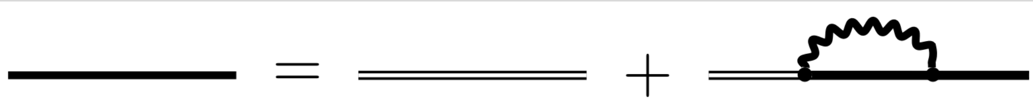
This is a part of SFQED-Loops script collection
developed for calculating loop processes in
Strong-Field Quantum Electrodynamics.
The scripts are available on https://github.com/ArsenyMironov/SFQED-Loops

If you use this script in your research, please, consider
citing our papers:
- A. A. Mironov, S. Meuren, and A. M. Fedotov, PRD 102, 053005 (2020),
  https://doi.org/10.1103/PhysRevD.102.053005
- A. A. Mironov, A. M. Fedotov, arXiv:2109.00634 (2021)

If you have any questions, please, don’t hesitate to contact:
mironov.hep@gmail.com



In[1]:=
```
NotebookEvaluate[NotebookOpen[NotebookDirectory[] <> "definitions.nb"]]
```

FeynCalc 9.3.1 (stable version). For help, use the documentation center, check out the wiki or visit the forum.

To save your and our time, please check our FAQ for answers to some common FeynCalc questions.

See also the supplied examples. If you use FeynCalc in your research, please cite

- V. Shtabovenko, R. Mertig and F. Orellana, Comput.Phys.Commun. 256 (2020) 107478, arXiv:2001.04407.
- V. Shtabovenko, R. Mertig and F. Orellana, Comput.Phys.Commun. 207 (2016) 432–444, arXiv:1601.01167.
- R. Mertig, M. Böhm, and A. Denner, Comput. Phys. Commun. 64 (1991) 345–359.

Electron propagator in E_p − representation satisfies the equation

$$S^c(p, q) = (2\pi)^4 \delta(p - q) S^c(p)$$

$$[\gamma p - m - M(p)] S^c(p) = i$$

Let

$$D(p) = \gamma p - m - M(p) = S + \gamma V + \sigma T + \gamma A \gamma^5$$

$$S = m\, s(p^2, \chi_p),$$

$$V^\mu = p^\mu v_1(p^2, \chi_p) + \frac{e^2 (F^2 p)^\mu}{m^4 \chi^2} v_2(p^2, \chi_p),$$

$$T_{\mu\nu} = \frac{e F_{\mu\nu}}{m \chi} t(p^2, \chi_p),$$

$$A^\mu = \frac{e (F^* p)^\mu}{m^2 \chi} a_s(p^2, \chi_p),$$ where s stands for 'scalar';

then

$$S^c(p) = i D^{-1}(p) =$$

$$\frac{i}{2}(S - \gamma V - \sigma T + \gamma A \gamma^5)\left[\frac{1}{D_+(p^2, \chi_p)}(1 + \gamma\epsilon^{(2)} \gamma^5) + \frac{1}{D_-(p^2, \chi_p)}(1 - \gamma\epsilon^{(2)} \gamma^5)\right] =$$

$$= \frac{i}{2}\left[m\, s(p^2, \chi_p) - (\gamma p) v_1(p^2, \chi_p) - \frac{e^2 (\gamma F^2 p)}{m^4} v_2(p^2, \chi_p) - \frac{e\,\sigma F}{m} t(p^2, \chi_p) + \frac{e (\gamma F^* p) \gamma^5}{m^2} a_s(p^2, \chi_p)\right] \times$$

$$\left[\frac{1}{D_+(p^2, \chi_p)}(1 + \gamma\epsilon^{(2)} \gamma^5) + \frac{1}{D_-(p^2, \chi_p)}(1 - \gamma\epsilon^{(2)} \gamma^5)\right],$$

$$\epsilon^{(2)}{}_{\mu} = \frac{e\,(F^{*}\,p)^{\mu}}{m^{3}\,\chi_{p}},$$

Electron propagator

$$S^{c}\,(x_2,\,x_1) = \Lambda^{4-D}\int\frac{d^{D}p}{(2\,\pi)^{D}}\,E_p\,(x_2)\,S^{c}\,(p)\,\overline{E_p}\,(x_1)$$

$$x = x_2 - x_1,$$

$$X = \frac{1}{2}\,(x_1 + x_2),$$

$$\xi^{2} = -\frac{e^{2}\,a^{2}}{m^{2}},$$

$[\Lambda] = m$ - mass scale,

$$E_p\,(x_2) = \left[1 - \frac{e\,(\gamma k)\,(\gamma a)}{2\,(kp)}\,(kx_2)\right]\mathrm{Exp}\left[-i\,(p\,x_2) + i\,\frac{e\,(a\,p)}{2\,(k\,p)}\,(k\,x_2)^{2} + i\,\frac{a^{2}\,e^{2}}{6\,(k\,p)}\,(k\,x_2)^{3}\right];$$

In[2]:=
```
NewMomentum["p"]
NewCoordinate["x1"]
NewCoordinate["x2"]
NewCoordinate["x"]
NewCoordinate["X"]
```

$$\left\{p^{\alpha},\ p^2,\ k\cdot p,\ \mathrm{Fp}^{\alpha},\ \mathrm{FFp}^{\alpha},\ \mathrm{FDp}^{\alpha},\ a\cdot p,\ 0,\ 0,\ 0,\ -a^2\,(k\cdot p),\ 0,\ 0,\ -\frac{m^6\,\chi\mathrm{p}^2}{e^2},\ -\frac{m^6\,\chi\mathrm{p}^2}{e^2},\ \frac{m^6\,\chi\mathrm{p}^2}{e^2},\ 0,\ 0,\ 0,\ 0,\ 0,\ 0\right\}$$

$$\left\{\mathrm{x1}^{\alpha},\ \mathrm{x1}^2,\ k\cdot\mathrm{x1},\ a\cdot\mathrm{x1},\ \mathrm{Fx1}^{\alpha},\ \mathrm{FFx1}^{\alpha},\ \mathrm{FDx1}^{\alpha},\ k\cdot\mathrm{x1},\ 0,\ 0,\ 0,\ -a^2\,(k\cdot\mathrm{x1}),\ 0,\ 0,\ -\frac{m^2\,\xi^2\,(k\cdot\mathrm{x1})^2}{e^2},\ -\frac{m^2\,\xi^2\,(k\cdot\mathrm{x1})^2}{e^2},\ \frac{m^2\,\xi^2\,(k\cdot\mathrm{x1})^2}{e^2},\ 0,\ 0,\ 0,\ 0,\ 0,\ 0\right\}$$

$$\left\{\mathrm{x2}^{\alpha},\ \mathrm{x2}^2,\ k\cdot\mathrm{x2},\ a\cdot\mathrm{x2},\ \mathrm{Fx2}^{\alpha},\ \mathrm{FFx2}^{\alpha},\ \mathrm{FDx2}^{\alpha},\ k\cdot\mathrm{x2},\ 0,\ 0,\ 0,\ -a^2\,(k\cdot\mathrm{x2}),\ 0,\ 0,\ -\frac{m^2\,\xi^2\,(k\cdot\mathrm{x2})^2}{e^2},\ -\frac{m^2\,\xi^2\,(k\cdot\mathrm{x2})^2}{e^2},\ \frac{m^2\,\xi^2\,(k\cdot\mathrm{x2})^2}{e^2},\ 0,\ 0,\ 0,\ 0,\ 0,\ 0\right\}$$

$$\left\{x^{\alpha},\ x^2,\ k\cdot x,\ a\cdot x,\ \mathrm{Fx}^{\alpha},\ \mathrm{FFx}^{\alpha},\ \mathrm{FDx}^{\alpha},\ k\cdot x,\ 0,\ 0,\ 0,\ -a^2\,(k\cdot x),\ 0,\ 0,\ -\frac{m^2\,\xi^2\,(k\cdot x)^2}{e^2},\ -\frac{m^2\,\xi^2\,(k\cdot x)^2}{e^2},\ \frac{m^2\,\xi^2\,(k\cdot x)^2}{e^2},\ 0,\ 0,\ 0,\ 0,\ 0,\ 0\right\}$$

$$\left\{X^{\alpha},\ X^2,\ k\cdot X,\ a\cdot X,\ \mathrm{FX}^{\alpha},\ \mathrm{FFX}^{\alpha},\ \mathrm{FDX}^{\alpha},\ k\cdot X,\ 0,\ 0,\ 0,\ -a^2\,(k\cdot X),\ 0,\ 0,\ -\frac{m^2\,\xi^2\,(k\cdot X)^2}{e^2},\ -\frac{m^2\,\xi^2\,(k\cdot X)^2}{e^2},\ \frac{m^2\,\xi^2\,(k\cdot X)^2}{e^2},\ 0,\ 0,\ 0,\ 0,\ 0,\ 0\right\}$$

DdInv[sgn] == $D_{\mathrm{sgn}}\left(\mathrm{p}^2,\ \chi_{\mathrm{p}}\right)$

$\epsilon == \epsilon^{(2)}$

```
In[7]:= FToak = {Ft[α_, β_] → kv[α] × av[β] - av[α] × kv[β], DiracGamma[Momentum[Fp, D], D] →
      DiracGamma[Momentum[k, D], D] × Pair[Momentum[a, D], Momentum[p, D]] -
        DiracGamma[Momentum[a, D], D] × Pair[Momentum[k, D], Momentum[p, D]],
     DiracGamma[Momentum[FFp, D], D] → -av2 DiracGamma[Momentum[k, D], D] ×
        Pair[Momentum[k, D], Momentum[p, D]],
     FFpv[μ_] → -av2 kp kv[μ]}
   FToEps =
    {FDpv[μ_] → Contract[1 / 2 Eps[LorentzIndex[μ, D], LorentzIndex[ν, D], LorentzIndex[α2, D],
          LorentzIndex[α3, D]] (kv[α2] × av[α3] - av[α2] × kv[α3]) pv[ν]]}
   Gamma5toTrippleGamma = {GAD[μ_].GA[5] × Eps[LorentzIndex[μ_, D],
        Momentum[a_, D], Momentum[b_, D], Momentum[c_, D]] →
      Contract[I Pair[LorentzIndex[α1, D], Momentum[a, D]] ×
        Pair[LorentzIndex[α2, D], Momentum[b, D]] × Pair[LorentzIndex[α3, D], Momentum[c, D]]
        (GAD[α1, α2, α3] - (MTD[α1, α2] × GAD[α3] + MTD[α2, α3] × GAD[α1] - MTD[α1, α3] × GAD[α2]))]}
```

Out[7]= $\left\{F(\alpha\_,\ \beta\_)\to a^{\beta}\,k^{\alpha}-a^{\alpha}\,k^{\beta},\ \gamma\cdot\mathrm{Fp}\to(a\cdot p)\,\gamma\cdot k-\gamma\cdot a\,(k\cdot p),\ \gamma\cdot\mathrm{FFp}\to a^2\,(-(\gamma\cdot k))\,(k\cdot p),\ \mathrm{FFp}^{\mu\_}\to a^2\left(-k^{\mu}\right)(k\cdot p)\right\}$

Out[8]= $\left\{\mathrm{FDp}^{\mu\_}\to-\epsilon^{\mu\,a\,k\,p}\right\}$

Out[9]= $\left\{\gamma^{\mu\_}.\bar{\gamma}^{5}\,\epsilon^{\mu\_\,\mathrm{a}\_\,\mathrm{b}\_\,\mathrm{c}\_}\to i\,(-(a\cdot b)\,\gamma\cdot c+(a\cdot c)\,\gamma\cdot b-\gamma\cdot a\,(b\cdot c)+(\gamma\cdot a).(\gamma\cdot b).(\gamma\cdot c))\right\}$

In[10]:=
```
FxToak = {Ft[α_, β_] → kv[α] × av[β] - av[α] × kv[β], DiracGamma[Momentum[Fx, D], D] →
    DiracGamma[Momentum[k, D], D] × Pair[Momentum[a, D], Momentum[x, D]] -
     DiracGamma[Momentum[a, D], D] × Pair[Momentum[k, D], Momentum[x, D]],
   DiracGamma[Momentum[FFx, D], D] → -av2 DiracGamma[Momentum[k, D], D] ×
     Pair[Momentum[k, D], Momentum[x, D]],
   FFxv[μ_] → -av2 kx kv[μ], σF → -2 I DiracGamma[Momentum[a, D], D].
      DiracGamma[Momentum[k, D], D]}
FxToEps = {FDx[μ_] → Contract[1 / 2 Eps[LorentzIndex[μ, D], LorentzIndex[ν, D],
       LorentzIndex[α2, D], LorentzIndex[α3, D]] (kv[α2] × av[α3] - av[α2] × kv[α3]) xv[ν]],
   DiracGamma[Momentum[FDx, D], D].DiracGamma[5] → Contract[1 / 2
      Eps[LorentzIndex[μ, D], LorentzIndex[ν, D], LorentzIndex[α2, D], LorentzIndex[α3, D]]
      (kv[α2] × av[α3] - av[α2] × kv[α3]) xv[ν] × GAD[μ].DiracGamma[5]]}
Gamma5toTrippleGammax = {DiracGamma[LorentzIndex[μ_, D], D].DiracGamma[5]
     Eps[LorentzIndex[μ_, D], Momentum[a_, D], Momentum[b_, D], Momentum[c_, D]] →
    Contract[I Pair[LorentzIndex[α1, D], Momentum[a, D]] ×
      Pair[LorentzIndex[α2, D], Momentum[b, D]] × Pair[LorentzIndex[α3, D], Momentum[c, D]]
      (GAD[α1, α2, α3] - (MTD[α1, α2] × GAD[α3] + MTD[α2, α3] × GAD[α1] - MTD[α1, α3] × GAD[α2]))]}
```

Out[10]= $\{F(\alpha\_, \beta\_) \to a^{\beta}\, k^{\alpha} - a^{\alpha}\, k^{\beta},\ \gamma\cdot \mathrm{Fx} \to (a\cdot x)\, \gamma\cdot k - \gamma\cdot a\, (k\cdot x),$
$\gamma\cdot \mathrm{FFx} \to a^2\, (-(\gamma\cdot k))\, (k\cdot x),\ \mathrm{FFx}^{\mu\_} \to a^2\, \left(-k^{\mu}\right) (k\cdot x),\ \sigma\, \mathrm{F} \to -2\, i\, (\gamma\cdot a).(\gamma\cdot k)\}$

Out[11]= $\{\mathrm{FDx}(\mu\_) \to -\epsilon^{\mu\, a\, k\, x},\ (\gamma\cdot \mathrm{FDx}).\bar{\gamma}^{5} \to -\gamma^{\mu}.\bar{\gamma}^{5}\, \epsilon^{\mu\, a\, k\, x}\}$

Out[12]= $\{\gamma^{\mu\_}.\bar{\gamma}^{5}\, \epsilon^{\mu\_\, a\_\, b\_\, c\_} \to i\, (-(a\cdot b)\, \gamma\cdot c + (a\cdot c)\, \gamma\cdot b - \gamma\cdot a\, (b\cdot c) + (\gamma\cdot a).(\gamma\cdot b).(\gamma\cdot c))\}$

In[13]:=
```
S = m sf
V[μ_] = pv[μ] v1 + e ^ 2 FFpv[μ] / m ^ 4 / χp ^ 2 v2
T[μ_, ν_] = e Ft[μ, ν] / m / χp tf
A[μ_] = e FDpv[μ] / m ^ 2 / χp af
ϵ[μ_] = e FDpv[μ] / m ^ 3 / χp
```

Out[13]= $m\, \mathrm{sf}$

Out[14]= $\dfrac{e^2\, \mathrm{v2}\, \mathrm{FFp}^{\mu}}{m^4\, \chi\mathrm{p}^2} + \mathrm{v1}\, p^{\mu}$

Out[15]= $\dfrac{e\, \mathrm{tf}\, F(\mu, \nu)}{m\, \chi\mathrm{p}}$

Out[16]= $\dfrac{\mathrm{af}\, e\, \mathrm{FDp}^{\mu}}{m^2\, \chi\mathrm{p}}$

Out[17]= $\dfrac{e\, \mathrm{FDp}^{\mu}}{m^3\, \chi\mathrm{p}}$

In[18]:=
```
Scp[sgn_] = (S - GAD[α] × V[α] - I / 2 (GAD[α, β] - GAD[β, α]) T[α, β] + A[α] × GAD[α].GA[5]).
    (1 + sgn ϵ[μ] × GAD[μ].GA[5]) /. FToEps /. FToak /. Gamma5toTrippleGamma
```

Out[18]=
$$\left(-\frac{i\,\text{af}\,e\,((a\cdot p)\,\gamma\cdot k-\gamma\cdot a\,(k\cdot p)+(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p))}{m^2\,\chi\text{p}}-\gamma^{\alpha}\left(\text{v1}\,p^{\alpha}-\frac{a^2\,e^2\,\text{v2}\,k^{\alpha}\,(k\cdot p)}{m^4\,\chi\text{p}^2}\right)-\frac{i\,e\,\text{tf}\,(\gamma^{\alpha}.\gamma^{\beta}-\gamma^{\beta}.\gamma^{\alpha})\,(a^{\beta}\,k^{\alpha}-a^{\alpha}\,k^{\beta})}{2\,m\,\chi\text{p}}+m\,\text{sf}\right)\left(1-\frac{i\,e\,\text{sgn}\,((a\cdot p)\,\gamma\cdot k-\gamma\cdot a\,(k\cdot p)+(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p))}{m^3\,\chi\text{p}}\right)$$

In[19]:=
```
Epx2 = Ep[x2, p]
EpBarx1 = EpC[x1, p]
```

Out[19]=
$$\left\{1-\frac{e\,(k\cdot \text{x2})\,(\gamma\cdot k).(\gamma\cdot a)}{2\,(k\cdot p)},\ \frac{a^2\,e^2\,(\,k\cdot\text{x2}\,)^3}{6\,(k\cdot p)}+\frac{e\,(a\cdot p)\,(\,k\cdot \text{x2}\,)^2}{2\,(k\cdot p)}-p\cdot\text{x2}\right\}$$

Out[20]=
$$\left\{1-\frac{e\,(k\cdot \text{x1})\,(\gamma\cdot a).(\gamma\cdot k)}{2\,(k\cdot p)},\ -\frac{a^2\,e^2\,(\,k\cdot\text{x1}\,)^3}{6\,(k\cdot p)}-\frac{e\,(a\cdot p)\,(\,k\cdot \text{x1}\,)^2}{2\,(k\cdot p)}+p\cdot\text{x1}\right\}$$

In[21]:=
```
Matrix = Epx2[[1]].Scp[ζ].EpBarx1[[1]]
Coeff = ⅈ / 2 Λ^(4 - D) / (2 π)^D / DdInv[ζ]
Phase = Epx2[[2]] + EpBarx1[[2]]
```

Out[21]=
$$\left(1-\frac{e\,(k\cdot \text{x2})\,(\gamma\cdot k).(\gamma\cdot a)}{2\,(k\cdot p)}\right)\left(-\frac{i\,\text{af}\,e\,((a\cdot p)\,\gamma\cdot k-\gamma\cdot a\,(k\cdot p)+(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p))}{m^2\,\chi\text{p}}-\gamma^{\alpha}\left(\text{v1}\,p^{\alpha}-\frac{a^2\,e^2\,\text{v2}\,k^{\alpha}\,(k\cdot p)}{m^4\,\chi\text{p}^2}\right)-\frac{i\,e\,\text{tf}\,(\gamma^{\alpha}.\gamma^{\beta}-\gamma^{\beta}.\gamma^{\alpha})\,(a^{\beta}\,k^{\alpha}-a^{\alpha}\,k^{\beta})}{2\,m\,\chi\text{p}}+m\,\text{sf}\right)\left(1-\frac{i\,e\,\zeta\,((a\cdot p)\,\gamma\cdot k-\gamma\cdot a\,(k\cdot p)+(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p))}{m^3\,\chi\text{p}}\right)\left(1-\frac{e\,(k\cdot \text{x1})\,(\gamma\cdot a).(\gamma\cdot k)}{2\,(k\cdot p)}\right)$$

Out[22]=
$$\frac{i\,2^{-D-1}\,\pi^{-D}\,\Lambda^{4-D}}{\text{DdInv}(\zeta)}$$

Out[23]=
$$-\frac{a^2\,e^2\,(\,k\cdot\text{x1}\,)^3}{6\,(k\cdot p)}+\frac{a^2\,e^2\,(\,k\cdot\text{x2}\,)^3}{6\,(k\cdot p)}-\frac{e\,(a\cdot p)\,(\,k\cdot \text{x1}\,)^2}{2\,(k\cdot p)}+\frac{e\,(a\cdot p)\,(\,k\cdot \text{x2}\,)^2}{2\,(k\cdot p)}+p\cdot\text{x1}-p\cdot\text{x2}$$

In[24]:=
```
Matrix1 = Contract[DiracSimplify[Matrix]]
Coeff1 = Coeff;
Phase1 = Phase;
```

Out[24]=

$$\frac{i\,\mathrm{v2}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,a^2\,(k\cdot p)^2\,e^3}{m^7\,\chi\mathrm{p}^3}+\frac{\mathrm{af}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot p)\,(k\cdot \mathrm{x1})\,e^3}{2\,m^5\,\chi\mathrm{p}^2}+\frac{\mathrm{af}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,a^2\,(k\cdot p)\,(k\cdot \mathrm{x2})\,e^3}{2\,m^5\,\chi\mathrm{p}^2}-$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot \mathrm{x1})\,(k\cdot \mathrm{x2})\,e^3}{2\,m^3\,\chi\mathrm{p}}-\frac{\mathrm{af}\,\zeta\,a^2\,(k\cdot p)^2\,e^2}{m^5\,\chi\mathrm{p}^2}+\frac{\mathrm{v2}\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2}+\frac{2\,\mathrm{tf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2}-$$
$$\frac{\mathrm{af}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot p)\,(k\cdot p)\,e^2}{m^5\,\chi\mathrm{p}^2}-\frac{\mathrm{af}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,(a\cdot p)\,(k\cdot p)\,e^2}{m^5\,\chi\mathrm{p}^2}+\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot \mathrm{x1})\,e^2}{2\,m^2\,\chi\mathrm{p}}+$$
$$\frac{i\,\mathrm{af}\,\gamma\cdot k\,a^2\,(k\cdot \mathrm{x1})\,e^2}{2\,m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,a^2\,(k\cdot \mathrm{x1})\,e^2}{2\,m^3\,\chi\mathrm{p}}-\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot \mathrm{x2})\,e^2}{2\,m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{af}\,\gamma\cdot k\,a^2\,(k\cdot \mathrm{x2})\,e^2}{2\,m^2\,\chi\mathrm{p}}+$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,a^2\,(k\cdot \mathrm{x2})\,e^2}{2\,m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot p)\,(k\cdot \mathrm{x2})\,e^2}{m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,(a\cdot p)\,(k\cdot \mathrm{x2})\,e^2}{m^3\,\chi\mathrm{p}}+$$
$$\frac{\mathrm{v1}\,\gamma\cdot k\,a^2\,(k\cdot \mathrm{x1})\,(k\cdot \mathrm{x2})\,e^2}{2\,(k\cdot p)}+\frac{i\,\mathrm{tf}\,(\gamma\cdot a).(\gamma\cdot k)\,e}{m\,\chi\mathrm{p}}-\frac{i\,\mathrm{tf}\,(\gamma\cdot k).(\gamma\cdot a)\,e}{m\,\chi\mathrm{p}}-\frac{i\,\mathrm{sf}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p)\,e}{m^2\,\chi\mathrm{p}}-$$
$$\frac{i\,\mathrm{af}\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p)\,e}{m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,(a\cdot p)\,e}{m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{af}\,\gamma\cdot k\,(a\cdot p)\,e}{m^2\,\chi\mathrm{p}}+\frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}}+$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot a\,(k\cdot p)\,e}{m^2\,\chi\mathrm{p}}+\frac{i\,\mathrm{af}\,\gamma\cdot a\,(k\cdot p)\,e}{m^2\,\chi\mathrm{p}}-\frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}}-$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot a)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}}-\frac{m\,\mathrm{sf}\,(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot \mathrm{x1})\,e}{2\,(k\cdot p)}+\frac{\mathrm{v1}\,(\gamma\cdot p).(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot \mathrm{x1})\,e}{2\,(k\cdot p)}-$$
$$\frac{m\,\mathrm{sf}\,(\gamma\cdot k).(\gamma\cdot a)\,(k\cdot \mathrm{x2})\,e}{2\,(k\cdot p)}+\frac{\mathrm{v1}\,(\gamma\cdot k).(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot \mathrm{x2})\,e}{2\,(k\cdot p)}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,p^2\,e}{m^3\,\chi\mathrm{p}}+m\,\mathrm{sf}-\mathrm{v1}\,\gamma\cdot p$$

In[27]:=
```
(*a small test*)
((Matrix1 /. {sf → 1, v1 → -1, v2 → 0, t → 0, af → 0, ζ → 1}) +
   (Matrix1 /. {sf → 1, v1 → -1, v2 → 0, t → 0, af → 0, ζ → -1})) / 2
```

Out[27]=

$$\frac{1}{2}\left(-\frac{a^2\,e^2\,\gamma\cdot k\,(k\cdot \mathrm{x1})\,(k\cdot \mathrm{x2})}{k\cdot p}-\frac{e\,m\,(k\cdot \mathrm{x1})\,(\gamma\cdot a).(\gamma\cdot k)}{k\cdot p}-\frac{e\,m\,(k\cdot \mathrm{x2})\,(\gamma\cdot k).(\gamma\cdot a)}{k\cdot p}+\frac{2\,i\,e\,\mathrm{tf}\,(\gamma\cdot a).(\gamma\cdot k)}{m\,\chi\mathrm{p}}-\right.$$
$$\left.\frac{2\,i\,e\,\mathrm{tf}\,(\gamma\cdot k).(\gamma\cdot a)}{m\,\chi\mathrm{p}}-\frac{e\,(k\cdot \mathrm{x1})\,(\gamma\cdot p).(\gamma\cdot a).(\gamma\cdot k)}{k\cdot p}-\frac{e\,(k\cdot \mathrm{x2})\,(\gamma\cdot k).(\gamma\cdot a).(\gamma\cdot p)}{k\cdot p}+2\,m+2\,\gamma\cdot p\right)$$

In[28]:=
```
Matrix2 =
 Expand[ExpandScalarProduct[Matrix1 /. {Momentum[x1, D] → Momentum[X, D] - Momentum[x, D] / 2,
     Momentum[x2, D] → Momentum[X, D] + Momentum[x, D] / 2}]]
Coeff2 = Coeff1;
Phase2 =
 Expand[ExpandScalarProduct[Phase1 /. {Momentum[x1, D] → Momentum[X, D] - Momentum[x, D] / 2,
     Momentum[x2, D] → Momentum[X, D] + Momentum[x, D] / 2}]]
```

Out[28]=

$$\frac{i\,\mathrm{v2}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,a^2\,(k\cdot p)^2\,e^3}{m^7\,\chi\mathrm{p}^3}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot x)^2\,e^3}{8\,m^3\,\chi\mathrm{p}}-\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot X)^2\,e^3}{2\,m^3\,\chi\mathrm{p}}-$$
$$\frac{\mathrm{af}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot p)\,(k\cdot x)\,e^3}{4\,m^5\,\chi\mathrm{p}^2}+\frac{\mathrm{af}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,a^2\,(k\cdot p)\,(k\cdot x)\,e^3}{4\,m^5\,\chi\mathrm{p}^2}+\frac{\mathrm{af}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot p)\,(k\cdot X)\,e^3}{2\,m^5\,\chi\mathrm{p}^2}+$$
$$\frac{\mathrm{af}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,a^2\,(k\cdot p)\,(k\cdot X)\,e^3}{2\,m^5\,\chi\mathrm{p}^2}-\frac{\mathrm{af}\,\zeta\,a^2\,(k\cdot p)^2\,e^2}{m^5\,\chi\mathrm{p}^2}-\frac{\mathrm{v1}\,\gamma\cdot k\,a^2\,(k\cdot x)^2\,e^2}{8\,(k\cdot p)}+\frac{\mathrm{v1}\,\gamma\cdot k\,a^2\,(k\cdot X)^2\,e^2}{2\,(k\cdot p)}+$$
$$\frac{\mathrm{v2}\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2}+\frac{2\,\mathrm{tf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2}-\frac{\mathrm{af}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot p)\,(k\cdot p)\,e^2}{m^5\,\chi\mathrm{p}^2}-\frac{\mathrm{af}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,(a\cdot p)\,(k\cdot p)\,e^2}{m^5\,\chi\mathrm{p}^2}-$$
$$\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot x)\,e^2}{2\,m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{af}\,\gamma\cdot k\,a^2\,(k\cdot x)\,e^2}{2\,m^2\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,a^2\,(k\cdot x)\,e^2}{4\,m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,a^2\,(k\cdot x)\,e^2}{4\,m^3\,\chi\mathrm{p}}+$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot p)\,(k\cdot x)\,e^2}{2\,m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,(a\cdot p)\,(k\cdot x)\,e^2}{2\,m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,a^2\,(k\cdot X)\,e^2}{2\,m^3\,\chi\mathrm{p}}-$$
$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,a^2\,(k\cdot X)\,e^2}{2\,m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot p)\,(k\cdot X)\,e^2}{m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot a)\,(a\cdot p)\,(k\cdot X)\,e^2}{m^3\,\chi\mathrm{p}}+$$
$$\frac{i\,\mathrm{tf}\,(\gamma\cdot a).(\gamma\cdot k)\,e}{m\,\chi\mathrm{p}}-\frac{i\,\mathrm{tf}\,(\gamma\cdot k).(\gamma\cdot a)\,e}{m\,\chi\mathrm{p}}-\frac{i\,\mathrm{sf}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p)\,e}{m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{af}\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot p)\,e}{m^2\,\chi\mathrm{p}}-\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,(a\cdot p)\,e}{m^2\,\chi\mathrm{p}}-$$
$$\frac{i\,\mathrm{af}\,\gamma\cdot k\,(a\cdot p)\,e}{m^2\,\chi\mathrm{p}}+\frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}}+\frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot a\,(k\cdot p)\,e}{m^2\,\chi\mathrm{p}}+\frac{i\,\mathrm{af}\,\gamma\cdot a\,(k\cdot p)\,e}{m^2\,\chi\mathrm{p}}-$$
$$\frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}}-\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot a)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}}+\frac{m\,\mathrm{sf}\,(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot x)\,e}{4\,(k\cdot p)}-\frac{m\,\mathrm{sf}\,(\gamma\cdot k).(\gamma\cdot a)\,(k\cdot x)\,e}{4\,(k\cdot p)}+$$
$$\frac{\mathrm{v1}\,(\gamma\cdot k).(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot x)\,e}{4\,(k\cdot p)}-\frac{\mathrm{v1}\,(\gamma\cdot p).(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot x)\,e}{4\,(k\cdot p)}-\frac{m\,\mathrm{sf}\,(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot X)\,e}{2\,(k\cdot p)}-\frac{m\,\mathrm{sf}\,(\gamma\cdot k).(\gamma\cdot a)\,(k\cdot X)\,e}{2\,(k\cdot p)}+$$
$$\frac{\mathrm{v1}\,(\gamma\cdot k).(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot X)\,e}{2\,(k\cdot p)}+\frac{\mathrm{v1}\,(\gamma\cdot p).(\gamma\cdot a).(\gamma\cdot k)\,(k\cdot X)\,e}{2\,(k\cdot p)}+\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,p^2\,e}{m^3\,\chi\mathrm{p}}+m\,\mathrm{sf}-\mathrm{v1}\,\gamma\cdot p$$

Out[30]=

$$\frac{a^2\,e^2\,(k\cdot x)\,(k\cdot X)^2}{2\,(k\cdot p)}+\frac{a^2\,e^2\,(k\cdot x)^3}{24\,(k\cdot p)}+\frac{e\,(a\cdot p)\,(k\cdot x)\,(k\cdot X)}{k\cdot p}-p\cdot x$$

In[31]:=
```
Matrix3 =
  (((Expand[Matrix2 /. TripleGamma]) /. EpsToF) /. FieldSubstitutions) /. akToF
Coeff3 = Coeff2;
Phase3 = Phase2;
```

Out[31]=

$$\frac{\mathrm{v2}\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot p)^2\,e^3}{2\,m^7\,\chi\mathrm{p}^3} - \frac{\mathrm{v1}\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot x)^2\,e^3}{16\,m^3\,\chi\mathrm{p}} + \frac{\mathrm{v1}\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot X)^2\,e^3}{4\,m^3\,\chi\mathrm{p}} - \frac{i\,\mathrm{af}\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot p)\,(k\cdot x)\,e^3}{4\,m^5\,\chi\mathrm{p}^2} -$$

$$\frac{\mathrm{af}\,\zeta\,a^2\,(k\cdot p)^2\,e^2}{m^5\,\chi\mathrm{p}^2} - \frac{\mathrm{v1}\,\gamma\cdot k\,a^2\,(k\cdot x)^2\,e^2}{8\,(k\cdot p)} + \frac{\mathrm{v1}\,\gamma\cdot k\,a^2\,(k\cdot X)^2\,e^2}{2\,(k\cdot p)} + \frac{\mathrm{v2}\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2} +$$

$$\frac{2\,\mathrm{tf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot p)\,e^2}{m^4\,\chi\mathrm{p}^2} - \frac{i\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,a^2\,(k\cdot x)\,e^2}{2\,m^2\,\chi\mathrm{p}} - \frac{i\,\mathrm{af}\,\gamma\cdot k\,a^2\,(k\cdot x)\,e^2}{2\,m^2\,\chi\mathrm{p}} + \frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,a^2\,(k\cdot x)\,e^2}{4\,m^3\,\chi\mathrm{p}} +$$

$$\frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,a^2\,(k\cdot x)\,e^2}{4\,m^3\,\chi\mathrm{p}} + \frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,a^2\,(k\cdot X)\,e^2}{2\,m^3\,\chi\mathrm{p}} - \frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,a^2\,(k\cdot X)\,e^2}{2\,m^3\,\chi\mathrm{p}} +$$

$$\frac{\mathrm{sf}\,\zeta\,\gamma^{\beta}.\overline{\gamma}^{5}\,\mathrm{FDp}^{\beta}\,e}{m^2\,\chi\mathrm{p}} + \frac{\mathrm{af}\,\gamma^{\beta}.\overline{\gamma}^{5}\,\mathrm{FDp}^{\beta}\,e}{m^2\,\chi\mathrm{p}} + \frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot k).(\gamma\cdot p)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}} + \frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot k)\,(a\cdot p)\,e}{m^3\,\chi\mathrm{p}} -$$

$$\frac{2\,i\,\mathrm{v1}\,\zeta\,(\gamma\cdot a).(\gamma\cdot p)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}} - \frac{i\,\mathrm{v1}\,\zeta\,(\gamma\cdot p).(\gamma\cdot a)\,(k\cdot p)\,e}{m^3\,\chi\mathrm{p}} + \frac{i\,m\,\mathrm{sf}\,\sigma\mathrm{F}(k\cdot x)\,e}{4\,(k\cdot p)} - \frac{i\,\mathrm{v1}\,\gamma^{\beta}.\overline{\gamma}^{5}\,\mathrm{FDp}^{\beta}\,(k\cdot x)\,e}{2\,(k\cdot p)} -$$

$$\mathrm{v1}\,\gamma\cdot a\,(k\cdot X)\,e + \frac{\mathrm{v1}\,\gamma\cdot k\,(a\cdot p)\,(k\cdot X)\,e}{k\cdot p} - \frac{\mathrm{v1}\,\zeta\,\sigma\mathrm{F}\,p^2\,e}{2\,m^3\,\chi\mathrm{p}} - \frac{\mathrm{tf}\,\sigma\mathrm{F}\,e}{m\,\chi\mathrm{p}} + m\,\mathrm{sf} - \mathrm{v1}\,\gamma\cdot p$$

In[34]:=
```
Matrix4 = Contract[
  DiracOrder[
    Matrix3 /. {DiracGamma[LorentzIndex[β, D], D].DiracGamma[5] ×
        Pair[LorentzIndex[β, D], Momentum[FDp, D]] → FVD[γγ5FD, α] × pv[α]}
   ] /. {
    DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[p, D], D] → FVD[γaγ, α] × pv[α],
    DiracGamma[Momentum[k, D], D].DiracGamma[Momentum[p, D], D] → FVD[γkγ, α] × pv[α]}
 ]
Coeff4 = Coeff3;
Phase4 = Phase3;
```

Out[34]=

$$-\frac{1}{16\, m^7\, \chi\text{p}^3\,(k\cdot p)}\Big(4\, i\, a^2\, \text{af}\, e^3\, \zeta\, m^2\, \sigma\text{F}\, \chi\text{p}\,(k\cdot x)\,(k\cdot p)^2 + 16\, a^2\, \text{af}\, e^2\, \zeta\, m^2\, \chi\text{p}\,(k\cdot p)^3 + a^2\, e^3\, \zeta\, m^4\, \sigma\text{Fv1}\, \chi\text{p}^2\,(k\cdot p)\,(k\cdot x)^2 - 4\, a^2\, e^3\, \zeta\, m^4\, \sigma\text{Fv1}\, \chi\text{p}^2\,(k\cdot p)\,(k\cdot X)^2 - 8\, a^2\, e^3\, \zeta\, \sigma\text{Fv2}\,(k\cdot p)^3 - 4\, i\, e\, m^8\, \text{sf}\, \sigma\text{F}\, \chi\text{p}^3\,(k\cdot x) + 16\, e\, m^6\, \sigma\text{Ftf}\, \chi\text{p}^2\,(k\cdot p) + 8\, e\, \zeta\, m^4\, p^2\, \sigma\text{Fv1}\, \chi\text{p}^2\,(k\cdot p) - 16\, m^8\, \text{sf}\, \chi\text{p}^3\,(k\cdot p)\Big) + \frac{1}{8\, m^4\, \chi\text{p}^2\,(k\cdot p)} e\gamma\cdot k\Big(a^2\,(-e)\, m^4\, \text{v1}\, \chi\text{p}^2\,(k\cdot x)^2 + 4\, a^2\, e\, m^4\, \text{v1}\, \chi\text{p}^2\,(k\cdot X)^2 + 16\, a^2\, e\, \zeta\, \text{tf}\,(k\cdot p)^2 + 8\, a^2\, e\text{v2}\,(k\cdot p)^2 - 4\, i\, a^2\, \text{af}\, e\, m^2\, \chi\text{p}\,(k\cdot p)\,(k\cdot x) - 4\, i\, a^2\, e\, \zeta\, m^2\, \text{sf}\, \chi\text{p}\,(k\cdot p)\,(k\cdot x) + 8\, m^4\, \text{v1}\, \chi\text{p}^2\,(a\cdot p)\,(k\cdot X)\Big) - \frac{i\, e\, \zeta\, \text{v1}\,(k\cdot p)\,(2\,(a\cdot p) - p\cdot\gamma\text{a}\gamma)}{m^3\, \chi\text{p}} + \frac{i\, e\, \zeta\, \text{v1}\,(2\,(k\cdot p) - p\cdot\gamma\text{k}\gamma)\,\big(a^2\, e\,(k\cdot x) - 2\, a^2\, e\,(k\cdot X) + 4\,(a\cdot p)\big)}{4\, m^3\, \chi\text{p}} + \frac{i\, e\, \zeta\, \text{v1}\,(p\cdot\gamma\text{k}\gamma)\,\big(a^2\, e\,(k\cdot x) + 2\, a^2\, e\,(k\cdot X) + 8\,(a\cdot p)\big)}{4\, m^3\, \chi\text{p}} - e\text{v1}\,\gamma\cdot a\,(k\cdot X) + \frac{e\,(p\cdot\gamma\gamma\text{5FD})\,\big(2\, \text{af}\,(k\cdot p) - i\, m^2\, \text{v1}\, \chi\text{p}\,(k\cdot x) + 2\, \zeta\, \text{sf}\,(k\cdot p)\big)}{2\, m^2\, \chi\text{p}\,(k\cdot p)} - \frac{2\, i\, e\, \zeta\, \text{v1}\,(k\cdot p)\,(p\cdot\gamma\text{a}\gamma)}{m^3\, \chi\text{p}} - \text{v1}\,\gamma\cdot p$$

Expanding scalar products into components and changing variables

$p \to \{p_- = 1/2\,(p^0 - p^3),\ p_+ = p^0 + p^3,\ p_\perp\}$

$p_- = x_- / 2\,s$

$p_+ = (p^2 + p_\perp{}^2) \big/ 2\,p_- = s\,(p^2 + p_\perp{}^2) \big/ x_-$

Integration measure

$\int đ^D \mathbf{p}\ \ldots = \int \frac{đ s}{2\,s}\, đ\, p^2\, đ^{D-2}\, p_\perp$

$x_- = kx / m$

$p_- = kx / 2\,m\,s$

$kp\ =\ m\,p_- = m\,xm / 2\,s = kx / 2\,s$

$ap = -at\,pt$

$\gamma p = \gamma_-\,p_+ + \gamma_+\,p_- - \gamma_\perp\,p_\perp = Gm\,\frac{s}{x_-}\,(p^2 + p_\perp{}^2) + Gp\,\frac{x_-}{2\,s} - Gt\,pt$

$\gamma k = \gamma_-\,k_+ = m\,Gm$

$kx = k_+\,x_- = m\,xm$

$(\gamma F^*)^\mu . \gamma^5 \to \{(\gamma F^*)_- . \gamma^5 = 0,\ (\gamma F^*)_+ . \gamma^5,\ (\gamma F^*)_\perp . \gamma^5\} = \{0,\ \gamma\gamma 5FDp,\ \gamma\gamma 5FDt\}$

$(\gamma F^*)_\mu\,k^\mu = 0\ \to\ (\gamma F^*)_- = 0$

$(\gamma F^*)_\mu\,a^\mu = 0 \to\ \gamma\gamma 5FDt\,at = 0$

$(\gamma F^*)^\mu . \gamma^5\,p_\mu = \gamma\gamma 5FDm * pp$

$\gamma k \gamma_- = (\gamma k)^2 \big/ m = 0$

In[37]:=
```
D[{xm / 2 / s, s (p2 + pt2) / xm}, {{s, p2}}]
Abs[Det[%]]
```

Out[37]=
$$\begin{pmatrix} -\frac{xm}{2\,s^2} & 0 \\ \frac{p2+pt2}{xm} & \frac{s}{xm} \end{pmatrix}$$

Out[38]=
$$\frac{1}{2\,|s|}$$

In[39]:=
```
Matrix5 =
 Collect[Expand[Matrix4 /. {DiracGamma[Momentum[p, D], D] → Gp * pm + Gm * pp - Gt[i] * pt[i],
        Pair[Momentum[a, D], Momentum[p, D]] → -at[i1] × pt[i1],
        Pair[Momentum[p, D], Momentum[γγ5FD, D]] → γγ5FDp * pm,
        Pair[Momentum[p, D], Momentum[γaγ, D]] → γaγp * pm + γaγm * pp - γaγt[i] * pt[i],
        Pair[Momentum[p, D], Momentum[γkγ, D]] → γkγp * pm - γkγt[i] * pt[i],
        (*av2→-at^2,*)
        DiracGamma[Momentum[k, D], D] → m Gm} /. {γkγm→ 0} /. {χp → ξ kp / m ^ 2} /.
     {kp → kx / 2 / s, pm → xm / 2 / s} /. {kx → m xm} /. {pp → s (pv2 + pt[i2] ^ 2) / xm}],
  {v1, pt[i2] × pt[i], pt[i2], pt[i_], pv2, γγ5FDm, γγ5FDp, γγ5FDt[i],
   γkγm, γkγp, γkγt[i], γaγm, γaγp, γaγt[i]}]
Coefficient[Matrix5, γkγt[i]]
Coeff5 = Coeff4 / 2 / s
Phase5 =
 Collect[Expand[Phase4 /. {Pair[Momentum[p, D], Momentum[x, D]] → pp xm + pm xp - pt * xt,
      kp → m pm, Pair[Momentum[a, D], Momentum[p, D]] → -at pt } /.
     {kp → kx / 2 / s, pm → xm / 2 / s} /. {pp → s (pv2 + pt ^ 2) / xm} /. {xm → kx / m}], {pt, pp}]
```

Out[39]=

$$
\begin{aligned}
&\mathrm{v1}\Bigg(\frac{a^2 e^3 \zeta\, s\, \sigma \mathrm{F} (k\cdot X)^2}{2 m^2 \xi\, \mathrm{xm}} + \frac{a^2 e^2\, \mathrm{Gm}\, s (k\cdot X)^2}{\mathrm{xm}} + \\
&\quad \mathrm{pt}(i)\left(-\frac{2 i a^2 e^2 \zeta\, s\, \gamma\mathrm{k}\gamma\mathrm{t}(i) (k\cdot X)}{m^2 \xi\, \mathrm{xm}} + \frac{2 i e \zeta\, s\, \mathrm{at}(\mathrm{i1})\, \gamma\mathrm{k}\gamma\mathrm{t}(i)\, \mathrm{pt}(\mathrm{i1})}{m^2 \xi\, \mathrm{xm}} + \frac{i e \zeta\, \gamma\mathrm{a}\gamma\mathrm{t}(i)}{m \xi} + \mathrm{Gt}(i)\right) - \\
&\quad \frac{a^2 e^3 \zeta\, s\, \sigma \mathrm{Fxm}}{8 \xi} - \frac{1}{4} a^2 e^2\, \mathrm{Gm}\, m^2 s\, \mathrm{xm} + \frac{i a^2\, \gamma\mathrm{k}\gamma\mathrm{p}\, e^2 \zeta (k\cdot X)}{m^2 \xi} - \frac{i a^2 e^2 \zeta (k\cdot X)}{m \xi} + \frac{i a^2 e^2 \zeta\, \mathrm{xm}}{2 \xi} - \\
&\quad e \gamma\cdot a (k\cdot X) + \mathrm{pt}(\mathrm{i1})\left(-\frac{2 e\, \mathrm{Gm}\, s\, \mathrm{at}(\mathrm{i1}) (k\cdot X)}{\mathrm{xm}} - \frac{i\, \gamma\mathrm{k}\gamma\mathrm{p}\, e \zeta\, \mathrm{at}(\mathrm{i1})}{m^2 \xi}\right) + \mathrm{pt}(\mathrm{i2})^2 \left(-\frac{\mathrm{Gm}\, s}{\mathrm{xm}} - \frac{i\, \gamma\mathrm{a}\gamma\mathrm{m}\, e \zeta\, s}{m \xi\, \mathrm{xm}}\right) + \\
&\quad p^2 \left(-\frac{e \zeta\, s\, \sigma \mathrm{F}}{m^2 \xi\, \mathrm{xm}} - \frac{i\, \gamma\mathrm{a}\gamma\mathrm{m}\, e \zeta\, s}{m \xi\, \mathrm{xm}} - \frac{\mathrm{Gm}\, s}{\mathrm{xm}}\right) - \frac{i\, \gamma\mathrm{a}\gamma\mathrm{p}\, e \zeta\, \mathrm{xm}}{2 m \xi\, s} - \frac{1}{2} i\, \gamma\gamma5\mathrm{FDp}\, e\, \mathrm{xm} - \frac{\mathrm{Gp}\, \mathrm{xm}}{2 s}\Bigg) - \\
&\frac{i a^2\, \mathrm{af}\, e^3 \zeta\, s\, \sigma \mathrm{F}}{2 m \xi^2} - \frac{i a^2\, \mathrm{af}\, e^2\, \mathrm{Gm}\, m s}{\xi} - \frac{a^2\, \mathrm{af}\, e^2 \zeta}{m \xi^2} + \frac{a^2 e^3 \zeta\, s\, \sigma \mathrm{Fv2}}{m^2 \xi^3\, \mathrm{xm}} - \\
&\frac{i a^2 e^2 \zeta\, \mathrm{Gm}\, m s\, \mathrm{sf}}{\xi} + \\
&\frac{4 a^2 e^2 \zeta\, \mathrm{Gm}\, s\, \mathrm{tf}}{\xi^2\, \mathrm{xm}} + \\
&\frac{2 a^2 e^2\, \mathrm{Gm}\, s\, \mathrm{v2}}{\xi^2\, \mathrm{xm}} + \gamma\gamma5\mathrm{FDp}\left(\frac{\mathrm{af}\, e}{m \xi} + \frac{e \zeta\, \mathrm{sf}}{m \xi}\right) + \\
&\frac{1}{2} i e m s\, \mathrm{sf}\, \sigma \mathrm{F} - \frac{2 e s \sigma \mathrm{F}\, \mathrm{tf}}{\xi\, \mathrm{xm}} + m\, \mathrm{sf}
\end{aligned}
$$

Out[40]= $$\frac{2\, i\, e\,\zeta\, s\, \text{v1}\, \text{at}(\text{i1})\, \text{pt}(i)\, \text{pt}(\text{i1})}{m^2\, \xi\, \text{xm}} - \frac{2\, i\, a^2\, e^2\, \zeta\, s\, \text{v1}\, \text{pt}(i)\, (k\cdot X)}{m^2\, \xi\, \text{xm}}$$

Out[41]= $$\frac{i\, 2^{-D-2}\, \pi^{-D}\, \Lambda^{4-D}}{s\, \text{DdInv}(\zeta)}$$

Out[42]= $$\frac{1}{12} a^2\, e^2\, s\, (k\cdot x)^2 + a^2\, e^2\, s\, (k\cdot X)^2 + \text{pt}\, (\text{xt} - 2\, \text{at}\, e\, s\, (k\cdot X)) - \frac{\text{xp}\, (k\cdot x)}{2\, m\, s} - p^2\, s + \text{pt}^2\, (-s)$$

Integration over
$\int d\!\!\!{}^{-}{}^{D-2} p_\perp \ldots$

$$I_0 = \int d^{D-2} p_\perp\, \text{Exp}[-I\, A\, p_\perp^2 + I\, (J.p_\perp)] =$$

$$= \text{Exp}\left[-I\, \frac{\pi}{2}\, \frac{D-2}{2}\right] \pi^{\frac{D-2}{2}} (\det A)^{-\frac{1}{2}}\, \text{Exp}\left[I\, \frac{1}{4}\, J.A^{-1}.J\right]$$

$$I_{1\,i} = \int d^{D-2} p_\perp\, p_{\perp i}\, \text{Exp}[-I\, A\, p_\perp^2 + I\, (J.p_\perp)] =$$

$$= \frac{1}{2} (A^{-1}.J)_i\, I_0$$

$$I_2 = \int d^{D-2} p_\perp\, p_\perp{}^2\, \text{Exp}[-I\, A\, p_\perp^2 + I\, (J.p_\perp)] =$$

$$= \left[-i\, \frac{1}{2}\, \text{Tr}\, A^{-1} + \left(\frac{1}{2}\, A^{-1}.J\right)^2\right]$$

$$I_{2\,ij} = \int d^{D-2} p_\perp\, p_{\perp i}\, p_{\perp j}\, \text{Exp}[-I\, A\, p_\perp^2 + I(J.p_\perp)] =$$

$$= \left[-i\, \frac{1}{2}\, A^{-1}{}_{ij} + \left(\frac{1}{2}\, A^{-1}.J\right)_i \left(\frac{1}{2}\, A^{-1}.J\right)_j\right] I_0$$

$$I_{3\,i} = -i\, \frac{\partial}{\partial J_i} I_2 = \int d^{D-2} p_\perp\, p_\perp{}^2\, p_{\perp i}\, \text{Exp}[-I\, A\, p_\perp^2 + I(J.p_\perp)] =$$

$$= \left\{\left[-i\, \frac{1}{2}\, \text{Tr}\, A^{-1} + \left(\frac{1}{2}\, A^{-1}.J\right)^2\right] \frac{1}{2} (A^{-1}.J)_i - i\, \frac{1}{2} (A^{-1\,T}\, A^{-1}.J)_i \right\} I_0 =$$

$$= \left(\frac{1}{2}\, A^{-1}.J\right)_i I_2 - i (A^{-1\,T})_{ij}\, I_{1\,j}$$

where
A = s,

$J = x_\perp - 2\, e a_\perp\, s\, kX$,

$\det A = s^{D-2}$,

$A^{-1} = 1/s$

We perform integrations

Integrations changes the coefficient (Coeff) and phase

Then recollect some scalar products

$a_\perp^2 = -a^2$

$a_\perp\, x_\perp = -(ax)$

$x_\perp^2 = 2\, x_-\, x_+ - x^2$

In[43]:=
```
Clear[J]
Amatr = -Coefficient[Phase5, pt^2]
J[i_] = Coefficient[Phase5, pt] /. {at → at[i], xt → xt[i]}
CI0 = Exp[-I Pi / 2 (D / 2 - 1)] Pi^(D / 2 - 1) / Amatr^(D / 2 - 1)
```

Out[44]= s

Out[45]= $\mathrm{xt}(i) - 2\, e\, s\, \mathrm{at}(i)\, (k \cdot X)$

Out[46]= $e^{-\frac{1}{2} i \pi \left(\frac{D}{2}-1\right)} \pi^{\frac{D}{2}-1} s^{1-\frac{D}{2}}$

In[47]:=
```
Phase6 = Expand[Expand[((Phase5 /. {pt → 0}) + 1 / 4 J[i]^2 / Amatr)] /.
    { at[i]^2 → -av2, at[i] × xt[i] → -ax, xt[i]^2 → 2 xm xp - xv2} /. {xm → kx / m}]
Coeff6 = Coeff5 * CI0
Expand[
  Expand[Matrix5] /. {pt[i2_]^2 × pt[i1_] → ((-I / 2 * (D - 2) / Amatr + ( 1 / 2 / Amatr * J[i2])^2) *
          1 / 2 / Amatr * J[i1] - I * 1 / 2 / Amatr^2 * J[i1])} /.
     {pt[i_] × pt[i1_] → (- I / 2 / Amatr δ[i, i1] + (1 / 2 / Amatr * J[i]) * (1 / 2 / Amatr * J[i1]))} /.
    {pt[i_]^2 → (-I / 2 * (D - 2) / Amatr + ( 1 / 2 / Amatr * J[i])^2) } /. {pt[i_] → ( 1 / 2 / Amatr * J[i])}
 ];
% - Coefficient[%, δ[i, i1]] × δ[i, i1] + (Coefficient[%, δ[i, i1]] /. {i1 → i});
Matrix6 =
 Collect[% /. {γγ5FDt[i_] × at[i_] → 0 } /. { at[i_]^2 → -av2} /. {at[i_] × xt[i_] → -ax} /.
    { xt[i_]^2 → 2 xm xp - xv2} /. {at[i_] ax kX xt[i_] → -ax ax kX},
  {v1, pt[i2] × pt[i], pt[i2], pt[i_], pv2, γγ5FDm, γγ5FDp, γγ5FDt[i],
   γkγm, γkγp, γkγt[i], γaγm, γaγp, γaγt[i]}]
(*Matrix6=Collect[Expand[Expand[(Matrix5/.{pt[i_]→0})+
      Coefficient[Matrix5,pt]*1/2/Amatr*J+
      Coefficient[Matrix5,pt^2]*(-I/2*(D-2)/Amatr+( 1/2/Amatr*J)^2)+
      Coefficient[Matrix5,pt^3]((-I/2*(D-2)/Amatr+( 1/2/Amatr*J)^2)*1/2/Amatr*J+
         1/2/Amatr^2*J)]/.{γγ5FDt at→ 0, at^4→ av2^2 ,
    at^3→ -av2 at, at^2→-av2,at xt→ -ax, xt^2→ 2xm xp -xv2}],
  {p2,Gm,Gp,Gt,γγ5FDm,γγ5FDp,γγ5FDt,γkγm,γkγp,γkγt,γaγm,γaγp,γaγt}]*)
```

Out[47]= $$\frac{1}{12} a^2 e^2 s\,(k\cdot x)^2 + e\,(a\cdot x)\,(k\cdot X) - p^2 s - \frac{x^2}{4 s}$$

Out[48]= $$\frac{i\, 2^{-D-2}\, e^{-\frac{1}{2} i \pi \left(\frac{D}{2}-1\right)}\, \pi^{-\frac{D}{2}-1}\, \Lambda^{4-D}\, s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[51]=

$$\text{v1}\left(\gamma\text{a}\gamma\text{m}\left(\frac{i\,a^2\,e^3\,\zeta\,s\,(k\cdot X)^2}{m\,\xi\,\text{xm}}-\frac{i\,e^2\,\zeta\,(a\cdot x)\,(k\cdot X)}{m\,\xi\,\text{xm}}-\frac{D\,e\,\zeta}{2\,m\,\xi\,\text{xm}}-\frac{i\,e\,\zeta\,(2\,\text{xm}\,\text{xp}-x^2)}{4\,m\,\xi\,s\,\text{xm}}+\frac{e\,\zeta}{m\,\xi\,\text{xm}}\right)+\right.$$

$$\frac{a^2\,e^3\,\zeta\,s\,\sigma\text{F}\,(k\cdot X)^2}{2\,m^2\,\xi\,\text{xm}}+\gamma\text{k}\gamma\text{t}(i)\left(\frac{i\,e^2\,\zeta\,\text{at}(i)\,(a\cdot x)\,(k\cdot X)}{m^2\,\xi\,\text{xm}}-\frac{i\,e\,\zeta\,\text{xt}(i)\,(a\cdot x)}{2\,m^2\,\xi\,s\,\text{xm}}+\frac{e\,\zeta\,\text{at}(i)}{m^2\,\xi\,\text{xm}}\right)-$$

$$\frac{a^2\,e^3\,\zeta\,s\,\sigma\text{F}\text{xm}}{8\,\xi}-\frac{1}{4}\,a^2\,e^2\,\text{Gm}\,m^2\,s\,\text{xm}-\frac{i\,a^2\,e^2\,\zeta\,(k\cdot X)}{m\,\xi}+\frac{i\,a^2\,e^2\,\zeta\,\text{xm}}{2\,\xi}-$$

$$e\,\gamma\cdot a\,(k\cdot X)+\frac{i\,\gamma\text{k}\gamma\text{p}\,e\,\zeta\,(a\cdot x)}{2\,m^2\,\xi\,s}+\gamma\text{a}\gamma\text{t}(i)\left(\frac{i\,e\,\zeta\,\text{xt}(i)}{2\,m\,\xi\,s}-\frac{i\,e^2\,\zeta\,\text{at}(i)\,(k\cdot X)}{m\,\xi}\right)-$$

$$e\,\text{at}(i)\,\text{Gt}(i)\,(k\cdot X)+\frac{i\,D\,\text{Gm}}{2\,\text{xm}}+p^2\left(-\frac{e\,\zeta\,s\,\sigma\text{F}}{m^2\,\xi\,\text{xm}}-\frac{i\,\gamma\text{a}\gamma\text{m}\,e\,\zeta\,s}{m\,\xi\,\text{xm}}-\frac{\text{Gm}\,s}{\text{xm}}\right)-\frac{i\,\gamma\text{a}\gamma\text{p}\,e\,\zeta\,\text{xm}}{2\,m\,\xi\,s}-$$

$$\left.\frac{1}{2}\,i\,\gamma\gamma5\text{FDp}\,e\,\text{xm}-\frac{\text{Gm}\,(2\,\text{xm}\,\text{xp}-x^2)}{4\,s\,\text{xm}}-\frac{i\,\text{Gm}}{\text{xm}}-\frac{\text{Gp}\,\text{xm}}{2\,s}+\frac{\text{Gt}(i)\,\text{xt}(i)}{2\,s}\right)-$$

$$\frac{i\,a^2\,\text{af}\,e^3\,\zeta\,s\,\sigma\text{F}}{2\,m\,\xi^2}-\frac{i\,a^2\,\text{af}\,e^2\,\text{Gm}\,m\,s}{\xi}-\frac{a^2\,\text{af}\,e^2\,\zeta}{m\,\xi^2}+\frac{a^2\,e^3\,\zeta\,s\,\sigma\text{F}\text{v2}}{m^2\,\xi^3\,\text{xm}}-$$

$$\frac{i\,a^2\,e^2\,\zeta\,\text{Gm}\,m\,s\,\text{sf}}{\xi}+$$

$$\frac{4\,a^2\,e^2\,\zeta\,\text{Gm}\,s\,\text{tf}}{\xi^2\,\text{xm}}+$$

$$\frac{2\,a^2\,e^2\,\text{Gm}\,s\,\text{v2}}{\xi^2\,\text{xm}}+$$

$$\gamma\gamma5\text{FDp}\left(\frac{\text{af}\,e}{m\,\xi}+\frac{e\,\zeta\,\text{sf}}{m\,\xi}\right)+$$

$$\frac{1}{2}\,i\,e\,m\,s\,\text{sf}\,\sigma\text{F}-\frac{2\,e\,s\,\sigma\text{F}\text{tf}}{\xi\,\text{xm}}+m\,\text{sf}$$

Next we substitute

$\gamma_\perp\, a_\perp = -\gamma a$

$\gamma_\perp\, x_\perp = \gamma_-\, x_+ + \gamma_+\, x_- - \gamma x$

$\gamma_- \, x_- = \frac{\gamma k}{m}\, x_-$

$x_- = kx / m$

In[52]:=
```
Matrix7 = Collect[
  DiracSimplify[
   Expand[Matrix6] /. {Gt[i_] × at[i_] → -Contract[GAD[α] × av[α]],
        Gt[i_] × xt[i_] → Gm xp + Gp xm - Contract[GAD[α] × xv[α]] ,
        (*γγ5FDt[i_] xt[i_] →γγ5FDp xm - DiracSlash[FDx,Dimension→D].GA[5],*)
        γγ5FDp → DiracSlash[FDx, Dimension → D].GA[5] / xm,
        γkγt[i_] × xt[i_] → -Pair[Momentum[x, D], Momentum[γkγ, D]] + γkγp* xm,
        γkγt[i_] × at[i_] → -Pair[Momentum[a, D], Momentum[γkγ, D]],
        γaγt[i_] × xt[i_] → - Pair[Momentum[x, D], Momentum[γaγ, D]] + γaγp* xm +
          γaγm* xp, γaγt[i_] × at[i_] → - Pair[Momentum[a, D], Momentum[γaγ, D]]} /.
      {Gm → DiracGamma[Momentum[k, D], D] / m } /. {γkγm→ 0} /.
     {γaγm→ DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[k, D], D] / m }
    /. {xm → kx / m}
  ],
  {v1, p2, Gm, Gp, Gt, γγ5FDm, γγ5FDp, γγ5FDt, γkγm, γkγp, γkγt, γaγm, γaγp, γaγt}]
Coeff7 = Coeff6
Phase7 = Phase6
```

Out[52]=
$$-\frac{i\,\mathrm{af}\,s\,\zeta\,\sigma\mathrm{F}\,a^2\,e^3}{2\,m\,\xi^2}+\frac{s\,\mathrm{v2}\,\zeta\,\sigma\mathrm{F}\,a^2\,e^3}{m\,\xi^3\,(k\cdot x)}-\frac{i\,\mathrm{af}\,s\,\gamma\cdot k\,a^2\,e^2}{\xi}-\frac{i\,s\,\mathrm{sf}\,\zeta\,\gamma\cdot k\,a^2\,e^2}{\xi}-\frac{\mathrm{af}\,\zeta\,a^2\,e^2}{m\,\xi^2}+\frac{2\,s\,\mathrm{v2}\,\gamma\cdot k\,a^2\,e^2}{\xi^2\,(k\cdot x)}+$$
$$\frac{4\,s\,\mathrm{tf}\,\zeta\,\gamma\cdot k\,a^2\,e^2}{\xi^2\,(k\cdot x)}+\frac{1}{2}\,i\,m\,s\,\mathrm{sf}\,\sigma\mathrm{F}\,e-\frac{2\,m\,s\,\mathrm{tf}\,\sigma\mathrm{F}\,e}{\xi\,(k\cdot x)}+\frac{\mathrm{af}\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5\,e}{\xi\,(k\cdot x)}+\frac{\mathrm{sf}\,\zeta\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5\,e}{\xi\,(k\cdot x)}+$$
$$m\,\mathrm{sf}+\mathrm{v1}\left(\frac{s\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot X)^2\,e^3}{2\,m\,\xi\,(k\cdot x)}+\frac{i\,s\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,a^2\,(k\cdot X)^2\,e^3}{m\,\xi\,(k\cdot x)}-\frac{s\,\zeta\,\sigma\mathrm{F}\,a^2\,(k\cdot x)\,e^3}{8\,m\,\xi}-\right.$$
$$\frac{1}{4}\,s\,\gamma\cdot k\,a^2\,(k\cdot x)\,e^2+\frac{i\,\zeta\,a^2\,(k\cdot x)\,e^2}{2\,m\,\xi}-\frac{i\,\zeta\,a^2\,(k\cdot X)\,e^2}{m\,\xi}+\frac{i\,\zeta\,(a\cdot\gamma\mathrm{a}\gamma)\,(k\cdot X)\,e^2}{m\,\xi}-$$
$$\frac{i\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,(a\cdot x)\,(k\cdot X)\,e^2}{m\,\xi\,(k\cdot x)}-\frac{i\,\zeta\,(a\cdot x)\,(a\cdot\gamma\mathrm{k}\gamma)\,(k\cdot X)\,e^2}{m\,\xi\,(k\cdot x)}-\frac{1}{2}\,i\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5\,e-\frac{s\,\zeta\,\sigma\mathrm{F}\,p^2\,e}{m\,\xi\,(k\cdot x)}-$$
$$\frac{i\,s\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,p^2\,e}{m\,\xi\,(k\cdot x)}+\frac{i\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,x^2\,e}{4\,m\,s\,\xi\,(k\cdot x)}-\frac{i\,\zeta\,(x\cdot\gamma\mathrm{a}\gamma)\,e}{2\,m\,s\,\xi}+\frac{i\,\zeta\,(a\cdot x)\,(x\cdot\gamma\mathrm{k}\gamma)\,e}{2\,m\,s\,\xi\,(k\cdot x)}-$$
$$\left.\frac{D\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,e}{2\,m\,\xi\,(k\cdot x)}+\frac{\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,e}{m\,\xi\,(k\cdot x)}-\frac{\zeta\,(a\cdot\gamma\mathrm{k}\gamma)\,e}{m\,\xi\,(k\cdot x)}-\frac{\gamma\cdot x}{2\,s}-\frac{s\,\gamma\cdot k\,p^2}{k\cdot x}+\frac{\gamma\cdot k\,x^2}{4\,s\,(k\cdot x)}+\frac{i\,D\,\gamma\cdot k}{2\,(k\cdot x)}-\frac{i\,\gamma\cdot k}{k\cdot x}\right)$$

Out[53]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}i\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[54]=
$$\frac{1}{12}\,a^2\,e^2\,s\,(k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

In[55]:=
```
Matrix8 = Collect[
  Expand[
   DiracSimplify[
       Matrix7 /.
        {Pair[Momentum[x, D], Momentum[γkγ, D]] →
          DiracGamma[Momentum[k, D], D].DiracGamma[Momentum[x, D], D],
         Pair[Momentum[a, D], Momentum[γkγ, D]] →  DiracGamma[Momentum[k, D], D].
           DiracGamma[Momentum[a, D], D],
         Pair[Momentum[x, D], Momentum[γaγ, D]] →  DiracGamma[Momentum[a, D], D].
           DiracGamma[Momentum[x, D], D],
         Pair[Momentum[a, D], Momentum[γaγ, D]] →  DiracGamma[Momentum[a, D], D].
           DiracGamma[Momentum[a, D], D]}
      ] /. FieldSubstitutions /. akToF /. {av2 → -ξ^2 m^2 / e^2}
  ],
  {sf, v1, v2, tf, af, ζ, σF}]
Coeff8 = Coeff7
Phase8 = Phase7 /. {av2 → -ξ^2 m^2 / e^2}
```

Out[55]=
$$\mathrm{v1}\left(-\frac{1}{2}\,i\,e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}+\zeta\left(\frac{i\,e\,(a\cdot x)\,(\gamma\cdot k).(\gamma\cdot x)}{2\,m\,\xi\,s\,(k\cdot x)}-\frac{i\,e\,(\gamma\cdot a).(\gamma\cdot x)}{2\,m\,\xi\,s}+\sigma\mathrm{F}\left(-\frac{i\,D\,e}{4\,m\,\xi\,(k\cdot x)}-\frac{e\,p^2\,s}{2\,m\,\xi\,(k\cdot x)}+\frac{1}{8}\,e\,m\,\xi\,s\,(k\cdot x)-\frac{e\,x^2}{8\,m\,\xi\,s\,(k\cdot x)}+\frac{i\,e}{m\,\xi\,(k\cdot x)}\right)-\frac{1}{2}\,i\,m\,\xi\,(k\cdot x)\right)+\frac{i\,D\,\gamma\cdot k}{2\,(k\cdot x)}+\frac{1}{4}\,m^2\,\xi^2\,s\,\gamma\cdot k\,(k\cdot x)-\frac{p^2\,s\,\gamma\cdot k}{k\cdot x}+\frac{x^2\,\gamma\cdot k}{4\,s\,(k\cdot x)}-\frac{i\,\gamma\cdot k}{k\cdot x}-\frac{\gamma\cdot x}{2\,s}\right)+$$
$$\mathrm{af}\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}}{\xi\,(k\cdot x)}+\zeta\left(m+\frac{1}{2}\,i\,e\,m\,s\,\sigma\mathrm{F}\right)+i\,m^2\,\xi\,s\,\gamma\cdot k\right)+$$
$$\mathrm{sf}\left(\zeta\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}}{\xi\,(k\cdot x)}+i\,m^2\,\xi\,s\,\gamma\cdot k\right)+\frac{1}{2}\,i\,e\,m\,s\,\sigma\mathrm{F}+m\right)+$$
$$\mathrm{tf}\left(-\frac{2\,e\,m\,s\,\sigma\mathrm{F}}{\xi\,(k\cdot x)}-\frac{4\,\zeta\,m^2\,s\,\gamma\cdot k}{k\cdot x}\right)+$$
$$\mathrm{v2}\left(-\frac{e\,\zeta\,m\,s\,\sigma\mathrm{F}}{\xi\,(k\cdot x)}-\frac{2\,m^2\,s\,\gamma\cdot k}{k\cdot x}\right)$$

Out[56]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}\,i\,\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[57]=
$$-\frac{1}{12}\,m^2\,\xi^2\,s\,(\,k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

In[58]:=
```
(*a small test*)Expand[((Matrix8 /. {sf → 1, v1 → -1, v2 → 0, tf → 0, af → 0, ζ → 1}) +
    (Matrix8 /. {sf → 1, v1 → -1, v2 → 0, tf → 0, af → 0, ζ → -1})) / 2]
```

Out[58]= $\frac{1}{2} i\, e (\gamma\cdot \text{FDx}).\bar{\gamma}^5 - \frac{i\, D \gamma\cdot k}{2\,(k\cdot x)} + \frac{1}{2} i\, e\, m\, s\, \sigma\text{F} - \frac{1}{4} m^2\, \xi^2\, s\, \gamma\cdot k\,(k\cdot x) + \frac{p^2\, s\, \gamma\cdot k}{k\cdot x} - \frac{x^2\, \gamma\cdot k}{4\, s\,(k\cdot x)} + \frac{i\, \gamma\cdot k}{k\cdot x} + m + \frac{\gamma\cdot x}{2\, s}$

In[59]:=
```
DiracSimplify[DiracGamma[Momentum[Fx, D], D].DiracGamma[Momentum[x, D], D] /. FxToak]
DiracSimplify[
  I DiracGamma[Momentum[FDx, D], D].DiracGamma[5].DiracGamma[Momentum[x, D], D] /. FxToEps /.
    FxToak /. Gamma5toTrippleGammax]
```

Out[59]= $(a\cdot x)\,(\gamma\cdot k).(\gamma\cdot x) - (k\cdot x)\,(\gamma\cdot a).(\gamma\cdot x)$

Out[60]= $(a\cdot x)\,(\gamma\cdot k).(\gamma\cdot x) - (k\cdot x)\,(\gamma\cdot a).(\gamma\cdot x) + x^2\,(\gamma\cdot a).(\gamma\cdot k)$

In[61]:=
```
Matrix9 = Collect[
  Expand[
   Matrix8 /. {ax DiracGamma[Momentum[k, D], D].DiracGamma[Momentum[x, D], D] →
        I DiracGamma[Momentum[FDx, D], D].DiracGamma[5].DiracGamma[Momentum[x, D], D] +
         kx DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[x, D], D] -
         (xv2 DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[k, D], D] /. akToF),
       DiracGamma[Momentum[k, D], D] → - DiracGamma[Momentum[FFx, D], D] / av2 / kx} /.
    {av2 → -ξ^2 m^2 / e^2}
  ],
  {sf, v1, v2, tf, af, ζ, e σF / m / ξ / kx,
   σF, e^2 DiracGamma[Momentum[FFx, D], D] / m^2 / ξ^2 / kx^2}]
Coeff9 = Coeff8
Phase9 = Phase8
```

Out[61]=
$$\mathrm{v1}\left(\zeta\left(-\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}.(\gamma\cdot x)}{2\,m\,\xi\,s\,(k\cdot x)}+\frac{e\,\sigma\,\mathrm{F}\left(-\frac{i\,D}{4}-\frac{p^2\,s}{2}+\frac{x^2}{8\,s}+i\right)}{m\,\xi\,(k\cdot x)}+\frac{1}{8}\,e\,m\,\xi\,s\,\sigma\,\mathrm{F}(k\cdot x)-\frac{1}{2}\,i\,m\,\xi\,(k\cdot x)\right)-\frac{1}{2}\,i\,e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}+\frac{e^2\,\gamma\cdot\mathrm{FFx}\left(\frac{i\,D}{2}-p^2\,s+\frac{x^2}{4\,s}-i\right)}{m^2\,\xi^2\,(k\cdot x)^2}+\frac{1}{4}\,e^2\,s\,\gamma\cdot\mathrm{FFx}-\frac{\gamma\cdot x}{2\,s}\right)+$$
$$\mathrm{af}\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}}{\xi\,(k\cdot x)}+\frac{i\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{\xi\,(k\cdot x)}+\zeta\left(m+\frac{1}{2}\,i\,e\,m\,s\,\sigma\,\mathrm{F}\right)\right)+$$
$$\mathrm{sf}\left(\zeta\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}}{\xi\,(k\cdot x)}+\frac{i\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{\xi\,(k\cdot x)}\right)+\frac{1}{2}\,i\,e\,m\,s\,\sigma\,\mathrm{F}+m\right)+$$
$$\mathrm{tf}\left(-\frac{4\,e^2\,\zeta\,s\,\gamma\cdot\mathrm{FFx}}{\xi^2\,(k\cdot x)^2}-\frac{2\,e\,m\,s\,\sigma\,\mathrm{F}}{\xi\,(k\cdot x)}\right)+\mathrm{v2}\left(-\frac{2\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{\xi^2\,(k\cdot x)^2}-\frac{e\,\zeta\,m\,s\,\sigma\,\mathrm{F}}{\xi\,(k\cdot x)}\right)$$

Out[62]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}\,i\,\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[63]=
$$-\frac{1}{12}\,m^2\,\xi^2\,s\,(k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

In[64]:=
```
Collect[Expand[Simplify[D[Coeff8 s f[χ[s]] Exp[I Phase8], s] / Exp[I Phase8] / Coeff8]], f[χ[s]]]
pv2Sol = pv2 /. Solve[% == dfds, pv2][[1]]
```

Out[64]=
$$s\,\chi'(s)\,f'(\chi(s))+f(\chi(s))\left(-\frac{1}{12}\,i\,m^2\,\xi^2\,s\,(k\cdot x)^2-\frac{D}{2}-i\,p^2\,s+\frac{i\,x^2}{4\,s}+1\right)$$

Out[65]=
$$\frac{-m^2\,\xi^2\,s^2\,f(\chi(s))\,(k\cdot x)^2+6\,i\left(D\,s\,f(\chi(s))+2\,\mathrm{dfds}\,s-2\,s^2\,\chi'(s)\,f'(\chi(s))-2\,s\,f(\chi(s))\right)+3\,x^2\,f(\chi(s))}{12\,s^2\,f(\chi(s))}$$

Let

$f(\zeta, p^2, \chi(s)) = v_1(p^2, \chi(s))\, D_\zeta^{-1}(p^2, \chi(s))$

In[66]:=
```
Matrix9pv2 = Coefficient[Matrix9, pv2] /. {v1 → f[ζ, pv2, χ[s]]} /. {χ[s] → ξ kx / 2 / m^2 / s}
CoeffNoD = Coeff9 * DdInv[ζ]
PhaseNopv2 = Phase9 - Coefficient[Phase9, pv2] pv2
Collect[
 Expand[
  Simplify[-I D[Matrix9pv2 * CoeffNoD * Exp[I PhaseNopv2], s] / (CoeffNoD * Exp[I PhaseNopv2])
  ]
 ],
 {f[ζ, pv2, ξ kx / 2 / m^2 / s]}]
Matrix91 = Coefficient[%, f[ζ, pv2, ξ kx / 2 / m^2 / s]] v1
Matrix92 = %% - Matrix91 / v1 * f[ζ, pv2, ξ kx / 2 / m^2 / s]
```

Out[66]= $-\frac{e^2\, s\, \gamma\cdot \text{FFx}\, f\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{m^2\, \xi^2\, (k\cdot x)^2} - \frac{e\, \zeta\, s\, \sigma \text{F}\, f\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{2\, m\, \xi\, (k\cdot x)}$

Out[67]= $i\, 2^{-D-2}\, e^{-\frac{1}{2} i \pi \left(\frac{D}{2}-1\right)}\, \pi^{-\frac{D}{2}-1}\, \Lambda^{4-D}\, s^{-D/2}$

Out[68]= $-\frac{1}{12} m^2\, \xi^2\, s\, (k\cdot x)^2 + e\,(a\cdot x)\,(k\cdot X) - \frac{x^2}{4\, s}$

Out[69]= $f\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)\left(-\frac{i\, D\, e^2\, \gamma\cdot\text{FFx}}{2\, m^2\, \xi^2\, (k\cdot x)^2} - \frac{e^2\, x^2\, \gamma\cdot\text{FFx}}{4\, m^2\, \xi^2\, s\, (k\cdot x)^2} + \frac{i\, e^2\, \gamma\cdot\text{FFx}}{m^2\, \xi^2\, (k\cdot x)^2} - \frac{i\, D\, e\, \zeta\, \sigma\text{F}}{4\, m\, \xi\, (k\cdot x)} + \frac{1}{12} e^2\, s\, \gamma\cdot\text{FFx} + \frac{1}{24} e\, \zeta\, m\, \xi\, s\, \sigma\text{F}\,(k\cdot x) - \frac{e\, \zeta\, \sigma\text{F}\, x^2}{8\, m\, \xi\, s\,(k\cdot x)} + \frac{i\, e\, \zeta\, \sigma\text{F}}{2\, m\, \xi\, (k\cdot x)}\right) - \frac{i\, e^2\, \gamma\cdot\text{FFx}\, f^{(0,0,1)}\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{2\, m^4\, \xi\, s\,(k\cdot x)} - \frac{i\, e\, \zeta\, \sigma\text{F}\, f^{(0,0,1)}\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{4\, m^3\, s}$

Out[70]= $\text{v1}\left(-\frac{i\, D\, e^2\, \gamma\cdot\text{FFx}}{2\, m^2\, \xi^2\, (k\cdot x)^2} - \frac{e^2\, x^2\, \gamma\cdot\text{FFx}}{4\, m^2\, \xi^2\, s\, (k\cdot x)^2} + \frac{i\, e^2\, \gamma\cdot\text{FFx}}{m^2\, \xi^2\, (k\cdot x)^2} - \frac{i\, D\, e\, \zeta\, \sigma\text{F}}{4\, m\, \xi\, (k\cdot x)} + \frac{1}{12} e^2\, s\, \gamma\cdot\text{FFx} + \frac{1}{24} e\, \zeta\, m\, \xi\, s\, \sigma\text{F}\,(k\cdot x) - \frac{e\, \zeta\, \sigma\text{F}\, x^2}{8\, m\, \xi\, s\,(k\cdot x)} + \frac{i\, e\, \zeta\, \sigma\text{F}}{2\, m\, \xi\, (k\cdot x)}\right)$

Out[71]= $-\frac{i\, e^2\, \gamma\cdot\text{FFx}\, f^{(0,0,1)}\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{2\, m^4\, \xi\, s\,(k\cdot x)} - \frac{i\, e\, \zeta\, \sigma\text{F}\, f^{(0,0,1)}\!\left(\zeta, p^2, \frac{\xi\,(k\cdot x)}{2\, m^2\, s}\right)}{4\, m^3\, s}$

In[72]:=
```
Matrix101 = Collect[
  (Expand[Matrix9] - Coefficient[Matrix9, pv2] pv2 + Matrix91) / m,
  {sf, v1, v2, tf, af, ζ, σF, DiracGamma[Momentum[FFx, D], D],
   DiracGamma[Momentum[x, D], D], DiracGamma[Momentum[FDx, D], D]}, Simplify]
Matrix102 = Expand[Matrix92 / m]
(*Matrix101=Collect[Matrix9/m,{sf,v1,v2,tf,af,ζ,σF, DiracGamma[Momentum[FFx,D],D],
     DiracGamma[Momentum[x,D],D],DiracGamma[Momentum[FDx,D],D]},Simplify]
   Matrix102=0*)
Coeff10 = Coeff9 * m
Phase10 = Phase9
```

Out[72]=
$$\mathrm{af}\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5}{m\,\xi\,(k\cdot x)}+\frac{i\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{m\,\xi\,(k\cdot x)}+\zeta\left(1+\frac{1}{2}\,i\,e\,s\,\sigma\mathrm{F}\right)\right)+\mathrm{v1}\left(\zeta\left(-\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5.(\gamma\cdot x)}{2\,m^2\,\xi\,s\,(k\cdot x)}+\sigma\mathrm{F}\left(\frac{1}{6}\,e\,\xi\,s\,(k\cdot x)-\frac{i\,(D-3)\,e}{2\,m^2\,\xi\,(k\cdot x)}\right)-\frac{1}{2}\,i\,\xi\,(k\cdot x)\right)-\frac{i\,e\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5}{2\,m}+\frac{e^2\,s\,\gamma\cdot\mathrm{FFx}}{3\,m}-\frac{\gamma\cdot x}{2\,m\,s}\right)+\mathrm{sf}\left(\zeta\left(\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5}{m\,\xi\,(k\cdot x)}+\frac{i\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{m\,\xi\,(k\cdot x)}\right)+\frac{1}{2}\,i\,e\,s\,\sigma\mathrm{F}+1\right)+\mathrm{tf}\left(-\frac{4\,e^2\,\zeta\,s\,\gamma\cdot\mathrm{FFx}}{m\,\xi^2\,(k\cdot x)^2}-\frac{2\,e\,s\,\sigma\mathrm{F}}{\xi\,(k\cdot x)}\right)+\mathrm{v2}\left(-\frac{2\,e^2\,s\,\gamma\cdot\mathrm{FFx}}{m\,\xi^2\,(k\cdot x)^2}-\frac{e\,\zeta\,s\,\sigma\mathrm{F}}{\xi\,(k\cdot x)}\right)$$

Out[73]=
$$-\frac{i\,e^2\,\gamma\cdot\mathrm{FFx}\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^5\,\xi\,s\,(k\cdot x)}-\frac{i\,e\,\zeta\,\sigma\mathrm{F}\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{4\,m^4\,s}$$

Out[74]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}\,i\,\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,m\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[75]=
$$-\frac{1}{12}\,m^2\,\xi^2\,s\,(k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

In[76]:=
```
Matrix101 // StandardForm;
```

In[77]:=
```
Matrix10 = Collect[Expand[Matrix101 + Matrix102],
  {e ^ 2 DiracGamma[Momentum[FFx, D], D], e DiracGamma[Momentum[FDx, D], D].DiracGamma[5],
   e DiracGamma[Momentum[FDx, D], D].DiracGamma[5].DiracGamma[Momentum[x, D], D],
   σF, DiracGamma[Momentum[x, D], D], sf, v1, v2, tf, af, ζ}]
```

Out[77]=

$$e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}\left(\frac{\mathrm{af}}{m\,\xi\,(k\cdot x)}+\frac{\zeta\,\mathrm{sf}}{m\,\xi\,(k\cdot x)}-\frac{i\,\mathrm{v1}}{2\,m}\right)-\frac{e\,\zeta\,\mathrm{v1}\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^{5}.(\gamma\cdot x)}{2\,m^2\,\xi\,s\,(k\cdot x)}+$$

$$e^2\,\gamma\cdot\mathrm{FFx}\left(-\frac{i\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^5\,\xi\,s\,(k\cdot x)}-\frac{4\,\zeta\,s\,\mathrm{tf}}{m\,\xi^2\,(k\cdot x)^2}-\frac{2\,s\,\mathrm{v2}}{m\,\xi^2\,(k\cdot x)^2}+\frac{i\,\mathrm{af}\,s}{m\,\xi\,(k\cdot x)}+\frac{i\,\zeta\,s\,\mathrm{sf}}{m\,\xi\,(k\cdot x)}+\frac{s\,\mathrm{v1}}{3\,m}\right)+$$

$$\sigma\mathrm{F}\left(-\frac{i\,e\,\zeta\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{4\,m^4\,s}+\frac{1}{2}\,i\,\mathrm{af}\,e\,\zeta\,s+\zeta\,\mathrm{v1}\left(-\frac{i\,D\,e}{2\,m^2\,\xi\,(k\cdot x)}+\frac{3\,i\,e}{2\,m^2\,\xi\,(k\cdot x)}+\frac{1}{6}\,e\,\xi\,s\,(k\cdot x)\right)-\right.$$

$$\left.\frac{2\,e\,s\,\mathrm{tf}}{\xi\,(k\cdot x)}-\frac{e\,\zeta\,s\,\mathrm{v2}}{\xi\,(k\cdot x)}+\frac{1}{2}\,i\,e\,s\,\mathrm{sf}\right)+\mathrm{af}\,\zeta-\frac{1}{2}\,i\,\zeta\,\xi\,\mathrm{v1}\,(k\cdot x)-\frac{\mathrm{v1}\,\gamma\cdot x}{2\,m\,s}+\mathrm{sf}$$

In[78]:=
```
Matrix10ReorderPart1 =
  Collect[Coefficient[Matrix10, e^2 DiracGamma[Momentum[FFx, D], D]] * m^1 ξ^2 (kx)^2, {sf,
      v1, v2, tf, af, ζ}, Simplify] e^2 DiracGamma[Momentum[FFx, D], D] / (m^1 ξ^2 (kx)^2) +
   Collect[Coefficient[Matrix10, e DiracGamma[Momentum[FDx, D], D].DiracGamma[5]] * m ξ (kx),
     {sf, v1, v2, tf, af, ζ}, Simplify] e
    DiracGamma[Momentum[FDx, D], D].DiracGamma[5] / (m ξ (kx)) +
   Collect[Coefficient[Matrix10, e σF] * 2 m^0 ξ (kx) / ζ, {sf, v1, v2, tf, af, ζ}, Simplify]
    e σF / (2 m^0 ξ (kx) / ζ) +
   Coefficient[Matrix10, e DiracGamma[Momentum[FDx, D], D].
       DiracGamma[5].DiracGamma[Momentum[x, D], D]] e
    DiracGamma[Momentum[FDx, D], D].DiracGamma[5].DiracGamma[Momentum[x, D], D] +
   Coefficient[Matrix10, DiracGamma[Momentum[x, D], D]] × DiracGamma[Momentum[x, D], D];
Matrix10Reorder =
 Matrix10ReorderPart1 + Expand[Matrix10 - Matrix10ReorderPart1] /. {1 / ζ → ζ}
Coeff10
Phase10
```

Out[79]=
$$\frac{e(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5\left(\mathrm{af}-\frac{1}{2}i\,\xi\,\mathrm{v1}\,(k\cdot x)+\zeta\,\mathrm{sf}\right)}{m\,\xi\,(k\cdot x)}-\frac{e\,\zeta\,\mathrm{v1}\,(\gamma\cdot\mathrm{FDx}).\overline{\gamma}^5.(\gamma\cdot x)}{2\,m^2\,\xi\,s\,(k\cdot x)}+$$
$$\frac{e\,\zeta\,\sigma\mathrm{F}\left(-\frac{i\,\xi\,(k\cdot x)\,f^{(0,0,1)}\left(\zeta,p^2,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^4\,s}+\frac{\mathrm{v1}\left(m^2\,\xi^2\,s\,(k\cdot x)^2-3\,i\,D+9\,i\right)}{3\,m^2}+i\,\mathrm{af}\,\xi\,s\,(k\cdot x)+i\,\zeta\,\xi\,s\,\mathrm{sf}\,(k\cdot x)-4\,\zeta\,s\,\mathrm{tf}-2\,s\,\mathrm{v2}\right)}{2\,\xi\,(k\cdot x)}+$$
$$\frac{e^2\,\gamma\cdot\mathrm{FFx}\left(-\frac{i\,\xi\,(k\cdot x)\,f^{(0,0,1)}\left(\zeta,p^2,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^4\,s}+\frac{1}{3}\,\xi^2\,s\,\mathrm{v1}\,(k\cdot x)^2+i\,\mathrm{af}\,\xi\,s\,(k\cdot x)+i\,\zeta\,\xi\,s\,\mathrm{sf}\,(k\cdot x)-4\,\zeta\,s\,\mathrm{tf}-2\,s\,\mathrm{v2}\right)}{m\,\xi^2\,(k\cdot x)^2}+$$
$$\mathrm{af}\,\zeta-\frac{1}{2}\,i\,\zeta\,\xi\,\mathrm{v1}\,(k\cdot x)-\frac{\mathrm{v1}\,\gamma\cdot x}{2\,m\,s}+\mathrm{sf}$$

Out[80]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}i\,\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,m\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[81]=
$$-\frac{1}{12}\,m^2\,\xi^2\,s\,(k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

Matrix10 without removing p^2 with integration by parts

In[82]:=
```
sf + af ζ - (v1 DiracGamma[Momentum[x, D], D])/(2 m s) -
 (e v1 ζ DiracGamma[Momentum[FDx, D], D].DiracGamma[5].DiracGamma[Momentum[x, D], D]) /
  (2 m^2 s ξ Pair[Momentum[k, D], Momentum[x, D]]) -
 1/2 ⅈ v1 ζ ξ Pair[Momentum[k, D], Momentum[x, D]] +
 (e DiracGamma[Momentum[FDx, D], D].DiracGamma[5]
    (af + sf ζ - 1/2 ⅈ v1 ξ Pair[Momentum[k, D], Momentum[x, D]])) /
  (m ξ Pair[Momentum[k, D], Momentum[x, D]]) +
 (e ζ σF (-2 s v2 - 4 s tf ζ + ⅈ af s ξ Pair[Momentum[k, D], Momentum[x, D]] +
      ⅈ s sf ζ ξ Pair[Momentum[k, D], Momentum[x, D]] +
      1/(4 m^2 s) v1 (8 ⅈ s - 2 ⅈ D s + m^2 s^2 ξ^2 Pair[Momentum[k, D], Momentum[x, D]]^2 -
          4 s^2 Pair[Momentum[p, D], Momentum[p, D]] + Pair[Momentum[x, D], Momentum[x, D]]))) /
  (2 ξ Pair[Momentum[k, D], Momentum[x, D]]) + (e^2 DiracGamma[Momentum[FFx, D], D]
    (-2 s v2 - 4 s tf ζ + ⅈ af s ξ Pair[Momentum[k, D], Momentum[x, D]] +
      ⅈ s sf ζ ξ Pair[Momentum[k, D], Momentum[x, D]] +
      1/(4 m^2 s) v1 (-4 ⅈ s + 2 ⅈ D s + m^2 s^2 ξ^2 Pair[Momentum[k, D], Momentum[x, D]]^2 -
          4 s^2 Pair[Momentum[p, D], Momentum[p, D]] + Pair[Momentum[x, D], Momentum[x, D]]))) /
  (m ξ^2 Pair[Momentum[k, D], Momentum[x, D]]^2)
```

Out[82]=

$$\frac{e(\gamma\cdot\text{FDx}).\overline{\gamma}^5\left(\text{af}-\frac{1}{2}\,i\,\xi\,\text{v1}\,(k\cdot x)+\zeta\,\text{sf}\right)}{m\,\xi\,(k\cdot x)}-\frac{e\,\zeta\,\text{v1}\,(\gamma\cdot\text{FDx}).\overline{\gamma}^5.(\gamma\cdot x)}{2\,m^2\,\xi\,s\,(k\cdot x)}+$$

$$\frac{e^2\,\gamma\cdot\text{FFx}\left(\frac{\text{v1}\,(m^2\,\xi^2\,s^2\,(k\cdot x)^2+2\,i\,D\,s-4\,p^2\,s^2-4\,i\,s+x^2)}{4\,m^2\,s}+i\,\text{af}\,\xi\,s\,(k\cdot x)+i\,\zeta\,\xi\,s\,\text{sf}\,(k\cdot x)-4\,\zeta\,s\,\text{tf}-2\,s\,\text{v2}\right)}{m\,\xi^2\,(k\cdot x)^2}+$$

$$\frac{e\,\zeta\,\sigma\text{F}\left(\frac{\text{v1}\,(m^2\,\xi^2\,s^2\,(k\cdot x)^2-2\,i\,D\,s-4\,p^2\,s^2+8\,i\,s+x^2)}{4\,m^2\,s}+i\,\text{af}\,\xi\,s\,(k\cdot x)+i\,\zeta\,\xi\,s\,\text{sf}\,(k\cdot x)-4\,\zeta\,s\,\text{tf}-2\,s\,\text{v2}\right)}{2\,\xi\,(k\cdot x)}+$$

$$\text{af}\,\zeta-\frac{1}{2}\,i\,\zeta\,\xi\,\text{v1}\,(k\cdot x)-\frac{\text{v1}\,\gamma\cdot x}{2\,m\,s}+\text{sf}$$

In[83]:=

```
(*a small test*)Expand[((Matrix101 /. {sf → 1, v1 → -1, v2 → 0, tf → 0, af → 0, ζ → 1}) +
    (Matrix101 /. {sf → 1, v1 → -1, v2 → 0, tf → 0, af → 0, ζ → -1})) / 2]
```

Out[83]=

$$\frac{i\,e(\gamma\cdot\text{FDx}).\overline{\gamma}^5}{2\,m}-\frac{e^2\,s\,\gamma\cdot\text{FFx}}{3\,m}+\frac{1}{2}\,i\,e\,s\,\sigma\text{F}+\frac{\gamma\cdot x}{2\,m\,s}+1$$

In[84]:=
```
Matrix111 = Collect[
  DiracOrder[DiracSimplify[Expand[Matrix101] /. FxToEps /. FxToak /.
      Gamma5toTrippleGammax /. {av2 → -ξ^2 m^2 / e^2}]],
  {sf, v1, v2, tf, af, ζ}, Simplify]
Matrix112 = Expand[Matrix102 /. FxToEps /. FxToak /. Gamma5toTrippleGammax]
Coeff10
Phase10
```

Out[84]=
$$\mathrm{v1}\left(\frac{s\left(\gamma\cdot k\left(2\,m^2\,\xi^2\,s\,(k\cdot x)-3\,e\,(a\cdot x)\right)+3\,e\gamma\cdot a\,(k\cdot x)-3\,e\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot x)\right)-3\,\gamma\cdot x}{6\,m\,s}-\frac{1}{6\,m^2\,\xi\,s\,(k\cdot x)}i\,\zeta\left(e\,(\gamma\cdot a).(\gamma\cdot k)\left(2\,m^2\,\xi^2\,s^2\,(k\cdot x)^2-6\,i\,(D-3)\,s-3\,x^2\right)+3\,(k\cdot x)\left(e\,(\gamma\cdot a).(\gamma\cdot x)+m^2\,\xi^2\,s\,(k\cdot x)\right)-3\,e\,(a\cdot x)\,(\gamma\cdot k).(\gamma\cdot x)\right)\right)+$$
$$\mathrm{af}\left(\zeta\,(e\,s\,(\gamma\cdot a).(\gamma\cdot k)+1)+\frac{i\left(\gamma\cdot k\left(m^2\,\xi^2\,s\,(k\cdot x)-e\,(a\cdot x)\right)+e\gamma\cdot a\,(k\cdot x)-e\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot x)\right)}{m\,\xi\,(k\cdot x)}\right)+$$
$$\mathrm{sf}\left(\frac{i\,\zeta\left(\gamma\cdot k\left(m^2\,\xi^2\,s\,(k\cdot x)-e\,(a\cdot x)\right)+e\gamma\cdot a\,(k\cdot x)-e\,(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot x)\right)}{m\,\xi\,(k\cdot x)}+e\,s\,(\gamma\cdot a).(\gamma\cdot k)+1\right)+$$
$$\mathrm{tf}\left(-\frac{4\,\zeta\,m\,s\,\gamma\cdot k}{k\cdot x}+\frac{4\,i\,e\,s\,(\gamma\cdot a).(\gamma\cdot k)}{\xi\,(k\cdot x)}\right)+$$
$$\mathrm{v2}\left(-\frac{2\,m\,s\,\gamma\cdot k}{k\cdot x}+\frac{2\,i\,e\,\zeta\,s\,(\gamma\cdot a).(\gamma\cdot k)}{\xi\,(k\cdot x)}\right)$$

Out[85]=
$$-\frac{e\,\zeta\,(\gamma\cdot a).(\gamma\cdot k)\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^4\,s}+\frac{i\,a^2\,e^2\,\gamma\cdot k\,f^{(0,0,1)}\left(\zeta,\,p^2,\,\frac{\xi\,(k\cdot x)}{2\,m^2\,s}\right)}{2\,m^5\,\xi\,s}$$

Out[86]=
$$\frac{i\,2^{-D-2}\,e^{-\frac{1}{2}\,i\,\pi\left(\frac{D}{2}-1\right)}\,\pi^{-\frac{D}{2}-1}\,m\,\Lambda^{4-D}\,s^{-D/2}}{\mathrm{DdInv}(\zeta)}$$

Out[87]=
$$-\frac{1}{12}\,m^2\,\xi^2\,s\,(k\cdot x)^2+e\,(a\cdot x)\,(k\cdot X)-p^2\,s-\frac{x^2}{4\,s}$$

In[88]:=
```
Collect[Expand[Matrix111],
  {
   DiracGamma[Momentum[x, D], D],
   DiracGamma[Momentum[k, D], D],
   DiracGamma[Momentum[a, D], D],
   DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[k, D], D] ,
   DiracGamma[Momentum[a, D], D].DiracGamma[Momentum[x, D], D] ,
   DiracGamma[Momentum[k, D], D].DiracGamma[Momentum[x, D], D] ,
   DiracGamma[Momentum[a, D], D].
    DiracGamma[Momentum[k, D], D].DiracGamma[Momentum[x, D], D],
   sf, v1, v2, tf, af, ζ}]
```

Out[88]=

$$(\gamma\cdot a).(\gamma\cdot k)\left(\text{af}\, e\zeta\, s+\zeta\,\text{v1}\left(-\frac{D e}{m^2\,\xi\,(k\cdot x)}+\frac{i\,e x^2}{2\,m^2\,\xi\,s\,(k\cdot x)}+\frac{3\,e}{m^2\,\xi\,(k\cdot x)}-\frac{1}{3}\,i\,e\,\xi\,s\,(k\cdot x)\right)+\frac{4\,i\,e\,s\,\text{tf}}{\xi\,(k\cdot x)}+\frac{2\,i\,e\zeta\,s\,\text{v2}}{\xi\,(k\cdot x)}+e\,s\,\text{sf}\right)+\gamma\cdot k\left(\text{af}\left(i\,m\,\xi\,s-\frac{i\,e(a\cdot x)}{m\,\xi\,(k\cdot x)}\right)+\zeta\,\text{sf}\left(i\,m\,\xi\,s-\frac{i\,e(a\cdot x)}{m\,\xi\,(k\cdot x)}\right)+\text{v1}\left(\frac{1}{3}\,m\,\xi^2\,s\,(k\cdot x)-\frac{e(a\cdot x)}{2\,m}\right)-\frac{4\,\zeta\,m\,s\,\text{tf}}{k\cdot x}-\frac{2\,m\,s\,\text{v2}}{k\cdot x}\right)+(\gamma\cdot a).(\gamma\cdot k).(\gamma\cdot x)\left(-\frac{i\,\text{af}\,e}{m\,\xi\,(k\cdot x)}-\frac{i\,e\zeta\,\text{sf}}{m\,\xi\,(k\cdot x)}-\frac{e\,\text{v1}}{2\,m}\right)+\gamma\cdot a\left(\frac{i\,\text{af}\,e}{m\,\xi}+\frac{e\,\text{v1}\,(k\cdot x)}{2\,m}+\frac{i\,e\zeta\,\text{sf}}{m\,\xi}\right)+\frac{i\,e\zeta\,\text{v1}\,(a\cdot x)\,(\gamma\cdot k).(\gamma\cdot x)}{2\,m^2\,\xi\,s\,(k\cdot x)}-\frac{i\,e\zeta\,\text{v1}\,(\gamma\cdot a).(\gamma\cdot x)}{2\,m^2\,\xi\,s}+\text{af}\,\zeta-\frac{1}{2}\,i\,\zeta\,\xi\,\text{v1}\,(k\cdot x)-\frac{\text{v1}\,\gamma\cdot x}{2\,m\,s}+\text{sf}$$

Final result for the electron propagator in a CCF

$$S^c(x_2, x_1) =$$

$$\Lambda^{4-D}\int\frac{d^D p}{(2\pi)^D}\,E_p(x_2)\sum_{\zeta=+-}\frac{i}{2}\left[m\,s(p^2,\ \chi_p)-(\gamma p)\,v_1(p^2,\ \chi_p)-\frac{e^2(\gamma F^2 p)}{m^4}\,v_2(p^2,\ \chi_p)-\frac{e\,\sigma F}{m}\,t(p^2,\ \chi_p)+\frac{e(\gamma F^* p)\,\gamma^5}{m^2}\,a_s(p^2,\ \chi_p)\right]\frac{1+\zeta\,\gamma\epsilon^{(2)}\,\gamma^5}{D_\zeta(p^2,\ \chi_p)}\,E_p^{bar}(x_1) =$$

$$= e^{-i\frac{\pi}{2}\left(\frac{D}{2}-2\right)}\,\frac{m\,\Lambda^{4-D}}{2^{D+2}\,\pi^{D/2+1}}\,e^{i\eta}\sum_{\zeta=+-}\int_0^\infty\frac{ds}{s^{D/2}}\left(\int_0^\infty\frac{dp^2}{D_\zeta(p^2,\ \chi_p(s))}\,e^{-i s p^2-i\frac{x^2}{4s}+i\frac{s}{12}e^2(Fx)^2}\times\left\{s(p^2,\ \chi_p(s))\left[1+\frac{1}{2}\,i\,s\,e\,\sigma F+\zeta\left(\frac{i\,e^2\,s(\gamma\,FFx)}{m\,\xi\,(kx)}+\frac{e\,F_{\alpha\beta}{}^*\,x^\beta\,\gamma^\alpha\,\gamma^5}{m\,\xi\,(kx)}\right)\right]\right.\right.$$

$$+ v_1\left(p^2,\ \chi_p(s)\right)\left[-\frac{(\gamma x)}{2\,m\,s} + \frac{e^2\,s\,(\gamma\,FFx)}{3\,m} - \frac{i\,e\,F_{\alpha\beta}{}^{*}\,x^{\beta}\,\gamma^{\alpha}\,\gamma^5}{2\,m}\right.$$

$$+ \zeta\left(-\frac{1}{2}\,i\,\xi\,(kx) - \frac{e\,\sigma F}{2\,m^2\,\xi\,(kx)}\right.$$

$$\left.\left.\left(i\,(D-3) - \frac{1}{3}\,m^2\,s\,\xi^2\,(kx)^2\right) - \frac{e\,(\gamma F^{*}\,x)\,\gamma^5\,(\gamma x)}{2\,m^2\,\xi\,s\,(kx)}\right)\right]$$

$$+ v_2\left(p^2,\ \chi_p(s)\right)\left[-\frac{2\,s\,e^2\,(\gamma\,FFx)}{m\,\xi^2\,(kx)^2} - \zeta\,\frac{s\,e\,\sigma F}{\xi\,(kx)}\right]$$

$$+ t\left(p^2,\ \chi_p(s)\right)\left[-\frac{2\,s\,e\,\sigma F}{\xi\,(kx)} - \zeta\,\frac{4\,s\,e^2\,(\gamma\,FFx)}{m\,\xi^2\,(kx)^2}\right]$$

$$+ a\left(p^2,\ \chi_p(s)\right)\left[\right.$$

$$\left.\left.\frac{e\,F_{\alpha\beta}{}^{*}\,x^{\beta}\,\gamma^{\alpha}\,\gamma^5}{m\,\xi\,(kx)} + \frac{i\,s\,e^2\,(\gamma\,FFx)}{m\,\xi\,(kx)} + \zeta\left(1 + \frac{1}{2}\,i\,s\,e\,\sigma F\right)\right]\right\}$$

$$+ \int_0^{\infty} d p^2\,\frac{\partial}{\partial\chi_p}\left(\frac{v_1\left(p^2,\ \chi_p\right)}{D_{\zeta}\left(p^2,\ \chi_p\right)}\right) e^{-i\,s\,p^2 - i\,\frac{x^2}{4\,s} + i\,\frac{s}{12}\,e^2\,(Fx)^2}\left[-\frac{i\,e^2\,(\gamma\,FFx)}{2\,m^5\,s\,\xi\,(kx)} - \zeta\,\frac{i\,e\,\sigma F}{4\,m^4\,s}\right]\Bigg)$$

$$= e^{-i\,\frac{\pi}{2}\left(\frac{D}{2}-2\right)}\,\frac{m\,\Lambda^{4-D}}{2^{D+2}\,\pi^{D/2+1}}\,e^{i\,\eta}\sum_{\zeta=+-}\int_0^{\infty}\frac{d s}{s^{D/2}}\int_0^{\infty}\frac{d p^2}{D_{\zeta}\left(p^2,\ \chi_p(s)\right)}\,e^{-i\,s\,p^2 - i\,\frac{x^2}{4\,s} + i\,\frac{s}{12}\,e^2\,(Fx)^2}\ \Bigg\{$$

$$s(p) + \zeta\left[a(p) - \frac{i}{2}\,\xi\,(kx)\,v_1(p)\right]$$

$$-\frac{(\gamma x)}{2\,m\,s}\,v_1(p)$$

$$+ \frac{e^2\,(\gamma F^2\,x)}{m\,\xi^2\,(kx)^2}\left[i\,\zeta\,\xi\,s\,s(p) + \left(\frac{1}{4}\,\xi^2\,s\,(kx)^2 - s\,\frac{p^2}{m^2} + \frac{x^2}{4\,m^2\,s} + \frac{i\,(D-2)}{2\,m^2}\right)\right.$$

$$\left.v_1(p) - 2\,s\,v_2(p) - 4\,\zeta\,s\,t(p) + i\,\xi\,s\,(kx)\,a(p)\right]$$

$$+ \zeta\,\frac{e\,\sigma F}{\xi\,(kx)}\left[i\,\zeta\,\xi\,s\,s(p) + \left(\frac{1}{4}\,\xi^2\,s\,(kx)^2 - s\,\frac{p^2}{m^2} + \frac{x^2}{4\,m^2\,s} - \frac{i\,(D-4)}{2\,m^2}\right)v_1(p) -\right.$$

$$\left.2\,s\,v_2(p) - 4\,\zeta\,s\,t(p) + i\,\xi\,s\,(kx)\,a(p)\right]$$

$$+ \frac{e\,(\gamma F^{*}\,x)\,\gamma^5}{m\,\xi\,(kx)}\left[\zeta\,s(p) - \frac{i}{2}\,\xi\,(kx)\,v_1(p) + a(p)\right]$$

$$-\zeta\,\frac{e\,(\gamma F^{*}\,x)\,\gamma^5\,(\gamma x)}{2\,m^2\,s\,\xi\,(kx)}\,v_1(p)\Bigg\}$$

$$= e^{-i\frac{\pi}{2}\left(\frac{D}{2}-2\right)} \frac{m\,\Lambda^{4-D}}{2^{D+2}\,\pi^{D/2+1}} e^{i\eta} \sum_{\zeta=+-} \int_0^\infty \frac{ds}{s^{D/2}} \int_0^\infty \frac{dp^2}{D_\zeta\left(p^2,\ \chi_p(s)\right)} e^{-i s p^2 - i\frac{x^2}{4s} + i\frac{s}{12} e^2 (Fx)^2} \Bigg\{$$

$$s(p) + \zeta\left[a(p) - \frac{i}{2}\xi(kx)\,v_1(p)\right]$$

$$- \frac{(\gamma x)}{2\,m\,s} v_1(p)$$

$$+ \frac{e^2 (\gamma F^2 x)}{m^3 \xi^2 (kx)^2} m^2 \Bigg[i\,\zeta\,\xi(kx)\,s\,s(p) + \frac{1}{3} s\,\xi^2 (kx)^2\,v_1(p) - 2\,s\,v_2(p) - 4\,\zeta\,s\,t$$

$$(p) + i\,\xi\,s\,(kx)\,a(p) - \frac{i\,\xi(kx)}{2\,m^4\,s} D_\zeta\left(p^2,\ \chi_p(s)\right) \frac{\partial}{\partial\chi_p}\left(\frac{v_1\left(p^2,\ \chi_p\right)}{D_\zeta\left(p^2,\ \chi_p\right)}\right)\Bigg]$$

$$+ \zeta\,\frac{e\,\sigma F}{m^2\,\xi(kx)} m^2 \Bigg[i\,\zeta\,\xi(kx)\,s\,s(p) + \left(\frac{1}{3} s\,\xi^2 (kx)^2 - \frac{i\,(D-3)}{m^2}\right) v_1(p) -$$

$$2\,s\,v_2(p) - 4\,\zeta\,s\,t(p) + i\,\xi\,s\,(kx)\,a(p) -$$

$$\frac{i\,\xi(kx)}{2\,m^4\,s} D_\zeta\left(p^2,\ \chi_p(s)\right) \frac{\partial}{\partial\chi_p}\left(\frac{v_1\left(p^2,\ \chi_p\right)}{D_\zeta\left(p^2,\ \chi_p\right)}\right)\Bigg]$$

$$+ \frac{e\,(\gamma F^* x)\,\gamma^5}{m\,\xi(kx)}\left[\zeta\,s(p) - \frac{i}{2}\xi(kx)\,v_1(p) + a(p)\right]$$

$$- \zeta\,\frac{e\,(\gamma F^* x)\,\gamma^5\,(\gamma x)}{2\,m^2\,s\,\xi(kx)} v_1(p)\Bigg\}$$

$$= e^{-i\frac{\pi}{2}\left(\frac{D}{2}-1\right)} \frac{\Lambda^{4-D}}{2^D\,\pi^{D/2}} m^{D-1} e^{i\eta}$$

$$\int_0^\infty \frac{ds}{s^{D/2}}\Bigg[1 + \frac{m(\gamma x)}{2\,s} + \frac{e\,(\gamma a)(kx)}{2\,m} - \frac{e\,(\gamma k)(ax)}{2\,m} + \frac{e\,(\gamma x)(\gamma a)(\gamma k)}{2\,m} +$$

$$\frac{e\,s\,(\gamma a)(\gamma k)}{m^2} + \frac{e^2\,a^2\,s\,(\gamma k)(kx)}{3\,m^3}\Bigg] e^{-i s - i\frac{m^2 x^2}{4s} + i\frac{s}{12}\frac{e^2}{m^2}(Fx)^2} =$$

$$= e^{-i\frac{\pi}{2}\left(\frac{D}{2}-1\right)} \frac{\Lambda^{4-D}}{2^{D+1}\,\pi^{D/2}} m^D e^{i\eta} \int_0^\infty \frac{ds}{s^{D/2+1}}\left[\frac{2\,s}{m} + \gamma^\alpha\left(g_{\alpha\beta} - \frac{es}{m^2}F_{\alpha\beta} + \frac{e^2 s^2}{3\,m^4} F_{\alpha\lambda} F^\lambda{}_\beta\right) x^\beta\right]$$

$$\left(1 + \frac{i\,es}{2}\sigma^{\alpha\beta} F_{\alpha\beta}\right) e^{-i s - i\frac{m^2 x^2}{4s} + i\frac{s}{12}\frac{e^2}{m^2}(Fx)^2}$$

$\eta = e\,(ax)\,(k,\ (x_1 + x_2)/2),$

$x = x_2 - x_1,$

$e > 0,$

$\sigma^{\alpha\beta} = \frac{i}{2}\left(\gamma^\alpha\gamma^\beta - \gamma^\beta\gamma^\alpha\right),$

$\gamma^5 = \mathrm{i}\gamma^0\, \gamma^1\, \gamma^2\, \gamma^3$,

$$e^{-i\,\frac{\pi}{2}\left(\frac{D}{2}-1\right)}\, \frac{\Lambda^{4-D}}{2^D\, \pi^{D/2}}\, m^{D-1} \to \frac{(-i)\, m^3}{16\, \pi^2},\quad D \to 4$$