}{2}p_1\\wedge q\\sum_i\\partial_{x_2}(L_iC_{i,0})\\partial_{x_1}(q^2\\,_i\\tilde{A}_{0,0})\\end{aligned}"]
```

Out[ ]=

$$\begin{aligned}X9\cong\frac{1}{2}\sum_i\partial_{x_2}(L_iC_{i,0})\partial_{x_1}(p_1\wedge q\,q^2\,_i\tilde{A}_{0,0})\\=\frac{1}{2}\partial_{x_1}(p_1\wedge q)\sum_iq^2\,_i\tilde{A}_{0,0}\partial_{x_2}(L_iC_{i,0})+\frac{1}{2}p_1\wedge q\sum_i\partial_{x_2}(L_iC_{i,0})\partial_{x_1}(q^2\,_i\tilde{A}_{0,0})\end{aligned}$$

In[ ]:=
```
X9 = 0;

Do[X9 += -1/2 D[Wedge[p1, q] × q ⊙ q × A0hbarl[i][0, ol], x1] × D[L[i] × Cfhbar[i][0], x2],
  {i, fromDiag, toDiag}];

X9 = simplifiedForm@onShellP[X9];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[X9 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

0

In[ ]:=
```
XSuml0 = 0;

Do[XSuml0 += ToExpression["X" <> ToString[n]], {n, 1, 9}];
```

In[ ]:=
```
YSuml0 = Y1 + Y2 + Y3;
```

In[ ]:=
```
cancelFactors@
 Coefficient[Expand@factorRho[(XSuml0 + YSuml0) /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

$$\frac{8 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(-i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2\, q\odot q}-\frac{4 i \gamma^2 l\odot q\, l\wedge p1}{(i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)^2\, q\odot q}-\frac{8 i \gamma^2 l\odot q\, l\wedge p1}{(-i\epsilon+l\odot p1)^3(i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i \gamma\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)\, q\odot q}-\frac{4 i \gamma^3 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i \gamma\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2\, q\odot q}-\frac{4 i \gamma^3 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2\, q\odot q}-\frac{4 i \gamma\, l\odot q\, p1\wedge p2}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2\, q\odot q}+\frac{4 i \gamma^3 l\odot q\, p1\wedge p2}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)^2\, q\odot q}-\frac{4 i \gamma\, l\odot q\, p1\wedge p2}{(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i \gamma^3 l\odot q\, p1\wedge p2}{S(-i\epsilon+l\odot p1)^2(i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i\, m2^2 \gamma^2\, p1\wedge q}{S(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-\frac{4 i\, m2^2 \gamma^2\, p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}-\frac{4 i \gamma^3\, p1\wedge q}{S(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}+\frac{4 i \gamma^3\, p1\wedge q}{S(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}$$

In[ ]:=
```
MaTeX["\\begin{aligned} Y=
  \\sum_ip_1\\wedge\\partial_{p_1}A_{1,1}+\\frac{1}{2}\\sum_i(\\partial_{x_1}-
  \\partial_{x_2})(q^2\\,p_1\\wedge\\partial_{p_1}A_{1,0})\\\\=\\sum_ip_1\\wedge
  \\partial_{p_1}(L_iC_{i,0}\\,_iA_{0,1}+L_iC_{i,1}\\,_iA_{0,0})-\\frac{1}{2}\\sum_i(
  \\partial_{x_1}-\\partial_{x_2})(q^2\\,p_1\\wedge\\partial_{p_1}(L_iC_{i,0}\\,_iA
  _{0,0}))\\end{aligned}"]
```

Out[ ]=

$$\begin{aligned} Y=\sum_i p_1\wedge\partial_{p_1}A_{1,1}+\frac{1}{2}\sum_i(\partial_{x_1}-\partial_{x_2})(q^2\,p_1\wedge \\ =\sum_i p_1\wedge\partial_{p_1}(L_iC_{i,0}\,_iA_{0,1}+L_iC_{i,1}\,_iA_{0,0})-\frac{1}{2}\sum_i(\partial_{x_1}-\partial_{x_2})(q^2\,p_1\wedge\partial_{p_1}(L_iC\end{aligned}$$

In[ ]:=
```
ol = 1;
fromDiag = 1;
toDiag = 4;
```

In[ ]:=
```
Y1 = 0;

Do[Y1 += aWedgeDb[L[i] × Cfhbar[i][0], p1, p1] × A0hbarl[i][1, ol], {i, fromDiag, toDiag}];

Y1 = simplifiedForm@onShellP@Y1;
```

In[ ]:=
```
Y2 = 0;

Do[Y2 += aWedgeDb[L[i] × Cfhbar[i][1] × A0hbarl[i][0, ol], p1, p1], {i, fromDiag, toDiag}];

Y2 = simplifiedForm@onShellP@Y2;
```

In[ ]:=
```
Y3 = 0;

Do[Y3 += -1/2
    (D[q ⊙ q * aWedgeDb[L[i] × Chbar[i][0] × A0hbarl[i][0, ol], p1, p1], x1] - D[q ⊙ q * aWedgeDb[
         L[i] × Cfhbar[i][0] × A0hbarl[i][0, ol], p1, p1], x2]), {i, fromDiag, toDiag}];

Y3 = simplifiedForm@onShellP@Y3;
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[Y1 /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

Out[ ]=

$$\frac{2\,i\,\gamma\,\text{p1}\wedge\text{q}}{(-i\,\epsilon+\text{l}\odot\text{p1})(-i\,\epsilon+\text{l}\odot\text{p2})\,\text{q}\odot\text{q}}+\frac{2\,i\,\gamma\,\text{p1}\wedge\text{q}}{(-i\,\epsilon+\text{l}\odot\text{p1})(i\,\epsilon+\text{l}\odot\text{p2})\,\text{q}\odot\text{q}}$$
$$-\frac{2\,i\,\gamma\,\text{p1}\wedge\text{q}}{(i\,\epsilon+\text{l}\odot\text{p1})(-i\,\epsilon+\text{l}\odot\text{p2})\,\text{q}\odot\text{q}}+\frac{6\,i\,\gamma\,\text{p1}\wedge\text{q}}{(i\,\epsilon+\text{l}\odot\text{p1})(i\,\epsilon+\text{l}\odot\text{p2})\,\text{q}\odot\text{q}}$$

In[ ]:=
```
X4 = 0;

Do[X4 += -Wedge[p1, q] * A0hbarl[i][1, ol] × D[L[i] × Cfhbar[i][0], x1],
  {i, fromDiag, toDiag}];

X4 = simplifiedForm@onShellP[X4];
```

In[ ]:=
```
MaTeX["\\begin{aligned} R_2 = -\\partial_{x_1}(p_1\\wedge
   q\\,A_{1,1})+\\frac{1}{2}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2})(q^2\\,
   p_1\\wedge q\\,A_{1,0}))\\\\=-\\partial_{x_1}(p_1\\wedge
   q\\,L_i(C_{i,1}A_{0,0}+C_{i,0}A_{0,1}))+\\frac{1}{2}(\\partial_{x_1}^2-\\partial_{x_
   1}\\partial_{x_2})(q^2\\,p_1\\wedge q\\,L_iC_{i,0}A_{0,0}))\\end{aligned}"]
```

Out[ ]=

$$R_2 = -\partial_{x_1}(p_1\wedge q\,A_{1,1})+\frac{1}{2}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})(q^2\,p_1\wedge q\,A$$
$$= -\partial_{x_1}(p_1\wedge q\,L_i(C_{i,1}A_{0,0}+C_{i,0}A_{0,1}))+\frac{1}{2}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})(q^2\,p_1\wedge q\,L_iC_{i,0}A$$

```
(*ol=0;
fromDiag=1;
toDiag=2;

ClearAll[X];
Do[X[i]=0;,{i,1,9}];

Do[X[1]+=D[Wedge[p1,q]*A0hbarl[i][1,ol],x1]×L[i]×Cfhbar[i][0];

  X[2]+=D[Wedge[p1,q]*A0hbarl[i][0,ol],x1]×L[i]×Cfhbar[i][1];

  X[3]+=-1/2 L[i]×Cfhbar[i][0]*(D[D[Wedge[p1,q]*q⊙q*A0hbarl[i][0,ol],x1],x1]-
        D[D[Wedge[p1,q]*q⊙q*A0hbarl[i][0,ol],x2],x1]);

  X[4]+=Wedge[p1,q]*A0hbarl[i][1,ol]×D[L[i]×Cfhbar[i][0],x1];

  X[5]+=Wedge[p1,q]×A0hbarl[i][0,ol]×D[L[i]×Cfhbar[i][1],x1];

  X[6]+=(-Wedge[p1,q]×q⊙q)/2 A0hbarl[i][0,ol]×
    (D[D[L[i]×Cfhbar[i][0],x1],x1]-D[D[L[i]×Cfhbar[i][0],x2],x1]);

  X[7]+=-D[Wedge[p1,q]×q⊙q×A0hbarl[i][0,ol],x1]×D[L[i]×Cfhbar[i][0],x1];

  X[8]+=1/2 D[Wedge[p1,q]×q⊙q×A0hbarl[i][0,ol],x2]×D[L[i]×Cfhbar[i][0],x1];

  X[9]+=1/2 D[Wedge[p1,q]×q⊙q×A0hbarl[i][0,ol],x1]×D[L[i]×Cfhbar[i][0],x2];
 ,{i,fromDiag,toDiag}];

Do[X[i]=simplifiedForm@onShellP[X[i]];,{i,1,9}];

XSum=0;
Do[XSum+=X[i],{i,1,9}];*)
```

```
ol = 2;
fromDiag = 1;
toDiag = 4;

ClearAll[X];
Do[X[i] = 0;, {i, 1, 3}];

Do[X[1] += -D[Wedge[p1, q] × L[i] × Cfhbar[i][0] × A0hbarl[i][1, ol], x1];
  X[2] += -D[Wedge[p1, q] × L[i] × Cfhbar[i][1] × A0hbarl[i][0, ol], x1];
  X[3] +=
   1/2 D[(D[q ⊙ q * Wedge[p1, q] × L[i] × Cfhbar[i][0] × A0hbarl[i][0, ol], x1] - D[q ⊙ q * Wedge[p1,
          q] × L[i] × Cfhbar[i][0] × A0hbarl[i][0, ol], x2]), x1], {i, fromDiag, toDiag}];

Do[X[i] = simplifiedForm@onShellP@X[i];, {i, 1, 3}];

XSum = 0;
Do[XSum += X[i], {i, 1, 3}];
```

In[ ]:=
```
ol = 0;
fromDiag = 1;
toDiag = 4;

ClearAll[Z];
Do[Z[i] = 0;, {i, 1, 3}];

Do[Z[1] += aWedgeDb[L[i] × Cfhbar[i][0] × A0hbarl[i][1, ol], p1, p1];
  Z[2] += aWedgeDb[L[i] × Cfhbar[i][1] × A0hbarl[i][0, ol], p1, p1];
  Z[3] += -1/2 (D[q ⊙ q * aWedgeDb[L[i] × Cfhbar[i][0] × A0hbarl[i][0, ol], p1, p1], x1] -
      D[q ⊙ q * aWedgeDb[L[i] × Cfhbar[i][0] × A0hbarl[i][0, ol], p1, p1],
       x2]), {i, fromDiag, toDiag}];

Do[Z[i] = simplifiedForm@onShellP@Z[i];, {i, 1, 3}];

ZSum = 0;
Do[ZSum += Z[i], {i, 1, 3}];
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[(XSum + ZSum) /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

In[ ]:=
```
cancelFactors@Coefficient[Expand@factorRho[(ZSum) /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

$$\frac{4\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{4\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{6\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}$$

(*ZSum: l^0, l*)

$$-\frac{2\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{6\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}+\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}$$

(*XSum: l^0, l*)

$$\frac{2\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{6\,i\,\gamma\,p1\wedge q}{(i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{2\,i\,\gamma\,p1\wedge q}{(-i\,\epsilon+l\odot p1)(i\,\epsilon+l\odot p2)\,q\odot q}$$

First Pair

In[ ]:=

$$Bx1=\frac{(2\,p1+\hbar\,l)\odot(2\,p2-\hbar\,l)\,(2\,p1+\hbar\,q+\hbar\,l)\odot(2\,p2-\hbar\,q-\hbar\,l)}{(q-l)\odot(q-l)\,(2\,p1\odot l+\hbar\,l\odot l+i\,\epsilon)\,(2\,p2\odot l-\hbar\,l\odot l-i\,\epsilon)};$$

$$Cx1=\big((2\,p1+\hbar\,q+\hbar\,l)\odot(2\,p2-\hbar\,q+\hbar\,l)\,(2\,p1+\hbar\,l)\odot(2\,p2-2\,\hbar\,q+\hbar\,l)\big)/\big((q-l)\odot(q-l)\,(2\,p1\odot l+\hbar\,l\odot l+i\,\epsilon)\,(2\,p2\odot(q-l)-\hbar\,(q-l)\odot(q-l)-i\,\epsilon)\big);$$

In[ ]:=

$$B1C1=Bx1+Cx1\;/.\;\{l\odot l-2\,l\odot q+q\odot q\to qml2,\;-l\odot l+2\,l\odot q-q\odot q\to -qml2\};$$

In[ ]:= B1C1

Out[ ]=

$$\big((\hbar^2\,l\odot l+2\,\hbar\,l\odot p1+2\,\hbar\,l\odot p2-2\,\hbar^2\,l\odot q+4\,p1\odot p2-4\,\hbar\,p1\odot q)\,(\hbar^2\,l\odot l+2\,\hbar\,l\odot p1+2\,\hbar\,l\odot p2+4\,p1\odot p2-2\,\hbar\,p1\odot q+2\,\hbar\,p2\odot q-\hbar^2\,q\odot q)\big)/\big(qml2\,(i\,\epsilon+\hbar\,l\odot l+2\,l\odot p1)\,(-i\,\epsilon-qml2\,\hbar+2\,(-l\odot p2+p2\odot q))\big)+\big((-\hbar^2\,l\odot l-2\,\hbar\,l\odot p1+2\,\hbar\,l\odot p2+4\,p1\odot p2)\,(-\hbar^2\,l\odot l-2\,\hbar\,l\odot p1+2\,\hbar\,l\odot p2-2\,\hbar^2\,l\odot q+4\,p1\odot p2-2\,\hbar\,p1\odot q+2\,\hbar\,p2\odot q-\hbar^2\,q\odot q)\big)/\big(qml2\,(i\,\epsilon+\hbar\,l\odot l+2\,l\odot p1)\,(-i\,\epsilon-\hbar\,l\odot l+2\,l\odot p2)\big)$$

In[ ]:=

```
Do[Bx1hbar[n] = Coefficient[Normal[Series[Bx1, {ℏ, 0, 1}]], ℏ, n];
  Cx1hbar[n] = Coefficient[Normal[Series[Cx1, {ℏ, 0, 1}]], ℏ, n], {n, 0, 1}];
```

In[ ]:= simplifiedForm@Bx1hbar[0]

Out[ ]=

$$\frac{4\,(\text{p1}\odot\text{p2})^2}{\left(i\,\epsilon+\text{l}\odot\text{p1}\right)\left(-i\,\epsilon+\text{l}\odot\text{p2}\right)\left(\text{l}\odot\text{l}-2\,\text{l}\odot\text{q}+\text{q}\odot\text{q}\right)}$$

In[ ]:= simplifiedForm@Cx1hbar[0]

Out[ ]=

$$-\frac{4\,(\text{p1}\odot\text{p2})^2}{\left(i\,\epsilon+\text{l}\odot\text{p1}\right)\left(i\,\epsilon+\text{l}\odot\text{p2}-\text{p2}\odot\text{q}\right)\left(\text{l}\odot\text{l}-2\,\text{l}\odot\text{q}+\text{q}\odot\text{q}\right)}$$

R_2

In[ ]:=
```
MaTeX["\\begin{aligned}R_2 = -\\partial_{x_1}(p_1\\wedge q\\,(B_0+C_0))+\\frac{1}{2}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2})(q^2\\,p_1\\wedge q\\,(B_{-1}+C_{-1}))\\\\=p_1\\wedge q\\,\\left(-\\partial_{x_1}(B_0+C_0)+\\frac{1}{2}\\,\\partial_{x_1}^2(q^2\\,(B_{-1}+C_{-1}))-\\frac{1}{2}\\,\\partial_{x_1}\\partial_{x_2}(q^2\\,(B_{-1}+C_{-1}))\\right)\\\\+\\,\\partial_{x_1}(p_1\\wedge q)\\left(-\\,(B_0+C_0)+\\,\\partial_{x_1}(q^2\\,(B_{-1}+C_{-1}))-\\frac{1}{2}\\,\\partial_{x_2}(q^2\\,(B_{-1}+C_{-1}))\\right)\\\\-\\frac{1}{2}\\,\\partial_{x_2}(p_1\\wedge q)\\,\\partial_{x_1}(q^2\\,(B_{-1}+C_{-1}))\\end{aligned}"]
```

Out[ ]=

$$\begin{aligned}R_2 = -\partial_{x_1}(p_1\wedge q\,(B_0+C_0))+\frac{1}{2}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})(q^2\,p_1\wedge q\,(B_{-1}+C_{-1}))\\=p_1\wedge q\,\left(-\partial_{x_1}(B_0+C_0)+\frac{1}{2}\,\partial_{x_1}^2(q^2\,(B_{-1}+C_{-1}))-\frac{1}{2}\,\partial_{x_1}\partial_{x_2}(q^2\,(B_{-1}+C_{-1}))\right)\\+\,\partial_{x_1}(p_1\wedge q)\left(-\,(B_0+C_0)+\,\partial_{x_1}(q^2\,(B_{-1}+C_{-1}))-\frac{1}{2}\,\partial_{x_2}(q^2\,(B_{-1}+C_{-1}))\right)\\-\frac{1}{2}\,\partial_{x_2}(p_1\wedge q)\,\partial_{x_1}(q^2\,(B_{-1}+C_{-1}))\end{aligned}$$

In[◦]:=
```
R21D1 = -simplifiedForm[onShellP[
    D[Wedge[p1, q] * (Expand[(Bx1hbar[1] + Cx1hbar[1]) /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2,
          -l ⊙ l + 2 l ⊙ q - q ⊙ q → -qml2}] /. qml2 → l ⊙ l - 2 l ⊙ q + q ⊙ q), x1]]];

R22D1 = (D[D[q ⊙ q × Wedge[p1, q] * (Bx1hbar[0] + Cx1hbar[0]), x1], x1] -
    D[D[q ⊙ q × Wedge[p1, q] * (Bx1hbar[0] + Cx1hbar[0]), x2], x1]) //.
   {(-(m2^2 p1 ⊙ p1)/s + (γ p1 ⊙ p2)/s) → 1, ((m2^2 p1 ⊙ p1)/s - (γ p1 ⊙ p2)/s) → -1,
    ((γ p1 ⊙ p2)/s - (m1^2 p2 ⊙ p2)/s) → 1, (-(γ p1 ⊙ p2)/s + (m1^2 p2 ⊙ p2)/s) → -1,
    ((γ p1 ⊙ p1)/s - (m1^2 p1 ⊙ p2)/s) → 0, (-(γ p1 ⊙ p1)/s + (m1^2 p1 ⊙ p2)/s) → 0,
    (-(m2^2 p1 ⊙ p2)/s + (γ p2 ⊙ p2)/s) → 0, ((m2^2 p1 ⊙ p2)/s - (γ p2 ⊙ p2)/s) → 0};
R22D1 = 1/2 simplifiedForm@onShellP[R22D1];
(*ClearAll[workspace1, workspace2];*)
```

In[◦]:=
```
R22D1 = 1/2 (D[D[q ⊙ q × Wedge[p1, q] * (Bx1hbar[0] + Cx1hbar[0]), x1], x1] -
    D[D[q ⊙ q × Wedge[p1, q] * (Bx1hbar[0] + Cx1hbar[0]), x2], x1]);
```

In[◦]:=
```
R22D1 = simplifiedForm[onShellP[R22D1]];
```

In[◦]:=
```
R2D1 = R21D1 + R22D1;
```

In[◦]:=
```
R2D1 = Collect[factorRho@(simplifiedForm[R2D1] /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2,
        -l ⊙ l + 2 l ⊙ q - q ⊙ q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}), ρ];
```

In[◦]:=
```
R2D1Div = Total@Select[List @@ R2D1, Exponent[#, ρ] < -1 &];
```

In[◦]:=
```
R2D1Div
```

In[◦]:=
```
R2D1Div = R2D1Div /. {(num_ a_) / (Power[den_, -n_]) :→
   num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l ⊙ p1 || a == l ⊙ p2}
```

In[◦]:=
```
Expand[simplifiedForm[
  onShellP[D[D[Bx1hbar[0] + Cx1hbar[0], x1], x1] - D[D[Bx1hbar[0] + Cx1hbar[0], x1], x2]]]]
```

In[ ]:=
```
Coefficient[
  Collect[factorRho[simplifyTerm[Expand[R22D1]] /. {l⊙l - 2 l⊙q + q⊙q → qml2,
      -l⊙l + 2 l⊙q - q⊙q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}], ρ], ρ, -2]
```

Out[ ]=

$$-\frac{4\,m2^2\,\gamma^2\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{4\,m2^2\,\gamma^2\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{4\,\gamma^3\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p2)^2}-\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}$$

$$C\to\frac{4\,m2^2\,\gamma^2\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}+\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}-\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p2)^2}-\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}$$

$$B\to-\frac{4\,m2^2\,\gamma^2\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{4\,\gamma^3\,q\odot q\,p1\wedge q}{qml2^2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}$$

R_1

In[ ]:=
```
MaTeX["\\begin{aligned}R_1= (p_1\\wedge
  \\partial_{p_1})(B_0+C_0)-\\frac{1}{2}(\\partial_{x_1}-\\partial_{x_2})(q^2
  (p_1\\wedge \\partial_{p_1})(B_{-1}+C_{-1}))\\end{aligned}"]
```

Out[ ]=

$$R_1=(p_1\wedge\partial_{p_1})(B_0+C_0)-\frac{1}{2}(\partial_{x_1}-\partial_{x_2})(q^2(p_1\wedge\partial_{p_1})(B_{-1}+C_{-1}))$$

```
In[•]:= R11D1 = simplifiedForm[
          onShellP[aWedgeDb[Expand[(Bx1hbar[1] + Cx1hbar[1]) /. {l⊙l - 2 l⊙q + q⊙q → qml2,
                -l⊙l + 2 l⊙q - q⊙q → -qml2}] /. qml2 → l⊙l - 2 l⊙q + q⊙q, p1, p1]]];
        R12D1 =
          -1/2 simplifiedForm[onShellP[D[q⊙q × aWedgeDb[Bx1hbar[0] + Cx1hbar[0], p1, p1], x1] -
              D[q⊙q × aWedgeDb[Bx1hbar[0] + Cx1hbar[0], p1, p1], x2]]];

In[•]:= simplifyTerm@
         Coefficient[Collect[factorRho@(Expand[R22D1] /. {l⊙l - 2 l⊙q + q⊙q → qml2,
               -l⊙l + 2 l⊙q - q⊙q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}), ρ], ρ, -2]

Out[•]=
        0

In[•]:= R1D1 = R11D1 + R12D1;
```

In[ ]:= **R12D1**

Out[ ]=

$$
\begin{aligned}
&\frac{1}{2}\Bigg(-q\odot q\Bigg(\frac{8\,\gamma^2\left(-\frac{m2^2\,l\odot p1}{s}+\frac{\gamma\,l\odot p2}{s}\right)l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{8\,\gamma^2\left(-\frac{m2^2\,l\odot p1}{s}+\frac{\gamma\,l\odot p2}{s}\right)l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}+\\
&\frac{16\,\gamma\left(-\frac{m2^2\,l\odot p1}{s}+\frac{\gamma\,l\odot p2}{s}\right)p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{16\,\gamma\left(-\frac{m2^2\,l\odot p1}{s}+\frac{\gamma\,l\odot p2}{s}\right)p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}\Bigg)+\\
&q\odot q\Bigg(\frac{8\,\gamma^2\left(\frac{\gamma\,l\odot p1}{s}-\frac{m1^2\,l\odot p2}{s}\right)l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{8\,\gamma^2\left(\frac{\gamma\,l\odot p1}{s}-\frac{m1^2\,l\odot p2}{s}\right)l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{4\,\gamma^2\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,(l\odot l-2\,l\odot q+q\odot q)}+\\
&\frac{16\,\gamma\left(\frac{\gamma\,l\odot p1}{s}-\frac{m1^2\,l\odot p2}{s}\right)p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{16\,\gamma\left(\frac{\gamma\,l\odot p1}{s}-\frac{m1^2\,l\odot p2}{s}\right)p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)^2}-\\
&\frac{8\,\gamma\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,(l\odot l-2\,l\odot q+q\odot q)}\Bigg)\Bigg)
\end{aligned}
$$

Singular terms

In[ ]:=
```
S1 = simplifiedForm@onShellP[aWedgeDb[Bx1hbar[0] + Cx1hbar[0], p1, p1]]
```

Out[ ]=

$$\frac{4\,\gamma^2\, l\wedge p1}{\left(i\,\epsilon + l\odot p1\right)^2 \left(-i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)} - \frac{4\,\gamma^2\, l\wedge p1}{\left(i\,\epsilon + l\odot p1\right)^2 \left(i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)} + \frac{8\,\gamma\, p1\wedge p2}{\left(i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)} - \frac{8\,\gamma\, p1\wedge p2}{\left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)}$$

In[ ]:=
```
simplifiedForm[expr_] := expr //. {(-m1^2 m2^2/S + γ^2/S) → 1, (m1^2 m2^2/S - γ^2/S) → -1} /. {ϵ → 2 ϵ} /.
  {(coef1_ ϵ + coef2_ l⊙p1)^(n_) → (coef2)^n * (ϵ * coef1 / coef2 + l⊙p1)^n,
   (coef1_ ϵ + coef2_ l⊙p2)^(n_) → (coef2)^n * (ϵ * coef1 / coef2 + l⊙p2)^n}
```

In[ ]:=
```
S2 = -simplifiedForm@onShellP[Expand[D[Wedge[p1, q] * (Bx1hbar[0] + Cx1hbar[0]), x1]]] /.
  {(num_ a_) / (Power[den_, -n_]) :>
    num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l⊙p1 || a == l⊙p2}
```

Out[ ]=

$$-\frac{4\,\gamma^3\, p1\wedge p2}{S\left(i\,\epsilon + l\odot p1\right)\left(-i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)} + \frac{4\,\gamma^3\, p1\wedge p2}{S\left(i\,\epsilon + l\odot p1\right)\left(i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)} + \frac{8\, m2^2\,\gamma^2\, p1\wedge q}{S\left(-i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)^2} - \frac{8\, m2^2\,\gamma^2\, p1\wedge q}{S\left(i\,\epsilon + l\odot p2\right)\left(l\odot l - 2\, l\odot q + q\odot q\right)^2}$$

In[ ]:=
```
S1 + S2
```
Out[ ]=

$$\frac{4\,\gamma^2\,l\wedge p1}{(i\,\epsilon + l\odot p1)^2\,(-i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} - \frac{4\,\gamma^2\,l\wedge p1}{(i\,\epsilon + l\odot p1)^2\,(i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} + \frac{8\,\gamma\,p1\wedge p2}{(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} - \frac{4\,\gamma^3\,p1\wedge p2}{S\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} - \frac{8\,\gamma\,p1\wedge p2}{(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} + \frac{4\,\gamma^3\,p1\wedge p2}{S\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)} + \frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)^2} - \frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\,(i\,\epsilon + l\odot p2)\,(l\odot l - 2\,l\odot q + q\odot q)^2}$$

In[ ]:=
```
R1D1 = Collect[factorRho@(simplifiedForm[R1D1] /. {l⊙l - 2 l⊙q + q⊙q → qml2,
      -l⊙l + 2 l⊙q - q⊙q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}), ρ];
```

In[ ]:=
```
R1D1Div = Total@Select[List @@ R1D1, Exponent[#, ρ] < -1 &];
```

In[ ]:=
```
R1D1Div = R1D1Div /. {(num_ a_) / (Power[den_, -n_]) :→
    num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l⊙p1 || a == l⊙p2}
```

Out[ ]=

$$\frac{\frac{2\,\gamma^2\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} - \frac{2\,\gamma^2\,q\odot q\,l\wedge p1}{qml2\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} + \frac{4\,\gamma\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2} - \frac{4\,\gamma\,q\odot q\,p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}}{\rho^3} + \frac{-\frac{2\,\gamma\,p1\wedge q}{qml2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)} + \frac{6\,\gamma\,p1\wedge q}{qml2\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}}{\rho^2}$$

In[◦]:=
```
Collect[factorRho[simplifyTerm[R11D1] /.
    {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}], ρ]
```

Out[◦]=

$$\frac{\frac{2\gamma^2\, l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}+\frac{4\gamma\, p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}}{\rho^3}+$$

$$\frac{1}{\rho}\left(\frac{2\gamma^2\, l\odot l\, l\wedge p1}{qml2\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2}-\frac{4\gamma^2\, l\odot l\, l\wedge p1}{qml2\,(i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}+\right.$$
$$\frac{4\gamma^2\, l\odot l\, l\wedge p1}{qml2\,(i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)}+\frac{4\gamma\, l\odot l\, p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}-\frac{4\, p1\wedge p2}{qml2\,(-i\,\epsilon+l\odot p2)}-$$
$$\left.\frac{4\gamma\, l\odot l\, p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{4\, p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p2)}+\frac{4\gamma\, l\odot l\, p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}\right)+$$
$$\frac{-\frac{2\gamma\, p1\wedge q}{qml2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{6\gamma\, p1\wedge q}{qml2\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}}{\rho^2}$$

Second Pair

R_2 for the last two diagrams

In[◦]:=
```
Bx2 = ((2 p1 + ℏ q - ℏ l)⊙(2 p2 - ℏ q + ℏ l) (2 p1 + 2 ℏ q - ℏ l)⊙(2 p2 - 2 ℏ q + ℏ l)) /
    ((q - l)⊙(q - l) (2 p1⊙(q - l) + ℏ (q - l)⊙(q - l) + ⅈ ϵ) (2 p2⊙(q - l) - ℏ (q - l)⊙(q - l) - ⅈ ϵ));
```

$$Cx2 = \frac{(2\,p1+2\hbar\,q-\hbar\,l)\odot(2\,p2-\hbar\,l)\,(2\,p1+\hbar\,q-\hbar\,l)\odot(2\,p2-\hbar\,q-\hbar\,l)}{(q-l)\odot(q-l)\,(2\,p1\odot(q-l)+\hbar\,(q-l)\odot(q-l)+i\,\epsilon)\,(2\,p2\odot l-\hbar\,l\odot l-i\,\epsilon)};$$

```
B2C2 = Bx2 + Cx2;
```

In[◦]:=
```
Do[Bx2hbar[n] = Coefficient[Normal[Series[Bx2, {ℏ, 0, 1}]], ℏ, n];
  Cx2hbar[n] = Coefficient[Normal[Series[Cx2, {ℏ, 0, 1}]], ℏ, n], {n, 0, 1}];
```

In[◦]:=
```
Distribute@simplifiedForm@B2xhbar[1]
```

Out[◦]=

$$\frac{16\,(p1\odot p2)^2}{(2\,\epsilon+2\,i\,l\odot p1-2\,i\,p1\odot q)^2\,(-2\,i\,\epsilon-2\,l\odot p2+2\,p2\odot q)}+$$
$$\frac{\frac{8\,p1\odot p2\,(l\odot p1-l\odot p2-p1\odot q+p2\odot q)+4\,p1\odot p2\,(2\,l\odot p1-2\,l\odot p2-4\,p1\odot q+4\,p2\odot q)}{-2\,i\,\epsilon-2\,l\odot p2+2\,p2\odot q}+\frac{16\,(p1\odot p2)^2\,(-l\odot l+2\,l\odot q-q\odot q)}{(2\,\epsilon-2\,i\,l\odot p2+2\,i\,p2\odot q)^2}}{(2\,i\,\epsilon-2\,l\odot p1+2\,p1\odot q)\,(l\odot l-2\,l\odot q+q\odot q)}$$

In[ ]:=
```
Distribute@simplifiedForm@C2xhbar[1]
```
Out[ ]=

$$\frac{8\,(\mathrm{p1}\odot\mathrm{p2})^2}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})\,(2\,\epsilon+2\,i\,\mathrm{l}\odot\mathrm{p1}-2\,i\,\mathrm{p1}\odot\mathrm{q})^2}+\frac{4\,\mathrm{p1}\odot\mathrm{p2}\left(\frac{\mathrm{l}\odot\mathrm{l}\,\mathrm{p1}\odot\mathrm{p2}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})^2}-\frac{\mathrm{l}\odot\mathrm{p1}+\mathrm{l}\odot\mathrm{p2}-2\,\mathrm{p2}\odot\mathrm{q}}{-i\,\epsilon+\mathrm{l}\odot\mathrm{p2}}\right)-\frac{4\,\mathrm{p1}\odot\mathrm{p2}\,(\mathrm{l}\odot\mathrm{p1}+\mathrm{l}\odot\mathrm{p2}+\mathrm{p1}\odot\mathrm{q}-\mathrm{p2}\odot\mathrm{q})}{-i\,\epsilon+\mathrm{l}\odot\mathrm{p2}}}{(2\,i\,\epsilon-2\,\mathrm{l}\odot\mathrm{p1}+2\,\mathrm{p1}\odot\mathrm{q})\,(\mathrm{l}\odot\mathrm{l}-2\,\mathrm{l}\odot\mathrm{q}+\mathrm{q}\odot\mathrm{q})}$$

In[ ]:=
```
MaTeX["\\begin{aligned}R_2 = -\\partial_{x_1}(p_1\\wedge
  q\\,(B_0+C_0))+\\frac{1}{2}(\\partial_{x_1}^2-\\partial_{x_1}\\partial_{x_2})(q^2\\
  ,p_1\\wedge q\\,(B_{-1}+C_{-1}))\\\\=p_1\\wedge
  q\\,\\left(-\\partial_{x_1}(B_0+C_0)+\\frac{1}{2}\\,\\partial_{x_1}^2(q^2\\,(B_{-1
  }+C_{-1}))-\\frac{1}{2}\\,\\partial_{x_1}\\partial_{x_2}(q^2\\,(B_{-1}+C_{-1}))\\
  right)\\\\+\\,\\partial_{x_1}(p_1\\wedge
  q)\\left(-\\,(B_0+C_0)+\\,\\partial_{x_1}(q^2\\,(B_{-1}+C_{-1}))-\\frac{1}{2}\\,\\
  partial_{x_2}(q^2\\,(B_{-1}+C_{-1}))\\right)\\\\-\\frac{1}{2}\\,\\partial_{x_2}(p_1
  \\wedge q)\\,\\partial_{x_1}(q^2\\,(B_{-1}+C_{-1}))\\end{aligned}"]
```
Out[ ]=

$$\begin{aligned}R_2 &= -\partial_{x_1}(p_1\wedge q\,(B_0+C_0))+\frac{1}{2}(\partial_{x_1}^2-\partial_{x_1}\partial_{x_2})(q^2\,p_1\wedge q\,(B_{-1}+C_{-1}))\\&=p_1\wedge q\,\left(-\partial_{x_1}(B_0+C_0)+\frac{1}{2}\,\partial_{x_1}^2(q^2\,(B_{-1}+C_{-1}))-\frac{1}{2}\,\partial_{x_1}\partial_{x_2}(q^2\,(B_{-1}+C_{-1}))\right)\\&+\,\partial_{x_1}(p_1\wedge q)\left(-\,(B_0+C_0)+\,\partial_{x_1}(q^2\,(B_{-1}+C_{-1}))-\frac{1}{2}\,\partial_{x_2}(q^2\,(B_{-1}+C_{-1}))\right)\\&-\frac{1}{2}\,\partial_{x_2}(p_1\wedge q)\,\partial_{x_1}(q^2\,(B_{-1}+C_{-1}))\end{aligned}$$

```
R21D2 = -simplifiedForm[onShellP[
    D[Wedge[p1, q] * (Expand[(Bx2hbar[1] + Cx2hbar[1]) /. {l⊙l - 2 l⊙q + q⊙q → qml2,
           -l⊙l + 2 l⊙q - q⊙q → -qml2}] /. qml2 → l⊙l - 2 l⊙q + q⊙q), x1]]];

R22D2 = D[q⊙q × Wedge[p1, q] * (Bx2hbar[0] + Cx2hbar[0]), x1];
workspace = D[R22D2, x2];
R22D2 = D[R22D2, x1] - workspace;
R22D2 = 1/2 simplifiedForm[onShellP[R22D2]];
ClearAll[workspace];
```

In[ ]:=
```
R2D2 = R21D2 + R22D2;
```

In[ ]:=
```
R2D2 = Collect[
   factorRho@(R2D2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2} /.
      {l → ρ l, ϵ → ρ ϵ}), ρ];
```

In[ ]:=
```
R2D2Div = Total@Select[List @@ R2D2, Exponent[#, ρ] < -1 &];
```

In[ ]:=
```
R2D2Div = R2D2Div /. {(num_ a_) / (Power[den_, -n_]) :→
    num / (den^(-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l⊙p1 || a == l⊙p2};
```

In[ ]:=
```
Coefficient[R1D2Div + R2D2Div, ρ, -4]
```

Out[ ]=

$$\frac{8\,\gamma^2\,q\odot q\;p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}+\frac{4\,\gamma^2\,q\odot q\;p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}-\frac{8\,\gamma^2\,q\odot q\;p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)}$$

In[ ]:=
```
Collect[factorRho[simplifyTerm[Expand[R11D2 /.
    {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}]] /. {l → ρ l, ϵ → ρ ϵ}], ρ]
```

Out[ ]=

$$\frac{-\frac{2\,\gamma^2\,l\odot l\;l\wedge p1}{qml2\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2}-\frac{4\,\gamma\,l\odot l\;p1\wedge p2}{qml2\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}+\frac{4\,p1\wedge p2}{qml2\,(-i\,\epsilon+l\odot p2)}+\frac{4\,p1\wedge p2}{qml2\,(i\,\epsilon+l\odot p2)}}{\rho}+$$

$$\frac{1}{\rho^3}\left(-\frac{4\,\gamma^2\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}-\frac{2\,\gamma^2\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}+\frac{4\,\gamma^2\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)}-\frac{4\,\gamma\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{4\,\gamma\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{4\,\gamma\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}\right)+$$

$$\frac{-\frac{4\,\gamma^2\,p1\wedge q}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)}-\frac{2\,\gamma^2\,p1\wedge q}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2}+\frac{4\,\gamma^2\,p1\wedge q}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)}}{\rho^4}+$$

$$\frac{-\frac{2\,\gamma^2\,l\odot l\;p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2}+\frac{6\,\gamma\,p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{2\,\gamma\,p1\wedge q}{qml2\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}}{\rho^2}$$

In[ ]:=
```
R22D2 = 1/2 (D[D[q⊙q × Wedge[p1, q] * (Bx2hbar[0] + Cx2hbar[0]), x1], x1] -
    D[D[q⊙q × Wedge[p1, q] * (Bx2hbar[0] + Cx2hbar[0]), x2], x1]);
```

In[ ]:=
```
R22D2 = simplifiedForm[onShellP[R22D2]];
```

In[ ]:=
```
R22 = R22D1 + R22D2;
```

R1 for the last two diagrams

In[ ]:=
```
MaTeX["\\begin{aligned}R_1= (p_1\\wedge
   \\partial_{p_1})(B_0+C_0)-\\frac{1}{2}(\\partial_{x_1}-\\partial_{x_2})(q^2
   (p_1\\wedge \\partial_{p_1})(B_{-1}+C_{-1}))\\end{aligned}"]
```

Out[ ]=

$$R_1 = (p_1 \wedge \partial_{p_1})(B_0 + C_0) - \frac{1}{2}(\partial_{x_1} - \partial_{x_2})(q^2(p_1 \wedge \partial_{p_1})(B_{-1} + C_{-1}))$$

In[ ]:=
```
B2xhbar[1]
```

Out[ ]=

$$\frac{\dfrac{\dfrac{8\,\text{p1}\odot\text{p2}\,(\text{l}\odot\text{p1}-\text{l}\odot\text{p2}-\text{p1}\odot\text{q}+\text{p2}\odot\text{q})+4\,\text{p1}\odot\text{p2}\,(2\,\text{l}\odot\text{p1}-2\,\text{l}\odot\text{p2}-4\,\text{p1}\odot\text{q}+4\,\text{p2}\odot\text{q})}{-i\,\epsilon-2\,\text{l}\odot\text{p2}+2\,\text{p2}\odot\text{q}}+\dfrac{16\,(\text{p1}\odot\text{p2})^2\,(-\text{l}\odot\text{l}+2\,\text{l}\odot\text{q}-\text{q}\odot\text{q})}{(\epsilon-2\,i\,\text{l}\odot\text{p2}+2\,i\,\text{p2}\odot\text{q})^2}}{i\,\epsilon-2\,\text{l}\odot\text{p1}+2\,\text{p1}\odot\text{q}}+\dfrac{16\,(\text{p1}\odot\text{p2})^2\,(\text{l}\odot\text{l}-2\,\text{l}\odot\text{q}+\text{q}\odot\text{q})}{(\epsilon+2\,i\,\text{l}\odot\text{p1}-2\,i\,\text{p1}\odot\text{q})^2\,(-i\,\epsilon-2\,\text{l}\odot\text{p2}+2\,\text{p2}\odot\text{q})}}{\text{l}\odot\text{l}-2\,\text{l}\odot\text{q}+\text{q}\odot\text{q}}$$

```
(*R11D2 = aWedgeDb[B2xhbar[1]+C2xhbar[1], p1,p1];
R12D2 = -1/2 D[q⊙q×aWedgeDb[B2xhbar[0]+C2xhbar[0], p1,p1],x1]+
  1/2 D[q⊙q×aWedgeDb[B2xhbar[0]+C2xhbar[0], p1,p1],x2];*)
```

In[ ]:=
```
R11D2 = aWedgeDb[Expand[(Bx2hbar[1] + Cx2hbar[1]) /. {l⊙l - 2 l⊙q + q⊙q → qml2,
      -l⊙l + 2 l⊙q - q⊙q → -qml2}] /. {qml2 → l⊙l - 2 l⊙q + q⊙q}, p1, p1];
R12D2 = -1/2 D[q⊙q × aWedgeDb[Bx2hbar[0] + Cx2hbar[0], p1, p1], x1] +
  1/2 D[q⊙q × aWedgeDb[Bx2hbar[0] + Cx2hbar[0], p1, p1], x2];

R11D2 = onShellP[R11D2];
R12D2 = onShellP[R12D2];

R11D2 = simplifiedForm@R11D2;
R12D2 = simplifiedForm@R12D2;
R1D2 = R11D2 + R12D2;
```

In[ ]:=
```
Coefficient[Collect[factorRho@
   (simplifyTerm[Expand[simplifiedForm[R11D2]]] /. {l⊙l - 2 l⊙q + q⊙q → qml2,
      -l⊙l + 2 l⊙q - q⊙q → -qml2} /. {l → ρ l, ϵ → ρ ϵ}), ρ], ρ, -4]
```

Out[ ]=

$$-\frac{4\,\gamma^2\,\text{p1}\wedge\text{q}}{(-2\,i\,\epsilon+\text{l}\odot\text{p1})^3\,(-2\,i\,\epsilon+\text{l}\odot\text{p2})}-\frac{2\,\gamma^2\,\text{p1}\wedge\text{q}}{(-2\,i\,\epsilon+\text{l}\odot\text{p1})^2\,(2\,i\,\epsilon+\text{l}\odot\text{p2})^2}+\frac{4\,\gamma^2\,\text{p1}\wedge\text{q}}{(-2\,i\,\epsilon+\text{l}\odot\text{p1})^3\,(2\,i\,\epsilon+\text{l}\odot\text{p2})}$$

In[ ]:=
```
R1D2 = simplifiedForm@R1D2;
```

In[ ]:=
```
R1D2 = Collect[
   factorRho@(R1D2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2} /.
      {l → ρ l, ϵ → ρ ϵ}), ρ];
```

In[ ]:=
```
R1D2Div = Total@Select[List @@ R1D2, Exponent[#, ρ] < -1 &];
R1D2Div = R1D2Div /. {(num_ a_) / (Power[den_, -n_]) :>
     num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l⊙p1 || a == l⊙p2};
```

In[ ]:=
$$-\frac{4\,m2^2\,\gamma^2\,l\odot p2\;q\odot q\;p1\wedge q}{qml2^2\,S\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}$$
```
/. {(num_ a_) / (Power[den_, -n_]) :>
   num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l⊙p1 || a == l⊙p2}
```

Out[ ]=
$$-\frac{4\,m2^2\,\gamma^2\,q\odot q\;p1\wedge q}{qml2^2\,S\left(-i\,\epsilon+l\odot p1\right)^2}$$

In[ ]:=
```
Coefficient[R1D2Div + R2D2Div, ρ, -2]
```

Out[ ]=
$$\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)}-\frac{4\,\gamma^3\,p1\wedge q}{qml2\,S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)}-\frac{4\,\gamma^3\,q\odot q\;p1\wedge q}{qml2^2\,S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)}+\frac{4\,m2^2\,\gamma^2\,q\odot q\;p1\wedge q}{qml2^2\,S\left(i\,\epsilon+l\odot p2\right)^2}$$

In[ ]:=
RD2LogDiv =
$$\frac{8\,\pi\,i\,\gamma^3\,p1\wedge q\;\delta[l\odot p2]}{qml2\,S\left(-i\,\epsilon+l\odot p1\right)}-\frac{4\,\gamma^3\,q\odot q\;p1\wedge q}{qml2^2\,S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)}+\frac{4\,m2^2\,\gamma^2\,q\odot q\;p1\wedge q}{qml2^2\,S\left(i\,\epsilon+l\odot p2\right)^2};$$

In[ ]:=
```
S2
```

Out[ ]=
$$-\frac{4\,\gamma^3\,p1\wedge p2}{S\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\,l\odot q+q\odot q\right)}+\frac{4\,\gamma^3\,p1\wedge p2}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\,l\odot q+q\odot q\right)}+\frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\,l\odot q+q\odot q\right)^2}-\frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\,l\odot q+q\odot q\right)^2}$$

In[ ]:=
```
S3 = simplifiedForm@onShellP[aWedgeDb[B2xhbar[0] + C2xhbar[0], p1, p1]]
```

Out[ ]=

$$-\frac{8\,\gamma\,p1\wedge p2}{(-i\,\epsilon + l\odot p1)(-i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)} + \frac{8\,\gamma\,p1\wedge p2}{(-i\,\epsilon + l\odot p1)(i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)} - \frac{2\,i\,\gamma^2\,(-2\,i\,l\wedge p1 - 2\,i\,p1\wedge q)}{(-i\,\epsilon + l\odot p1)^2(-i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)} + \frac{2\,\gamma^2\,(2\,l\wedge p1 + 2\,p1\wedge q)}{(-i\,\epsilon + l\odot p1)^2(i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)}$$

In[ ]:=
```
S4 = -Expand[simplifiedForm@onShellP[D[Wedge[p1, q] * (B2xhbar[0] + C2xhbar[0]), x1]]] /.
  {(num_ a_) / (Power[den_, -n_]) :>
    num / (den ^ (-n - 1)) /; ContainsAll[Variables[den], {ϵ, a}] /; a == l ⊙ p1 || a == l ⊙ p2}
```

In[ ]:=
```
Expand[S1 + S2 + S3 + S4]
```

In[ ]:=
```
simplifyTerm[Total@
  Select[List @@ Expand[R12D1 + R12D2], ContainsAll[List @@ Numerator[#], {p1 ∧ q}] &]]
```

Out[ ]=

$$-\frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{S\,(-i\,\epsilon + l\odot p1)(-i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)^2} - \frac{4\,\gamma^3\,q\odot q\,p1\wedge q}{S\,(-i\,\epsilon + l\odot p1)(-i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)^2} + \frac{4\,m2^2\,\gamma^2\,q\odot q\,p1\wedge q}{S\,(-i\,\epsilon + l\odot p1)(i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)^2} + \frac{4\,\gamma^3\,q\odot q\,p1\wedge q}{S\,(-i\,\epsilon + l\odot p1)(i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)^2} + \frac{4\,\gamma^2\,q\odot q\,p1\wedge q}{(-i\,\epsilon + l\odot p1)^3(-i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)} + \frac{2\,\gamma^2\,q\odot q\,p1\wedge q}{(-i\,\epsilon + l\odot p1)^2(i\,\epsilon + l\odot p2)^2(l\odot l - 2\,l\odot q + q\odot q)} - \frac{4\,\gamma^2\,q\odot q\,p1\wedge q}{(-i\,\epsilon + l\odot p1)^3(i\,\epsilon + l\odot p2)(l\odot l - 2\,l\odot q + q\odot q)}$$

In[ ]:=
```
simplifyTerm[Total@
  Select[List @@ Expand[R22D1 + R22D2], ContainsAll[List @@ Numerator[#], {p1 ∧ q}] &]]
```

Out[ ]=

$$\frac{4\, m2^2\, \gamma^2\, q\odot q\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}+$$
$$\frac{4\, m2^2\, \gamma^2\, q\odot q\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}+$$
$$\frac{4\, \gamma^3\, q\odot q\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}-$$
$$\frac{4\, m2^2\, \gamma^2\, q\odot q\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}-$$
$$\frac{4\, \gamma^3\, q\odot q\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}-$$
$$\frac{4\, m2^2\, \gamma^2\, q\odot q\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)^2}+$$
$$\frac{4\, m2^2\, \gamma^2\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}+$$
$$\frac{4\, \gamma^3\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}-$$
$$\frac{4\, m2^2\, \gamma^2\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}-$$
$$\frac{4\, \gamma^3\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}-$$
$$\frac{4\, m2^2\, \gamma^2\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}-$$
$$\frac{4\, \gamma^3\, p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}+$$
$$\frac{4\, m2^2\, \gamma^2\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}+$$
$$\frac{4\, \gamma^3\, p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)\left(l\odot l-2\, l\odot q+q\odot q\right)}-$$

$$\frac{4\,\gamma^2\, q\odot q\, p1\wedge q}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)}-$$
$$\frac{2\,\gamma^2\, q\odot q\, p1\wedge q}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,(l\odot l-2\,l\odot q+q\odot q)}+$$
$$\frac{4\,\gamma^2\, q\odot q\, p1\wedge q}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)\,(l\odot l-2\,l\odot q+q\odot q)}$$

R_2 for first two diagrams

In[ ]:=

$$Bx = \frac{(2\,p1+\hbar\,l)\odot(2\,p2-\hbar\,l)\,(2\,p1+\hbar\,q+\hbar\,l)\odot(2\,p2-\hbar\,q-\hbar\,l)}{(q-l)\odot(q-l)\,(2\,p1\odot l+\hbar\,l\odot l+i\,\epsilon)\,(2\,p2\odot l-\hbar\,l\odot l-i\,\epsilon)};$$

$$Cx = \frac{(2\,p1+\hbar\,q+\hbar\,l)\odot(2\,p2-\hbar\,q+\hbar\,l)\,(2\,p1+\hbar\,l)\odot(2\,p2-2\,\hbar\,q+\hbar\,l)}{(q-l)\odot(q-l)\,(2\,p1\odot l+\hbar\,l\odot l+i\,\epsilon)\,(2\,p2\odot(q-l)-\hbar\,(q-l)\odot(q-l)-i\,\epsilon)};$$

In[ ]:=
```
BC = Bx + Cx;
```

In[ ]:=
```
Do[Bxhbar[n] = Coefficient[Normal[Series[Bx, {ħ, 0, 1}]], ħ, n];
  Cxhbar[n] = Coefficient[Normal[Series[Cx, {ħ, 0, 1}]], ħ, n], {n, 0, 1}];
```

In[ ]:=

$$R21 = -D[Bxhbar[1] + Cxhbar[1], x1];$$
$$R22 = \frac{1}{2}\, D[q\odot q \times (Bxhbar[0] + Cxhbar[0]), \{x1, 2\}];$$
$$R23 = \frac{-1}{2}\, D[q\odot q \times (Bxhbar[0] + Cxhbar[0]), \{x1, 1\}, \{x2, 1\}];$$

In[ ]:=
```
R21 = onShellP[R21];
R22 = onShellP[R22];
R23 = onShellP[R23];
```

In[ ]:=
```
Rpwq = R21 + R22 + R23;
```

In[ ]:=
```
factorRho[exp_] :=
  exp /. {(expr_Plus)^(n_) :> Factor[expr]^n /; ContainsAll[Variables[expr], {ϵ, l⊙p1}] ||
       ContainsAll[Variables[expr], {ϵ, l⊙p2}]}
```

In[ ]:=
```
Coefficient[factorRho@
  Expand[simplifiedForm[Rpwq] /. {l⊙l - 2 l⊙q + q⊙q → qml2} /. {l → ρ l, ϵ → ρ ϵ}], ρ, -2]
```

In[ ]:= R2D1Div =

$$\frac{\text{Wedge[p1, q]}}{\text{qml2}}\left(\frac{2\gamma}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{6\gamma}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}-\frac{8\pi i\gamma^3\,\delta[l\odot p2]}{S\,(i\epsilon+l\odot p1)}\right)+$$
$$\frac{\text{Wedge[p1, q]}\,q\odot q}{S\,\text{qml2}^2}\left(\frac{4\gamma^3}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{4\,m2^2\gamma^2}{(i\epsilon+l\odot p2)^2}+\frac{8\pi i\,m2^2\gamma^2\,\delta[l\odot p2]}{(i\epsilon+l\odot p1)}\right);$$

R_1 for the first two diagrams

In[ ]:= R11 = aWedgeDb[Bxhbar[1] + Cxhbar[1], p1, p1];

$$\text{R12} = \frac{-1}{2}\,\text{D}[q\odot q\times\text{aWedgeDb}[\text{Bxhbar[0]}+\text{Cxhbar[0]}, \text{p1}, \text{p1}], \text{x1}]+\frac{1}{2}\,\text{D}[q\odot q\times\text{aWedgeDb}[\text{Bxhbar[0]}+\text{Cxhbar[0]}, \text{p1}, \text{p1}], \text{x2}];$$

In[ ]:= R11 = onShellP[R11];
R12 = onShellP[R12];

In[ ]:= R1D1Log = Coefficient[factorRho@Expand[
simplifiedForm[R11 + R12] /. {l⊙l − 2 l⊙q + q⊙q → qml2} /. {l → ρ l, ϵ → ρ ϵ}], ρ, −2]

Out[ ]=

$$-\frac{2\gamma\,p1\wedge q}{\text{qml2}\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{6\gamma\,p1\wedge q}{\text{qml2}\,(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}$$

In[ ]:= RD1LogDiv = Expand[R1D1Log + R2D1Div]

Out[ ]=

$$\frac{4\gamma^3\,q\odot q\,p1\wedge q}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{4\,m2^2\gamma^2\,q\odot q\,p1\wedge q}{\text{qml2}^2\,S\,(i\epsilon+l\odot p2)^2}-\frac{8\,i\,\pi\gamma^3\,p1\wedge q\,\delta[l\odot p2]}{\text{qml2}\,S\,(i\epsilon+l\odot p1)}+\frac{8\,i\,m2^2\pi\gamma^2\,q\odot q\,p1\wedge q\,\delta[l\odot p2]}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)}$$

In[ ]:= RD1LogDiv + RD2LogDiv

$$-\frac{8\pi i\gamma^3\,q\odot q\,p1\wedge q\,\delta[l\odot p1]}{\text{qml2}^2\,S\,(-i\epsilon+l\odot p1)}+\frac{8\,i\,\pi\gamma^3\,p1\wedge q\,\delta[l\odot p2]}{\text{qml2}\,S\,(-i\epsilon+l\odot p1)}-\frac{8\,i\,\pi\gamma^3\,p1\wedge q\,\delta[l\odot p2]}{\text{qml2}\,S\,(i\epsilon+l\odot p1)}+\frac{8\,i\,m2^2\pi\gamma^2\,q\odot q\,p1\wedge q\,\delta[l\odot p2]}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)}$$

In[∘]:=
```
Coefficient[Collect[
  factorRho@(R1D2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2} /.
     {l → ρ l, ϵ → ρ ϵ}), ρ], ρ, -4]
```

$$\mathrm{R1D2}\to -\frac{4\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}-\frac{2\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^2\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})^2}+\frac{4\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}+\frac{4\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}+\frac{2\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^2\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})^2}-\frac{4\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}$$

$$\mathrm{R2D2}\to \frac{4\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}+\frac{2\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^2\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})^2}-\frac{4\,\gamma^2\,\mathrm{p1}\wedge\mathrm{q}}{(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}-\frac{4\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}-\frac{2\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^2\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})^2}+\frac{4\,\gamma^2\,\mathrm{q}\odot\mathrm{q}\,\mathrm{p1}\wedge\mathrm{q}}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1})^3\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}$$

In[∘]:=
```
Normal[Series[1 / (l⊙l - 2 l⊙q + q⊙q) /. {l → ρ l}, {ρ, 0, 2}]]
```

Out[∘]=

$$\frac{2\,\rho\,\mathrm{l}\odot\mathrm{q}}{(\mathrm{q}\odot\mathrm{q})^2}+\frac{1}{\mathrm{q}\odot\mathrm{q}}+\frac{\rho^2\left(4\,(\mathrm{l}\odot\mathrm{q})^2-\mathrm{l}\odot\mathrm{l}\,\mathrm{q}\odot\mathrm{q}\right)}{(\mathrm{q}\odot\mathrm{q})^3}$$

```
wsp = q⊙q * aWedgeDb[(Bx1hbar[0] + Bx2hbar[0] + Cx1hbar[0] + Cx2hbar[0]), p1, p1];

t1 = Expand[simplifiedForm[onShellP[D[wsp, x1] - D[wsp, x2]]]];
ClearAll[wsp];
wsp = List @@ t1;
ClearAll[t1];
t1 = {};
Do[AppendTo[t1, simplifyTerm[wsp[[i]]]], {i, 1, Length[wsp]}];
t1 = Total[t1];
ClearAll[wsp];
```

In[ ]:=
```
wsp = q⊙q*Wedge[p1, q]*(Bx1hbar[0] + Bx2hbar[0] + Cx1hbar[0] + Cx2hbar[0]);

t2 = Expand[simplifiedForm[onShellP[D[D[wsp, x1] - D[wsp, x2], x1]]]];
ClearAll[wsp];
wsp = List @@ t2;
ClearAll[t2];
t2 = {};
Do[AppendTo[t2, simplifyTerm[wsp[[i]]]], {i, 1, Length[wsp]}];
t2 = Total[t2];
ClearAll[wsp];
```

In[ ]:=
```
t1 = factorRho[t1 /. {l → ρ l, ϵ → ρ ϵ}];
t2 = factorRho[t2 /. {l → ρ l, ϵ → ρ ϵ}];
```

In[ ]:=
```
t1 = t1 /. {(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q) →
    1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 2}]]};
t2 = t2 /.
   {(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q) → 1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 2}]]};
```

In[ ]:=
```
Coefficient[Expand[t1], ρ, -2] - Coefficient[Expand[t2], ρ, -2]
```

Out[ ]=

$$
\begin{aligned}
&-\frac{16\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\\
&\frac{8\,\gamma^2\,l\odot q\,l\wedge p1}{(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{16\,\gamma^2\,l\odot q\,l\wedge p1}{(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)\,q\odot q}-\\
&\frac{16\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{8\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)\,q\odot q}-\\
&\frac{16\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\frac{8\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\\
&\frac{16\,\gamma\,l\odot q\,p1\wedge p2}{(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}-\frac{8\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2\,q\odot q}+\\
&\frac{16\,\gamma\,l\odot q\,p1\wedge p2}{(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,\gamma^3\,l\odot q\,p1\wedge p2}{S\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)\,q\odot q}-\\
&\frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)\,q\odot q}+\frac{8\,m2^2\,\gamma^2\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}+\\
&\frac{8\,\gamma^3\,p1\wedge q}{S\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}-\frac{8\,\gamma^3\,p1\wedge q}{S\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)\,q\odot q}
\end{aligned}
$$

In[ ]:=
```
s1 = simplifyTerm@Expand[simplifiedForm[
    onShellP[aWedgeDb[(Bx1hbar[1] + Bx2hbar[1] + Cx1hbar[1] + Cx2hbar[1]), p1, p1]]]];
s2 = simplifyTerm@Expand[simplifiedForm[
    onShellP[D[Wedge[p1, q] * (Bx1hbar[1] + Bx2hbar[1] + Cx1hbar[1] + Cx2hbar[1]), x1]]]];
```

In[ ]:=
```
s1 = factorRho[s1 /. {l → ρ l, ϵ → ρ ϵ}];
s2 = factorRho[s2 /. {l → ρ l, ϵ → ρ ϵ}];
```

In[ ]:=
```
s1 = s1 /. {(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q) →
    1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 3}]]};
s2 = s2 /.
  {(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q) → 1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 3}]]};
```

In[ ]:=
```
Coefficient[Expand[s1], ρ, -2]
```

Out[ ]=

$$-\frac{2\gamma^2\, l\odot l\, p1\wedge q}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)^2\, q\odot q}+\frac{6\gamma\, p1\wedge q}{(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-\frac{2\gamma\, p1\wedge q}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-\frac{2\gamma\, p1\wedge q}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}+\frac{6\gamma\, p1\wedge q}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}$$

In[ ]:=
```
Coefficient[Expand[s2], ρ, -2]
```

Out[ ]=

$$-\frac{2\gamma^2\, l\odot l\, p1\wedge q}{(-i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)^2\, q\odot q}+\frac{6\gamma\, p1\wedge q}{(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-\frac{2\gamma\, p1\wedge q}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)\, q\odot q}-\frac{2\gamma\, p1\wedge q}{(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}+\frac{6\gamma\, p1\wedge q}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)\, q\odot q}$$

In[ ]:=
```
sum = 0;
Do[sum += L[i] × Cf[i] (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] +
    ℏ A0hbarl[i][1, 0] + ℏ A0hbarl[i][1, 1] + ℏ A0hbarl[i][1, 2]), {i, 1, 4}]
```

In[ ]:=
```
sum = 0;
Do[sum += L[i] × Cf[i] × A0[i], {i, 1, 4}]
```

In[ ]:=
```
Expand[simplifyTerm[Expand[simplifiedForm[sum]]] /. {(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q) →
    1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 2}]]} /. {ρ → 1}]
```

In[ ]:=
```
simplifyTerm[
  Expand[Expand[simplifiedForm[Bx1hbar[1] + Bx2hbar[0] + Cx1hbar[0] + Cx2hbar[1]]] /.
      {l → ρ l, ϵ → ρ ϵ} /. {Power[(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), -1] →
        1 / Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 2}]]} /. {ρ → 1}]] -
 simplifyTerm[simplifiedForm[Expand[sum]]]
```

In[ ]:=
```
simplifyTerm[simplifiedForm[Expand[sum]]]
```

In[ ]:=
```
a = simplifyTerm[
   simplifiedForm[factorRho[Expand[Expand[Bx1hbar[1]] /. {l → ρ l, ϵ → ρ ϵ} /.
        {Power[(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), -1] → Normal[Series[1 /
              (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), {ρ, 0, 2}]], Power[(ρ^2 l⊙l - 2 ρ l⊙q + q⊙q), -2] →
          Normal[Series[1 / (ρ^2 l⊙l - 2 ρ l⊙q + q⊙q)^2, {ρ, 0, 2}]]}]]] /. {ρ → 1}];
```

In[ ]:=
```
b = simplifyTerm[simplifiedForm[
    Expand[(L[i] × Cf[i] (A0hbarl[i][0, 0] + A0hbarl[i][0, 1] + A0hbarl[i][0, 2] +
           ℏ A0hbarl[i][1, 0] + ℏ A0hbarl[i][1, 1] + ℏ A0hbarl[i][1, 2]) /. {i → 1})]]];
```

In[ ]:=
```
Length[a]
Length[Coefficient[b, ℏ, 1]]
Length[factorRho@(Expand[ⅈ a] - Coefficient[b, ℏ, 1]) /. p1⊙p2 → γ]
```

Out[ ]=
```
24
```

Out[ ]=
```
28
```

Out[ ]=
```
4
```

In[ ]:=
```
(Expand[ⅈ a] - Coefficient[b, ℏ, 0]) /. p1⊙p2 → γ
```

Out[ ]=
```
0
```

In[ ]:=
```
factorRho[Expand[ⅈ a] /. p1⊙p2 → γ /. {l → ρ l, ϵ → ρ ϵ}]
```

In[ ]:=
```
Complement[List @@ factorRho[Coefficient[b, ℏ, 1] /. p1⊙p2 → γ /. {l → ρ l, ϵ → ρ ϵ}],
 List @@ factorRho[Expand[ⅈ a] /. p1⊙p2 → γ /. {l → ρ l, ϵ → ρ ϵ}]]
```

Out[ ]=

$$\left\{\frac{8 i \gamma \rho (l \odot q)^2}{(i \epsilon + l \odot p1)(q \odot q)^3}, -\frac{8 i \gamma \rho (l \odot q)^2}{(-i \epsilon + l \odot p2)(q \odot q)^3}, -\frac{2 i \gamma \rho\, l \odot l}{(i \epsilon + l \odot p1)(q \odot q)^2}, \frac{2 i \gamma \rho\, l \odot l}{(-i \epsilon + l \odot p2)(q \odot q)^2}\right\}$$

In[ ]:=
```
Complement[List @@ factorRho[Expand[ⅈ a] /. p1⊙p2 → γ /. {l → ρ l, ϵ → ρ ϵ}],
  List @@ factorRho[Coefficient[b, ℏ, 1] /. p1⊙p2 → γ /. {l → ρ l, ϵ → ρ ϵ}]]
```

Out[ ]=

$$\left\{\frac{16\,i\,\gamma\,\rho\,(l\odot q)^2}{(i\,\epsilon+l\odot p1)\,(q\odot q)^3},-\frac{16\,i\,\gamma\,\rho\,(l\odot q)^2}{(-i\,\epsilon+l\odot p2)\,(q\odot q)^3},-\frac{4\,i\,\gamma\,\rho\,l\odot l}{(i\,\epsilon+l\odot p1)\,(q\odot q)^2},\frac{4\,i\,\gamma\,\rho\,l\odot l}{(-i\,\epsilon+l\odot p2)\,(q\odot q)^2}\right\}$$

In[ ]:=
```
Coefficient[Expand[simplifyTerm[Expand[L[1] × Cf[1]]] (A0hbar[1][0] + ℏ A0hbar[1][1])], ℏ, 1]
```

In[ ]:=
```
Expand[L[1] × Cf[1]]
```

Out[ ]=

$$\frac{\gamma\,\hbar\,l\odot l}{2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}-\frac{\gamma\,\hbar\,l\odot l}{2\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+\frac{\gamma}{(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}-\frac{\hbar\,l\odot p1}{2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}+\frac{\hbar\,l\odot p2}{2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)}$$

One Loop: Calculation 3

In[ ]:=
```
MaTeX[
 "\\begin{aligned}Q_1=J_1|_{O(l^{-2}),O(\\hbar^0)},\\;\\;Q_2=J_1|_{O(l^{-2}),O(\\hbar)},
   \\\\Q_3=J_2|_{O(l^{-2}),O(\\hbar^0)}\\\\Q_4=J_3|_{O(l^{-2}),O(\\hbar^0)},\\;\\;Q_5=
   J_3|_{O(l^{-2}),O(\\hbar)}\\\\Q_6=J_4|_{O(l^{-2}),O(\\hbar^0)}\\\\Q_7=J_1|_{O(l^{-3}),O
   (\\hbar^0)},\\;\\;Q_8=J_1|_{O(l^{-3}),O(\\hbar)},\\\\Q_9=J_2|_{O(l^{-3}),O(\\hbar^0)}
   \\\\Q_{10}=J_3|_{O(l^{-3}),O(\\hbar^0)},\\;\\;Q_{11}=J_3|_{O(l^{-3}),O(\\hbar)}\\\\Q_{
   12}=J_4|_{O(l^{-3}),O(\\hbar^0)}\\\\Q_{13}=J_1|_{O(l^{-4}),O(\\hbar^0)},\\;\\;Q_{14}=
   J_1|_{O(l^{-4}),O(\\hbar)},\\\\Q_{15}=J_2|_{O(l^{-4}),O(\\hbar^0)}\\\\Q_{16}=J_3|_{O(l^{-4
   \\hbar^0)}\\end{aligned}"]
```

Out[ ]=

$$\begin{aligned}Q_1=J_1|_{O(l^{-2}),O(\hbar^0)},\;\;Q_2=J_1|_{O(l^{-2}),O(\hbar)},\\Q_3=J_2|_{O(l^{-2}),O(\hbar^0)}\\Q_4=J_3|_{O(l^{-2}),O(\hbar^0)},\;\;Q_5=J_3|_{O(l^{-2}),O(\hbar)}\\Q_6=J_4|_{O(l^{-2}),O(\hbar^0)}\\Q_7=J_1|_{O(l^{-3}),O(\hbar^0)},\;\;Q_8=J_1|_{O(l^{-3}),O(\hbar)},\\Q_9=J_2|_{O(l^{-3}),O(\hbar^0)}\\Q_{10}=J_3|_{O(l^{-3}),O(\hbar^0)},\;\;Q_{11}=J_3|_{O(l^{-3}),O(\hbar)}\\Q_{12}=J_4|_{O(l^{-3}),O(\hbar^0)}\\Q_{13}=J_1|_{O(l^{-4}),O(\hbar^0)},\;\;Q_{14}=J_1|_{O(l^{-4}),O(\hbar)},\\Q_{15}=J_2|_{O(l^{-4}),O(\hbar^0)}\\Q_{16}=J_3|_{O(l^{-4}),O(\hbar^0)},\;\;Q_{17}=J_3|_{O(l^{-4}),O(\hbar)}\\Q_{18}=J_4|_{O(l^{-4}),O(\hbar^0)}\end{aligned}$$

In[ ]:=
```
MaTeX["J1=\\sum_iL_iC_i,\\;\\;J2=\\partial_{\\Delta
   x}\\sum_iL_iC_i,\;\;J3=p_1\\wedge \\partial p_1\\sum_iL_iC_i-p_1\\wedge
   q\\partial_{x_1}\\sum_iL_iC_i,\\\\J4=\\partial_{\\Delta x}\\Big(p_1\\wedge
   \\partial p_1\\sum_iL_iC_i-p_1\\wedge q\\partial_{x_1}\\sum_iL_iC_i\\Big)"]
```

Out[ ]=

$$J1=\sum_i L_iC_i,\;\;J2=\partial_{\Delta x}\sum_i L_iC_i,\;\;J3=p_1\wedge\partial p_1\sum_i L_iC_i-p_1\wedge q\partial_{x_1}\sum_i L_iC_i, J4=\partial_{\Delta x}\Big(p_1\wedge\partial p_1\sum_i L_iC_i-p_1\wedge q\partial_{x_1}\sum_i$$

In[ ]:=
```
ClearAll[sum];
sum = 0;
Do[sum += L[i] * Cf[i] /. {γ → p1 ⊙ p2}, {i, 1, 4}]
```

In[ ]:=
```
ClearAll[J1, J2, J3, J4];
J1 = sum;
J2 = delx[J1];
J3 = aWedgeDb[sum, p1, p1] - p1 ∧ q * D[sum, x1];
J4 = delx[J3];

J1 = simplifiedForm[onShellP[J1]];
J2 = simplifiedForm[onShellP[J2]];
J3 = simplifiedForm[onShellP[J3]];
J4 = simplifiedForm[onShellP[J4]];
```

In[ ]:=
```
ClearAll[J1lm2, J2lm2, J3lm2, J4lm2];
J1lm2 = extractLog[J1, -2];
J2lm2 = extractLog[J2, -2];
J3lm2 = extractLog[J3, -2];
J4lm2 = extractLog[J4, -2];
```

In[ ]:=
```
ClearAll[J1lm3, J2lm3, J3lm3, J4lm3];
J1lm3 = extractLog[J1, -3];
J2lm3 = extractLog[J2, -3];
J3lm3 = extractLog[J3, -3];
J4lm3 = extractLog[J4, -3];
```

In[ ]:=
```
ClearAll[J1lm4, J2lm4, J3lm4, J4lm4];
J1lm4 = extractLog[J1, -4];
J2lm4 = extractLog[J2, -4];
J3lm4 = extractLog[J3, -4];
J4lm4 = extractLog[J4, -4];
```

In[ ]:=

```
MaTeX["\\begin{aligned}R_{(1)}=\\frac{1}{\\hbar}\\Big(p_1\\wedge
   \\partial p_1A_0-\\partial_{x_1}(p_1\\wedge
   q\,A_0)\\Big)J1-\\frac{1}{2}\\partial_{\\Delta x}\\Big(q^2\\,p_1\\wedge
   \\partial p_1A_0-\\partial_{x_1}(q^2\\,p_1\\wedge
   q\,A_0)\\Big)J1\\\\-\\frac{1}{2}\\Big(q^2\\,p_1\\wedge
   \\partial p_1A_0-\\partial_{x_1}(q^2\\,p_1\\wedge
   q\,A_0)\\Big)J2\\\\+\\frac{1}{\\hbar}A_0J_3-\\frac{1}{2}\\partial_{\\Delta
   x}(q^2\\,A_0)J_3\\\\-\\frac{1}{2}q^2\\,A_0\\,J_4\\\\-\\frac{1}{\\hbar}l^{(1)}\\Big
   [J_3\\partial_q\,A_0+J_1(p_1\\partial_{p_1}\\,\\partial_qA_0-\\partial_{x_1}(p_
   1\\wedge
   q\,\\partial_q\\,A_0))\\Big]\\\\+\\frac{1}{2}\\,l^{(1)}\\Big[J_1\\,\\partial_{\\
   Delta
   x}(q^2\\,p_1\\wedge\\partial_{p_1}\\,\\partial_qA_0-\\partial_{x_1}(q^2\\,p_1\\
   wedge
   q\,\\partial_q\\,A_0))+J_2(q^2\\,p_1\\wedge\\partial_{p_1}\\,\\partial_qA_0-\\
   partial_{x_1}(q^2\\,p_1\\wedge
   q\,\\partial_q\\,A_0))\\\\+J_3\\,\\partial_{\\Delta
   x}(q^2\\,\\partial_q\,A_0)+J_4\\,q^2\\,\\partial_q\,A_0\\Big]\\\\+\\frac{1}{2
   \\hbar}l^{(2)}\\Big[J_3\\partial_q^2\,A_0+J_1(p_1\\partial_{p_1}\\,\\partial_q^2
   A_0-\\partial_{x_1}(p_1\\wedge
   q\,\\partial_q^2\\,A_0))\\Big]\\\\-\\frac{1}{4}\\,l^{(2)}\\Big[J_1\\,\\partial_{
   \\Delta
   x}(q^2\\,p_1\\wedge\\partial_{p_1}\\,\\partial_q^2A_0-\\partial_{x_1}(q^2\\,p_1
   \\wedge
   q\,\\partial_q^2\\,A_0))+J_2(q^2\\,p_1\\wedge\\partial_{p_1}\\,\\partial_q^2A_
   0-\\partial_{x_1}(q^2\\,p_1\\wedge
   q\,\\partial_q^2\\,A_0))\\\\+J_3\\,\\partial_{\\Delta
   x}(q^2\\,\\partial_q^2\,A_0)+J_4\\,q^2\\,\\partial_q^2\,A_0\\Big]\\end{aligned
   }"]
```

Out[ ]=

$$\begin{aligned}R_{(1)}=\frac{1}{\hbar}\Big(p_1\wedge \partial p_1A_0-\partial_{x_1}(p_1\wedge q\,A_0)\Big)J1-\frac{1}{2}\partial_{\Delta x}\Big(q^2\,p_1\wedge \partial p_1A_0-\partial_{x_1}(q^2\,p_1\wedge q\,A_0)\Big)J1\\-\frac{1}{2}\Big(q^2\,p_1\wedge \partial p_1A_0-\partial_{x_1}(q^2\,p_1\wedge q\,A_0)\Big)J2\\+\frac{1}{\hbar}A_0J_3-\frac{1}{2}\partial_{\Delta x}(q^2\,A_0)J_3\\-\frac{1}{2}q^2\,A_0\,J_4\\-\frac{1}{\hbar}l^{(1)}\Big[J_3\partial_q\,A_0+J_1(p_1\partial_{p_1}\,\partial_qA_0-\partial_{x_1}(p_1\wedge q\,\partial_q\,A_0))\Big]\\+\frac{1}{2}\,l^{(1)}\Big[J_1\,\partial_{\Delta x}(q^2\,p_1\wedge\partial_{p_1}\,\partial_qA_0-\partial_{x_1}(q^2\,p_1\wedge q\,\partial_q\,A_0))+J_2(q^2\,p_1\wedge\partial_{p_1}\,\partial_qA_0-\partial_{x_1}(q^2\,p_1\wedge q\,\partial_q\,A_0))\\+J_3\,\partial_{\Delta x}(q^2\,\partial_q\,A_0)+J_4\,q^2\,\partial_q\,A_0\Big]\\+\frac{1}{2\hbar}l^{(2)}\Big[J_3\partial_q^2\,A_0+J_1(p_1\partial_{p_1}\,\partial_q^2A_0-\partial_{x_1}(p_1\wedge q\,\partial_q^2\,A_0))\Big]\\-\frac{1}{4}\,l^{(2)}\Big[J_1\,\partial_{\Delta x}(q^2\,p_1\wedge\partial_{p_1}\,\partial_q^2A_0-\partial_{x_1}(q^2\,p_1\wedge q\,\partial_q^2\,A_0))+J_2(q^2\,p_1\wedge\partial_{p_1}\,\partial_q^2A_0-\partial_{x_1}(q^2\,p_1\wedge q\,\partial_q^2\,A_0))\\+J_3\,\partial_{\Delta x}(q^2\,\partial_q^2\,A_0)+J_4\,q^2\,\partial_q^2\,A_0\Big]\end{aligned}$$

In[ ]:=
```
J4lm3
```

Out[ ]=

$$-\frac{2\,\gamma\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^3\left(-i\,\epsilon+l\odot p2\right)}-\frac{\gamma\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}+$$
$$\frac{\gamma\,l\wedge p1}{\left(i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}+\frac{2\,\gamma\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^3\left(i\,\epsilon+l\odot p2\right)}+\frac{6\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^4\left(-i\,\epsilon+l\odot p2\right)}-$$
$$\frac{2\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^3}+\frac{2\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{\left(i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^3}+\frac{4\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^3\left(i\,\epsilon+l\odot p2\right)^2}-$$
$$\frac{6\,\gamma\,\hbar\,l\odot q\,l\wedge p1}{\left(-i\,\epsilon+l\odot p1\right)^4\left(i\,\epsilon+l\odot p2\right)}-\frac{p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}-\frac{p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+$$
$$\frac{p1\wedge p2}{\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+\frac{p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)}+\frac{2\,\hbar\,l\odot q\,p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^3\left(-i\,\epsilon+l\odot p2\right)}-$$
$$\frac{2\,\hbar\,l\odot q\,p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^3}+\frac{2\,\hbar\,l\odot q\,p1\wedge p2}{\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^3}+\frac{2\,\hbar\,l\odot q\,p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)^2}-$$
$$\frac{2\,\hbar\,l\odot q\,p1\wedge p2}{\left(-i\,\epsilon+l\odot p1\right)^3\left(i\,\epsilon+l\odot p2\right)}+\frac{m2^2\,\gamma\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}-\frac{\gamma^2\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(-i\,\epsilon+l\odot p2\right)}+$$
$$\frac{m2^2\,\gamma\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+\frac{\gamma^2\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}+\frac{m2^2\,\gamma\,\hbar\,p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}-$$
$$\frac{\gamma^2\,\hbar\,p1\wedge q}{S\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2\right)^2}-\frac{m2^2\,\gamma\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)}-\frac{\gamma^2\,\hbar\,p1\wedge q}{S\left(-i\,\epsilon+l\odot p1\right)^2\left(i\,\epsilon+l\odot p2\right)}$$

In[ ]:=
```
ClearAll[B0C0, B1C1];
B0C0 = Bx1hbar[0] + Bx2hbar[0] + Cx1hbar[0] + Cx2hbar[0];
B1C1 = Bx1hbar[1] + Bx2hbar[1] + Cx1hbar[1] + Cx2hbar[1];
```

In[ ]:=
```
simplifiedForm[B0C0 /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2, -l ⊙ l + 2 l ⊙ q - q ⊙ q → -qml2}]
```

Out[ ]=

$$\frac{4\,(p1\odot p2)^2}{qml2\left(i\,\epsilon+l\odot p1\right)\left(-i\,\epsilon+l\odot p2\right)}-\frac{4\,(p1\odot p2)^2}{qml2\left(-i\,\epsilon+l\odot p2\right)\left(-i\,\epsilon+l\odot p1-p1\odot q\right)}-$$
$$\frac{4\,(p1\odot p2)^2}{qml2\left(i\,\epsilon+l\odot p1\right)\left(i\,\epsilon+l\odot p2-p2\odot q\right)}+\frac{4\,(p1\odot p2)^2}{qml2\left(-i\,\epsilon+l\odot p1-p1\odot q\right)\left(i\,\epsilon+l\odot p2-p2\odot q\right)}$$

In[•]:=
```
simplifiedForm[B1C1 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}]
```

Out[•]=

$$\frac{-\frac{2\,qml2\,(p1\odot p2)^2}{(-i\epsilon+l\odot p2)(-i\epsilon+l\odot p1-p1\odot q)^2}-\frac{4\,p1\odot p2\left(\frac{l\odot l\;p1\odot p2}{(-i\epsilon+l\odot p2)^2}-\frac{l\odot p1+l\odot p2-2\,p2\odot q}{-i\epsilon+l\odot p2}\right)-\frac{4\,p1\odot p2\,(l\odot p1+l\odot p2+p1\odot q-p2\odot q)}{-i\epsilon+l\odot p2}}{2\,(-i\epsilon+l\odot p1-p1\odot q)}}{qml2}+$$

$$\frac{1}{qml2}\left(4\,p1\odot p2\left(\frac{-2\,l\odot p1+2\,l\odot p2}{4\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+4\left(\frac{l\odot l}{8\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)^2}-\frac{l\odot l}{8\,(i\epsilon+l\odot p1)^2(-i\epsilon+l\odot p2)}\right)p1\odot p2\right)-\frac{2\,p1\odot p2\,(l\odot p1-l\odot p2+p1\odot q-p2\odot q)}{(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}\right)+$$

$$\frac{\frac{2\,qml2\,(p1\odot p2)^2}{(i\epsilon+l\odot p1)(i\epsilon+l\odot p2-p2\odot q)^2}-\frac{4\,p1\odot p2\left(-\frac{l\odot l\;p1\odot p2}{(i\epsilon+l\odot p1)^2}+\frac{l\odot p1+l\odot p2-2\,p1\odot q}{i\epsilon+l\odot p1}\right)+\frac{4\,p1\odot p2\,(l\odot p1+l\odot p2-p1\odot q+p2\odot q)}{i\epsilon+l\odot p1}}{2\,(i\epsilon+l\odot p2-p2\odot q)}}{qml2}+$$

$$\frac{\frac{2\,qml2\,(p1\odot p2)^2}{(-i\epsilon+l\odot p1-p1\odot q)^2\,(i\epsilon+l\odot p2-p2\odot q)}-\frac{\frac{4\,qml2\,(p1\odot p2)^2}{(i\epsilon+l\odot p2-p2\odot q)^2}-\frac{8\,p1\odot p2\,(l\odot p1-l\odot p2-p1\odot q+p2\odot q)+4\,p1\odot p2\,(2\,l\odot p1-2\,l\odot p2-4\,p1\odot q+4\,p2\odot q)}{2\,(i\epsilon+l\odot p2-p2\odot q)}}{2\,(-i\epsilon+l\odot p1-p1\odot q)}}{qml2}$$

In[•]:=
```
Coefficient[Expand[
  simplifiedForm[B1C1] /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}],
  1/((-ⅈ ϵ + l⊙p1 - p1⊙q) (ⅈ ϵ + l⊙p2 - p2⊙q)), 1]
```

Out[•]=

$$\frac{4\,l\odot p1\;p1\odot p2}{qml2}-\frac{4\,l\odot p2\;p1\odot p2}{qml2}-\frac{6\,p1\odot p2\;p1\odot q}{qml2}+\frac{6\,p1\odot p2\;p2\odot q}{qml2}$$

In[•]:=
```
ClearAll[R1B1C1];
R1B1C1 =
  simplifyTerm[Expand[simplifiedForm[onShellP[aWedgeDb[B1C1, p1, p1] / l⊙l] /.
        {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}] / 4]];

ClearAll[R1B1C1p1q, R1B1C1p1p2, R1B1C1p1l];
R1B1C1p1q = Coefficient[R1B1C1, p1∧q, 1];
R1B1C1p1p2 = Coefficient[R1B1C1, p1∧p2, 1];
R1B1C1p1l = Coefficient[R1B1C1, l∧p1, 1];
```

In[ ]:=
```
ClearAll[R1B0C0];
R1B0C0 = simplifyTerm[
   Expand[simplifiedForm[onShellP[delx[-q ⊙ q * aWedgeDb[B0C0, p1, p1]] / (8 * l ⊙ l)]]]];

ClearAll[R1B0C0p1q, R1B0C0p1p2, R1B0C0p1l];
R1B0C0p1q = Coefficient[R1B0C0, p1 ∧ q, 1];
R1B0C0p1p2 = Coefficient[R1B0C0, p1 ∧ p2, 1];
R1B0C0p1l = Coefficient[R1B0C0, l ∧ p1, 1];
```

In[ ]:=
```
ClearAll[R2B1C1];
R2B1C1 = simplifyTerm[Expand[simplifiedForm[
     onShellP[D[-p1 ∧ q * (Expand[B1C1 /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2, -l ⊙ l + 2 l ⊙ q -
                q ⊙ q → -qml2}] /. {qml2 → l ⊙ l - 2 l ⊙ q + q ⊙ q}), x1] / (4 * l ⊙ l)]]]];

ClearAll[R2B1C1p1q, R2B1C1p1p2, R2B1C1p1l];
R2B1C1p1q = Coefficient[R2B1C1, p1 ∧ q, 1];
R2B1C1p1p2 = Coefficient[R2B1C1, p1 ∧ p2, 1];
R2B1C1p1l = Coefficient[R2B1C1, l ∧ p1, 1];
```

In[ ]:=
```
ClearAll[R2B0C0];
R2B0C0 = simplifyTerm[
   Expand[simplifiedForm[onShellP[delx[D[q ⊙ q * p1 ∧ q * B0C0, x1]] / (8 * l ⊙ l)]]]];

ClearAll[R2B0C0p1q, R2B0C0p1p2, R2B0C0p1l];
R2B0C0p1q = Coefficient[R2B0C0, p1 ∧ q, 1];
R2B0C0p1p2 = Coefficient[R2B0C0, p1 ∧ p2, 1];
R2B0C0p1l = Coefficient[R2B0C0, l ∧ p1, 1];
```

In[ ]:=
```
R1B0C0p1p2 /. {l ⊙ l - 2 l ⊙ q + q ⊙ q → qml2, -l ⊙ l + 2 l ⊙ q - q ⊙ q → -qml2}
```

Out[ ]=

$$\frac{\gamma\, q\odot q}{\mathrm{qml2}\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(-i\epsilon+l\odot p2)}+\frac{m1^2\,\gamma^2\, q\odot q}{2\,\mathrm{qml2}\; S\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(-i\epsilon+l\odot p2)}+$$
$$\frac{\gamma^3\, q\odot q}{2\,\mathrm{qml2}\; S\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(-i\epsilon+l\odot p2)}+\frac{\gamma\, q\odot q}{\mathrm{qml2}\; l\odot l\,(-i\epsilon+l\odot p1)\,(i\epsilon+l\odot p2)^2}-$$
$$\frac{\gamma\, q\odot q}{\mathrm{qml2}\; l\odot l\,(i\epsilon+l\odot p1)\,(i\epsilon+l\odot p2)^2}-\frac{\gamma\, q\odot q}{\mathrm{qml2}\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(i\epsilon+l\odot p2)}-$$
$$\frac{m1^2\,\gamma^2\, q\odot q}{2\,\mathrm{qml2}\; S\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(i\epsilon+l\odot p2)}-\frac{\gamma^3\, q\odot q}{2\,\mathrm{qml2}\; S\; l\odot l\,(-i\epsilon+l\odot p1)^2\,(i\epsilon+l\odot p2)}$$

In[ ]:= R2B0C0p1p2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$-\frac{m1^2\,\gamma^2\,q\odot q}{2\,qml2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{\gamma^3\,q\odot q}{qml2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{\gamma^3\,q\odot q}{2\,qml2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{\gamma^3\,q\odot q}{2\,qml2\,S\,l\odot l\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{m1^2\,\gamma^2\,q\odot q}{2\,qml2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}+\frac{\gamma^3\,q\odot q}{qml2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}$$

In[ ]:= R1B1C1p1p2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$-\frac{\gamma}{qml2\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}+\frac{\gamma}{qml2\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}-\frac{\gamma}{l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{\gamma}{qml2\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}-\frac{\gamma}{l\odot l\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{\gamma}{l\odot l\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}+\frac{\gamma}{l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}+\frac{\gamma}{qml2\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}$$

In[ ]:= R2B1C1p1p2 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$\frac{\gamma^3}{2\,qml2\,S\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}-\frac{\gamma^3}{2\,qml2\,S\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)^2}+\frac{\gamma^3}{2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+\frac{\gamma^3}{2\,qml2\,S\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)}+\frac{\gamma^3}{2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}-\frac{\gamma^3}{2\,S\,l\odot l\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)^2}-\frac{\gamma^3}{2\,S\,l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}-\frac{\gamma^3}{2\,qml2\,S\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)}$$

In[ ]:= R1B0C0p1q /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$\frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^3\,(-i\,\epsilon + l\odot p2)} - \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{\gamma^2\, q\odot q}{2\, qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^2\,(i\,\epsilon + l\odot p2)^2} - \frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^3\,(i\,\epsilon + l\odot p2)} + \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} + \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)}$$

In[ ]:= R2B0C0p1q /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$\frac{m2^2\,\gamma^2}{qml2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{\gamma^3}{qml2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{m2^2\,\gamma^2}{qml2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{\gamma^3}{qml2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{m2^2\,\gamma^2}{qml2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{\gamma^3}{qml2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} + \frac{m2^2\,\gamma^2}{qml2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} + \frac{\gamma^3}{qml2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^3\,(-i\,\epsilon + l\odot p2)} + \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} + \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(-i\,\epsilon + l\odot p2)} - \frac{\gamma^2\, q\odot q}{2\, qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^2\,(i\,\epsilon + l\odot p2)^2} + \frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon + l\odot p1)^3\,(i\,\epsilon + l\odot p2)} - \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)} - \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon + l\odot p1)\,(i\,\epsilon + l\odot p2)}$$

In[ ]:= R1B1C1p1q /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$-\frac{\gamma^2}{2\,\text{qml2}\,(-i\epsilon+l\odot p1)^2\,(-i\epsilon+l\odot p2)^2}-\frac{\gamma^2}{l\odot l\,(-i\epsilon+l\odot p1)^3\,(-i\epsilon+l\odot p2)}+\frac{3\gamma}{2\,\text{qml2}\,l\odot l\,(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\gamma}{2\,\text{qml2}\,l\odot l\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\gamma^2}{2\,l\odot l\,(-i\epsilon+l\odot p1)^2\,(i\epsilon+l\odot p2)^2}+\frac{\gamma^2}{l\odot l\,(-i\epsilon+l\odot p1)^3\,(i\epsilon+l\odot p2)}-\frac{\gamma}{2\,\text{qml2}\,l\odot l\,(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}+\frac{3\gamma}{2\,\text{qml2}\,l\odot l\,(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}$$

In[ ]:= R2B1C1p1q /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}

Out[ ]=

$$\frac{\gamma^2}{2\,\text{qml2}\,(-i\epsilon+l\odot p1)^2\,(-i\epsilon+l\odot p2)^2}+\frac{\gamma^2}{l\odot l\,(-i\epsilon+l\odot p1)^3\,(-i\epsilon+l\odot p2)}+\frac{\gamma^3}{\text{qml2}^2\,S\,(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{3\gamma}{2\,\text{qml2}\,l\odot l\,(-i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\text{m2}^2\,\gamma^2}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}-\frac{\gamma^3}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{\gamma}{2\,\text{qml2}\,l\odot l\,(i\epsilon+l\odot p1)(-i\epsilon+l\odot p2)}+\frac{\gamma^2}{2\,l\odot l\,(-i\epsilon+l\odot p1)^2\,(i\epsilon+l\odot p2)^2}-\frac{\gamma^2}{l\odot l\,(-i\epsilon+l\odot p1)^3\,(i\epsilon+l\odot p2)}+\frac{\gamma}{2\,\text{qml2}\,l\odot l\,(-i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}+\frac{\text{m2}^2\,\gamma^2}{\text{qml2}^2\,S\,(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}-\frac{3\gamma}{2\,\text{qml2}\,l\odot l\,(i\epsilon+l\odot p1)(i\epsilon+l\odot p2)}$$

In[ ]:= `R1B0C0p1l /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}`

Out[ ]=

$$\frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)} - \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)} - \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)} + \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)} + \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon+l\odot p1)\,(-i\,\epsilon+l\odot p2)} + \frac{\gamma^2\, q\odot q}{2\, qml2\; l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} - \frac{\gamma^2\, q\odot q}{2\, qml2\; l\odot l\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} - \frac{\gamma^2\, q\odot q}{qml2\; l\odot l\,(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)} + \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)} + \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(-i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)} - \frac{m2^2\,\gamma^2\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)} - \frac{\gamma^3\, q\odot q}{qml2^2\; S\; l\odot l\,(i\,\epsilon+l\odot p1)\,(i\,\epsilon+l\odot p2)}$$

In[ ]:= `R2B0C0p1l /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}`

Out[ ]=

0

In[ ]:= `R1B1C1p1l /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}`

Out[ ]=

$$-\frac{\gamma^2}{2\, qml2\,(-i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2} + \frac{\gamma^2}{2\, qml2\,(i\,\epsilon+l\odot p1)^2\,(-i\,\epsilon+l\odot p2)^2} - \frac{\gamma^2}{l\odot l\,(-i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)} - \frac{\gamma^2}{qml2\,(i\,\epsilon+l\odot p1)^3\,(-i\,\epsilon+l\odot p2)} - \frac{\gamma^2}{2\; l\odot l\,(-i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} + \frac{\gamma^2}{2\; l\odot l\,(i\,\epsilon+l\odot p1)^2\,(i\,\epsilon+l\odot p2)^2} + \frac{\gamma^2}{l\odot l\,(-i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)} + \frac{\gamma^2}{qml2\,(i\,\epsilon+l\odot p1)^3\,(i\,\epsilon+l\odot p2)}$$

In[ ]:= `R2B1C1p1l /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}`

Out[ ]=

0

In[ ]:= simplifiedForm[B0C0 /. {l⊙l - 2 l⊙q + q⊙q → qml2, -l⊙l + 2 l⊙q - q⊙q → -qml2}]

Out[ ]=

$$\frac{4\,(\mathrm{p1}\odot\mathrm{p2})^2}{\mathrm{qml2}\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p1})\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})}-\frac{4\,(\mathrm{p1}\odot\mathrm{p2})^2}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p2})\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1}-\mathrm{p1}\odot\mathrm{q})}-$$

$$\frac{4\,(\mathrm{p1}\odot\mathrm{p2})^2}{\mathrm{qml2}\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p1})\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2}-\mathrm{p2}\odot\mathrm{q})}+\frac{4\,(\mathrm{p1}\odot\mathrm{p2})^2}{\mathrm{qml2}\,(-i\,\epsilon+\mathrm{l}\odot\mathrm{p1}-\mathrm{p1}\odot\mathrm{q})\,(i\,\epsilon+\mathrm{l}\odot\mathrm{p2}-\mathrm{p2}\odot\mathrm{q})}$$