TL

Amplitude

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In[∘]:= Ma = I e^2 Spinor[Momentum[p3], m].GA[ν].Spinor[Momentum[p1], m]
        MT[μ, ν] / SP[p1 - p3] Spinor[Momentum[p4], M].GA[μ].Spinor[Momentum[p2], M]
```

Out[∘]=

$$\frac{i e^2 \overline{g}^{\mu\nu} (\varphi(\overline{\mathrm{p3}}, m)).\overline{\gamma}^{\nu}.(\varphi(\overline{\mathrm{p1}}, m)) (\varphi(\overline{\mathrm{p4}}, M)).\overline{\gamma}^{\mu}.(\varphi(\overline{\mathrm{p2}}, M))}{(\overline{\mathrm{p1}} - \overline{\mathrm{p3}})^2}$$

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In[∘]:= X0 = 1/4 Contract[FermionSpinSum[Ma * ComplexConjugate[Ma]]] /. e^4 → alpha^2 * 16 π^2 //
        DiracSimplify // FullSimplify
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Out[∘]=

$$\frac{32 \pi^2 \mathrm{alpha}^2 \left(2 \left(m^2 + M^2 - s\right)^2 + 2 s t + t^2\right)}{t^2}$$

Electron vertex

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In[12]:= Γ[q_, p_, m_, μ_] :=
         - I e^2 PaVeReduce[TID[GAD[ρ].(GSD[p + q + k] + m).GAD[μ].(GSD[p + k] + m).GAD[ρ] ×
            FAD[{k, SmallVariable[λ]}, {p + q + k, m}, {p + k, m}], k, ToPaVe → True]]

In[13]:= δ1[m_] := ((-e^2) / (8 π^2)) (1 / (2 Epsilon) + (1 / 2) Log[4 π] +
            (1 / 2) Log[ScaleMu^2 / m^2] + (5 - EulerGamma) / 2 + Log[SmallVariable[λ]^2 / m^2])

In[14]:= ΓRenE := 1/(16 π^4) Γ[p2 - p4, p1, m, ν] + GAD[ν] × δ1[m]

In[15]:= VertexERen = I e^2 Spinor[Momentum[p3], m].ΓRenE.Spinor[Momentum[p1], m]
         MT[μ, ν] / SP[p1 - p3] Spinor[Momentum[p4], M].GAD[μ].Spinor[Momentum[p2], M];
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In[18]:=
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1/4 ChangeDimension[Contract[FermionSpinSum[ComplexConjugate[Ma] * VertexERen]], D] //
  DiracSimplify;
X2 = % /. e^6 → alpha^3 * 64 * π^3 // FullSimplify
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Out[19]=

$$-\frac{1}{\varepsilon t^2 (t-4m^2)^2} 4\,\text{alpha}^3 \pi \Big(-8(D-2)\varepsilon(4m^2-t)\left((m^2+M^2-s)^2+(s-M^2)t\right)B_0(0,m^2,m^2)m^2-(4m^2-t)\Big(8(\varepsilon(D+2(-6+\gamma))-2)m^6+4\left(4(\varepsilon(D+2(-6+\gamma))-2)(M^2-s)-\varepsilon(-5+\gamma)t+t\right)m^4+4\Big(2(\varepsilon(D+2(-6+\gamma))-2)(M^2-s)^2+(D-2)(\varepsilon(-5+\gamma)-1)t^2+2\left(-\varepsilon(D+\gamma-7)M^2+M^2+\varepsilon(D+3\gamma-17)s-3s\right)t\Big)m^2-(\varepsilon(-5+\gamma)-1)t\left(4(M^2-s)^2+(D-2)t^2+4st\right)-\varepsilon(4m^2-t)\left(4(m^2+M^2-s)^2+(D-2)t^2+4st\right)\left(\log\left(\frac{4\pi\mu^2}{m^2}\right)+2\log\left(\frac{\lambda^2}{m^2}\right)\right)\Big)-2\varepsilon B_0(m^2,m^2,\lambda^2)\Big(\Big((D-2)t^3-4((D-2)(m-M)(m+M)+(D-3)s)t^2-4\Big((D-3)m^4+2\left((5D-9)M^2-5Ds+11s\right)m^2+(D-3)(M^2-s)^2\Big)t+32(D-2)m^2(m^2+M^2-s)^2\Big)\lambda^2+2(4m^2-t)\Big(-((D-2)t^3)+4((D-2)m^2-s)t^2-4\left(m^4-4sm^2+(M^2-s)^2\right)t+8m^2(m^2+M^2-s)^2\Big)\Big)+\varepsilon\Big(B_0(t,m^2,m^2)\Big(2\Big((D-2)t^3+4\left(s-(D-2)m^2\right)t^2+4\left(m^4+((6-4D)M^2+2(2D-5)s)m^2+(M^2-s)^2\right)t+16(D-2)m^2(m^2+M^2-s)^2\Big)\lambda^2+(4m^2-t)\Big((D-7)(D-2)t^3-4(D-7)((D-2)m^2-s)t^2+4\Big((D-7)m^4-2\left((D-3)M^2+(D-11)s\right)m^2+(D-7)(M^2-s)^2\Big)t+32m^2(m^2+M^2-s)^2\Big)\Big)+C_0(m^2,m^2,t,m^2,\lambda^2,m^2)\Big(2\Big((D-2)t^3+4\left(s-(D-2)m^2\right)t^2+4\Big(m^4+((6-4D)M^2+2(2D-5)s)m^2+(M^2-s)^2\Big)t+16(D-2)m^2(m^2+M^2-s)^2\Big)\lambda^4+(t-4m^2)\Big(-((D-8)(D-2)t^3)+4(D-8)((D-2)m^2-s)t^2-4\Big((D-8)m^4+2\left(DM^2-3Ds+16s\right)m^2+(D-8)(M^2-s)^2\Big)t+16(D-4)m^2(m^2+M^2-s)^2\Big)\lambda^2-2(2m^2-t)(t-4m^2)^2\left(4(m^2+M^2-s)^2+(D-2)t^2+4st\right)\Big)\Big)\Big)$$

In[20]:=
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PaXEvaluateUV[X2] // FullSimplify
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Out[20]=

$$\frac{64\pi\,\text{alpha}^3\lambda^2\left((m^2+M^2-s)^2+t(s-M^2)\right)}{t^2(4m^2-t)\varepsilon_{\text{UV}}}$$