Anexos

A. Producción de pares en DSR

In[∘]:= `Solve[Refine[e^2 - p^2 + α1 / M * e^3 + α2 / M * e * p^2 - m^2, e ∈ Reals && e > 0 && p > 0] == 0, e]`

resue·· refina números reales

Out[∘]=
$$\left\{\left\{e \to -\frac{M}{3\,\alpha1} - \left(2^{1/3}\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)\right) \Big/ \left(3\,\alpha1\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right) + \frac{1}{3 \times 2^{1/3}\,\alpha1}\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right\},$$

$$\left\{e \to -\frac{M}{3\,\alpha1} + \left(\left(1 + i\sqrt{3}\right)\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)\right) \Big/ \left(3 \times 2^{2/3}\,\alpha1\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right) - \frac{1}{6 \times 2^{1/3}\,\alpha1}\left(1 - i\sqrt{3}\right)\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right\},$$

$$\left\{e \to -\frac{M}{3\,\alpha1} + \left(\left(1 - i\sqrt{3}\right)\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)\right) \Big/ \left(3 \times 2^{2/3}\,\alpha1\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right) - \frac{1}{6 \times 2^{1/3}\,\alpha1}\left(1 + i\sqrt{3}\right)\left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2 + \sqrt{4\left(-M^2 + 3\,p^2\,\alpha1\,\alpha2\right)^3 + \left(-2\,M^3 + 27\,m^2\,M\,\alpha1^2 + 27\,M\,p^2\,\alpha1^2 + 9\,M\,p^2\,\alpha1\,\alpha2\right)^2}\right)^{1/3}\right\}\right\}$$

In[∘]:= `m = a * ϵ;`

In[∘]:= Refine[Normal[Series[$-\frac{M}{3\,\alpha 1}-\left(2^{1/3}\left(-M^2+3\,p^2\,\alpha 1\,\alpha 2\right)\right)\Big/\left(3\,\alpha 1\left(-2\,M^3+27\,m^2\,M\,\alpha 1^2+27\,M\,p^2\,\alpha 1^2+9\,M\,p^2\,\alpha 1\,\alpha 2+\sqrt{4\left(-M^2+3\,p^2\,\alpha 1\,\alpha 2\right)^3+\left(-2\,M^3+27\,m^2\,M\,\alpha 1^2+27\,M\,p^2\,\alpha 1^2+9\,M\,p^2\,\alpha 1\,\alpha 2\right)^2}\right)^{1/3}\right)+\frac{1}{3\times 2^{1/3}\,\alpha 1}\left(-2\,M^3+27\,m^2\,M\,\alpha 1^2+27\,M\,p^2\,\alpha 1^2+9\,M\,p^2\,\alpha 1\,\alpha 2+\sqrt{4\left(-M^2+3\,p^2\,\alpha 1\,\alpha 2\right)^3+\left(-2\,M^3+27\,m^2\,M\,\alpha 1^2+27\,M\,p^2\,\alpha 1^2+9\,M\,p^2\,\alpha 1\,\alpha 2\right)^2}\right)^{1/3}$,
{M, Infinity, 1}, {ϵ, 0, 2}]], p > 0 && a > 0]

refina normal serie infinito

Out[∘]=
$$\frac{-(-1)^{1/3}\sqrt{3}\,p\,\sqrt{-M^4\,\alpha 1^2}-(-1)^{2/3}\sqrt{3}\,p\,\sqrt{-M^4\,\alpha 1^2}}{3\,M^2\,\alpha 1}+\frac{\left(-(-1)^{1/3}\sqrt{3}\,a^2\,p\,\sqrt{-M^4\,\alpha 1^2}-(-1)^{2/3}\sqrt{3}\,a^2\,p\,\sqrt{-M^4\,\alpha 1^2}\right)\epsilon^2}{6\,M^2\,p^2\,\alpha 1}+\frac{1}{M}\left(\frac{1}{2}\left(-(-1)^{1/3}\,p^2\,\alpha 1+(-1)^{2/3}\,p^2\,\alpha 1-(-1)^{1/3}\,p^2\,\alpha 2+(-1)^{2/3}\,p^2\,\alpha 2\right)+\frac{1}{2}\left(-(-1)^{1/3}\,a^2\,\alpha 1+(-1)^{2/3}\,a^2\,\alpha 1\right)\epsilon^2\right)$$

In[∘]:= ϵ = 1;

In[∘]:= Simplify[$\frac{-(-1)^{1/3}\sqrt{3}\,p\,\sqrt{-M^4\,\alpha 1^2}-(-1)^{2/3}\sqrt{3}\,p\,\sqrt{-M^4\,\alpha 1^2}}{3\,M^2\,\alpha 1}+\frac{\left(-(-1)^{1/3}\sqrt{3}\,a^2\,p\,\sqrt{-M^4\,\alpha 1^2}-(-1)^{2/3}\sqrt{3}\,a^2\,p\,\sqrt{-M^4\,\alpha 1^2}\right)\epsilon^2}{6\,M^2\,p^2\,\alpha 1}+\frac{1}{M}\left(\frac{1}{2}\left(-(-1)^{1/3}\,p^2\,\alpha 1+(-1)^{2/3}\,p^2\,\alpha 1-(-1)^{1/3}\,p^2\,\alpha 2+(-1)^{2/3}\,p^2\,\alpha 2\right)+\frac{1}{2}\left(-(-1)^{1/3}\,a^2\,\alpha 1+(-1)^{2/3}\,a^2\,\alpha 1\right)\epsilon^2\right)$]

simplifica

Out[∘]=
$$\frac{a^2\left(-3\,M\,p\,\alpha 1^2-3\,i\,\sqrt{-M^4\,\alpha 1^2}\right)-3\,p^2\left(2\,i\,\sqrt{-M^4\,\alpha 1^2}+M\,p\,\alpha 1\,(\alpha 1+\alpha 2)\right)}{6\,M^2\,p\,\alpha 1}$$

In[∘]:= Refine[$\frac{a^2\left(-3\,M\,p\,\alpha 1^2-3\,i\,\sqrt{-M^4\,\alpha 1^2}\right)-3\,p^2\left(2\,i\,\sqrt{-M^4\,\alpha 1^2}+M\,p\,\alpha 1\,(\alpha 1+\alpha 2)\right)}{6\,M^2\,p\,\alpha 1}$,
M > 0 && α1 > 0 && α2 > 0]

refina

Out[∘]=
$$\frac{a^2\left(3\,M^2\,\alpha 1-3\,M\,p\,\alpha 1^2\right)-3\,p^2\left(-2\,M^2\,\alpha 1+M\,p\,\alpha 1\,(\alpha 1+\alpha 2)\right)}{6\,M^2\,p\,\alpha 1}$$

In[∘]:= Simplify[$\frac{a^2\left(3\,M^2\,\alpha 1-3\,M\,p\,\alpha 1^2\right)-3\,p^2\left(-2\,M^2\,\alpha 1+M\,p\,\alpha 1\,(\alpha 1+\alpha 2)\right)}{6\,M^2\,p\,\alpha 1}$]

simplifica

Out[∘]=
$$\frac{2\,M\,p^2+a^2\,(M-p\,\alpha 1)-p^3\,(\alpha 1+\alpha 2)}{2\,M\,p}$$

Esta es la expresión de la energía E (p).

```
In[•]:= e[p_, m_] := (2 * M * p^2 + M * m^2 - p^3 * (α1 + α2)) / (2 * M * p);
```

Ecuación de conservación del momento para obtener p (el momento del electrón/positrón) en función de k (momento del fotón).

```
In[•]:= Clear[ϵ];
        borra
```

```
In[•]:= a = me * ϵ; c = ω * ϵ;
```

Lado izquierdo de la ecuación.

```
In[•]:= Refine[Normal[Series[k - c - γ1 * e[k, 0] * c / M + γ2 * k * c / M, {M, Infinity, 0}, {ϵ, 0, 2}]],
        refina  normal  serie                                                  infinito
         me > 0 && k > 0 && ω > 0]
```

Out[•]= $k - \epsilon\,\omega$

Lado derecho de la ecuación.

```
In[•]:= Refine[Normal[Series[2 * p + (γ1 + γ2) * e[p, a] * p / M, {M, Infinity, 1}, {ϵ, 0, 2}]],
        refina  normal  serie                                      infinito
         me > 0 && k > 0 && ω > 0]
```

Out[•]= $2\,p + \frac{p^2\,(\gamma1 + \gamma2) + \frac{1}{2}\,me^2\,(\gamma1 + \gamma2)\,\epsilon^2}{M}$

```
In[•]:= Solve[k - ω == 2 * p + p^2 * (γ1 + γ2) / M, p]
        resuelve
```

Out[•]= $\left\{\left\{p \to \frac{-1 - \frac{\sqrt{M + k\,\gamma1 + k\,\gamma2 - \gamma1\,\omega - \gamma2\,\omega}}{\sqrt{M}}}{\frac{\gamma1}{M} + \frac{\gamma2}{M}}\right\}, \left\{p \to \frac{-1 + \frac{\sqrt{M + k\,\gamma1 + k\,\gamma2 - \gamma1\,\omega - \gamma2\,\omega}}{\sqrt{M}}}{\frac{\gamma1}{M} + \frac{\gamma2}{M}}\right\}\right\}$

Elegimos la segunda que es la positiva.

In[•]:= $\text{Refine}\left[\text{Normal}\left[\text{Series}\left[\frac{-1 + \frac{\sqrt{M + k\,\gamma1 + k\,\gamma2 - \gamma1\,\omega - \gamma2\,\omega}}{\sqrt{M}}}{\frac{\gamma1}{M} + \frac{\gamma2}{M}}, \{M, \text{Infinity}, 1\}, \{\epsilon, 0, 2\}\right]\right],\right.$
refina normal serie infinito

$\left.\text{me} > 0\ \&\&\ k > 0\ \&\&\ \omega > 0\right]$

Out[•]= $\frac{k - \omega}{2} - \frac{(\gamma1 + \gamma2)\,(k - \omega)^2}{8\,M}$

```
In[•]:= mome = (k - c) / 2 - k^2 * (γ1 + γ2) / (8 * M);
```

Ecuación de conservación de la energía.

In[∘]:=
```
Refine[Normal[Series[e[k, 0] + c, {M, Infinity, 1}, {ϵ, 0, 0}]], me > 0 && k > 0 && ω > 0] -
  Refine[Normal[Series[e[k, 0] + c, {M, Infinity, 0}, {ϵ, 0, 0}]], me > 0 && k > 0 && ω > 0] +
  Refine[Normal[Series[e[k, 0] + c, {M, Infinity, 0}, {ϵ, 0, 2}]], me > 0 && k > 0 && ω > 0] ==
 Refine[Normal[Series[2 * e[mome, a] + β1 * (e[mome, a]) ^2 / M + β2 * mome^2 / M,
     {M, Infinity, 1}, {ϵ, 0, 0}]], me > 0 && k > 0 && ω > 0] -
  Refine[Normal[Series[2 * e[mome, a] + β1 * (e[mome, a]) ^2 / M + β2 * mome^2 / M,
     {M, Infinity, 0}, {ϵ, 0, 0}]], me > 0 && k > 0 && ω > 0] +
  Refine[Normal[Series[2 * e[mome, a] + β1 * (e[mome, a]) ^2 / M + β2 * mome^2 / M,
     {M, Infinity, 0}, {ϵ, 0, 2}]], me > 0 && k > 0 && ω > 0]
```

Out[∘]=
$$k-\frac{k^2\,(\alpha 1+\alpha 2)}{2\,M}+\epsilon\,\omega == k+\frac{-k^2\,\alpha 1-k^2\,\alpha 2+k^2\,\beta 1+k^2\,\beta 2-k^2\,\gamma 1-k^2\,\gamma 2}{4\,M}+\frac{2\,me^2\,\epsilon^2}{k}-\epsilon\,\omega$$

In[∘]:=
```
ϵ = 1;
```

In[∘]:=
```
Simplify[k - k^2 (α1 + α2)/(2 M) + ϵ ω == k + (-k^2 α1 - k^2 α2 + k^2 β1 + k^2 β2 - k^2 γ1 - k^2 γ2)/(4 M) + 2 me^2 ϵ^2/k - ϵ ω]
```

Out[∘]=
$$\frac{8\,me^2}{k}+\frac{k^2\,(\alpha 1+\alpha 2+\beta 1+\beta 2-\gamma 1-\gamma 2)}{M} == 8\,\omega$$

B. Fotoproducción de piones en DSR

In[ ]:= `e[p_, m_] := (2 * M * p^2 + M * m^2 - p^3 * (α1 + α2)) / (2 * M * p);`

In[ ]:= `a = mp * ϵ; b = mpi * ϵ; c = ω * ϵ;`

In[ ]:= `momp = mompi * a / b;`

In[ ]:= `Refine[Normal[Series[momp + mompi + γ1 * e[momp, a] * mompi / M + γ2 * momp * e[mompi, b] / M, {M, Infinity, 1}, {ϵ, 0, 2}]], mp > 0 && mpi > 0 && k > 0 && ω > 0]`
refina normal serie infinito

Out[ ]= $$\text{mompi} + \frac{\text{mompi mp}}{\text{mpi}} + \frac{\frac{\text{mompi}^2\,\text{mp}\,\gamma1 + \text{mompi}^2\,\text{mp}\,\gamma2}{\text{mpi}} + \frac{1}{2}\left(\text{mp mpi}\,\gamma1 + \text{mp mpi}\,\gamma2\right)\epsilon^2}{M}$$

In[ ]:= `ϵ = 1;`

In[ ]:= $$\text{Simplify}\left[\text{mompi} + \frac{\text{mompi mp}}{\text{mpi}} + \frac{\frac{\text{mompi}^2\,\text{mp}\,\gamma1 + \text{mompi}^2\,\text{mp}\,\gamma2}{\text{mpi}} + \frac{1}{2}\left(\text{mp mpi}\,\gamma1 + \text{mp mpi}\,\gamma2\right)\epsilon^2}{M}\right]$$
simplifica

Out[ ]= $$\frac{2\,M\,\text{mompi}\,(\text{mp} + \text{mpi}) + \text{mp}\,(2\,\text{mompi}^2 + \text{mpi}^2)\,(\gamma1 + \gamma2)}{2\,M\,\text{mpi}}$$

In[ ]:= $$\text{Solve}\left[k - \omega == \frac{2\,M\,\text{mompi}\,(\text{mp} + \text{mpi}) + \text{mp}\,(2\,\text{mompi}^2)\,(\gamma1 + \gamma2)}{2\,M\,\text{mpi}}, \text{mompi}\right]$$
resuelve

Out[ ]= $$\left\{\left\{\text{mompi} \to \frac{-1 - \frac{\text{mp}}{\text{mpi}} - \sqrt{\left(-1 - \frac{\text{mp}}{\text{mpi}}\right)^2 - 4\left(-\frac{\text{mp}\,\gamma1}{M\,\text{mpi}} - \frac{\text{mp}\,\gamma2}{M\,\text{mpi}}\right)(k - \omega)}}{2\left(\frac{\text{mp}\,\gamma1}{M\,\text{mpi}} + \frac{\text{mp}\,\gamma2}{M\,\text{mpi}}\right)}\right\},\right.$$
$$\left.\left\{\text{mompi} \to \frac{-1 - \frac{\text{mp}}{\text{mpi}} + \sqrt{\left(-1 - \frac{\text{mp}}{\text{mpi}}\right)^2 - 4\left(-\frac{\text{mp}\,\gamma1}{M\,\text{mpi}} - \frac{\text{mp}\,\gamma2}{M\,\text{mpi}}\right)(k - \omega)}}{2\left(\frac{\text{mp}\,\gamma1}{M\,\text{mpi}} + \frac{\text{mp}\,\gamma2}{M\,\text{mpi}}\right)}\right\}\right\}$$

In[ ]:= `Clear[ϵ];`
borra

In[ ]:= Refine[
refina

$$\text{Normal}\left[\text{Series}\left[\frac{-1 - \frac{a}{b} + \sqrt{\left(-1 - \frac{a}{b}\right)^2 - 4\left(-\frac{a\,\gamma1}{M\,b} - \frac{a\,\gamma2}{M\,b}\right)(k - c)}}{2\left(\frac{a\,\gamma1}{M\,b} + \frac{a\,\gamma2}{M\,b}\right)}, \{M, \text{Infinity}, 1\}, \{\epsilon, 0, 2\}\right]\right],$$
normal serie infinito

`mp > 0 && mpi > 0 && k > 0 && ω > 0]`

Out[ ]= $$\frac{k\,\text{mpi}}{\text{mp} + \text{mpi}} + \frac{M\,\text{mpi}\left(-1 - \frac{\text{mp}}{\text{mpi}} + \frac{\text{mp}+\text{mpi}}{\text{mpi}}\right)}{2\,\text{mp}\,(\gamma1 + \gamma2)} - \frac{\text{mpi}\,\epsilon\,\omega}{\text{mp} + \text{mpi}} + \frac{-\frac{k^2\,\text{mp}\,\text{mpi}^2\,(\gamma1+\gamma2)}{(\text{mp}+\text{mpi})^3} + \frac{2\,k\,\text{mp}\,\text{mpi}^2\,(\gamma1+\gamma2)\,\epsilon\,\omega}{(\text{mp}+\text{mpi})^3} - \frac{\text{mp}\,\text{mpi}^2\,(\gamma1+\gamma2)\,\epsilon^2\,\omega^2}{(\text{mp}+\text{mpi})^3}}{M}$$

In[ ]:= `ϵ = 1;`

In[ ]:=
$$\text{Simplify}\left[\frac{k\,\text{mpi}}{\text{mp}+\text{mpi}}+\frac{M\,\text{mpi}\left(-1-\frac{\text{mp}}{\text{mpi}}+\frac{\text{mp}+\text{mpi}}{\text{mpi}}\right)}{2\,\text{mp}\,(\gamma 1+\gamma 2)}-\right.$$
$$\left.\frac{\text{mpi}\,\epsilon\,\omega}{\text{mp}+\text{mpi}}+\frac{-\frac{k^2\,\text{mp}\,\text{mpi}^2\,(\gamma 1+\gamma 2)}{(\text{mp}+\text{mpi})^3}+\frac{2\,k\,\text{mp}\,\text{mpi}^2\,(\gamma 1+\gamma 2)\,\epsilon\,\omega}{(\text{mp}+\text{mpi})^3}-\frac{\text{mp}\,\text{mpi}^2\,(\gamma 1+\gamma 2)\,\epsilon^2\,\omega^2}{(\text{mp}+\text{mpi})^3}}{M}\right]$$
simplifica

Out[ ]=
$$\frac{\text{mpi}\left(M\,(\text{mp}+\text{mpi})^2-\text{mp}\,\text{mpi}\,(\gamma 1+\gamma 2)\,(k-\omega)\right)(k-\omega)}{M\,(\text{mp}+\text{mpi})^3}$$

Definimos el momento del pion a partir del del fotón incidente.

In[ ]:=
```
Clear[ϵ];
```
borra

In[ ]:=
```
mompi = (b * M * (a + b) ^2 * (k - c) - a * b^2 * (γ1 + γ2) * k^2) / (M * (a + b) ^3);
```

In[ ]:=
```
momp = mompi * a / b;
```

In[ ]:=
```
Refine[Normal[Series[e[k, a] + c, {M, Infinity, 1}, {ϵ, 0, 0}]],
   mp > 0 && mpi > 0 && k > 0 && ω > 0] -
  Refine[Normal[Series[e[k, a] + c, {M, Infinity, 0}, {ϵ, 0, 0}]],
   mp > 0 && mpi > 0 && k > 0 && ω > 0] +
  Refine[Normal[Series[e[k, a] + c, {M, Infinity, 0}, {ϵ, 0, 2}]],
   mp > 0 && mpi > 0 && k > 0 && ω > 0] ==
 Refine[Normal[Series[e[momp, a] + e[mompi, b] + β1 * e[momp, a] * e[mompi, b] / M +
      β2 * momp * mompi / M, {M, Infinity, 1}, {ϵ, 0, 0}]], mp > 0 && mpi > 0 && k > 0 && ω > 0] -
  Refine[Normal[Series[e[momp, a] + e[mompi, b] + β1 * e[momp, a] * e[mompi, b] / M +
      β2 * momp * mompi / M, {M, Infinity, 0}, {ϵ, 0, 0}]], mp > 0 && mpi > 0 && k > 0 && ω > 0] +
  Refine[Normal[Series[e[momp, a] + e[mompi, b] + β1 * e[momp, a] * e[mompi, b] / M +
      β2 * momp * mompi / M, {M, Infinity, 0}, {ϵ, 0, 2}]], mp > 0 && mpi > 0 && k > 0 && ω > 0]
```
refina normal serie infinito

Out[ ]=
$$k-\frac{k^2\,(\alpha 1+\alpha 2)}{2\,M}+\frac{\text{mp}^2\,\epsilon^2}{2\,k}+\epsilon\,\omega==$$
$$k+\frac{1}{2\,M\,(\text{mp}+\text{mpi})^2}\left(-k^2\,\text{mp}^2\,\alpha 1-k^2\,\text{mpi}^2\,\alpha 1-k^2\,\text{mp}^2\,\alpha 2-k^2\,\text{mpi}^2\,\alpha 2+2\,k^2\,\text{mp}\,\text{mpi}\,\beta 1+\right.$$
$$\left.2\,k^2\,\text{mp}\,\text{mpi}\,\beta 2-2\,k^2\,\text{mp}\,\text{mpi}\,\gamma 1-2\,k^2\,\text{mp}\,\text{mpi}\,\gamma 2\right)+\frac{(\text{mp}^2+2\,\text{mp}\,\text{mpi}+\text{mpi}^2)\,\epsilon^2}{2\,k}-\epsilon\,\omega$$

In[ ]:=
```
ϵ = 1;
```

In[∘]:= Simplify[k - (k^2 (α1 + α2))/(2 M) + (mp^2 ϵ^2)/(2 k) + ϵ ω ==
simplifica

$$k + \frac{1}{2\,M\,(mp + mpi)^2}\left(-k^2\,mp^2\,\alpha 1 - k^2\,mpi^2\,\alpha 1 - k^2\,mp^2\,\alpha 2 - k^2\,mpi^2\,\alpha 2 + 2\,k^2\,mp\,mpi\,\beta 1 + 2\,k^2\,mp\,mpi\,\beta 2 - 2\,k^2\,mp\,mpi\,\gamma 1 - 2\,k^2\,mp\,mpi\,\gamma 2\right) + \frac{(mp^2 + 2\,mp\,mpi + mpi^2)\,\epsilon^2}{2\,k} - \epsilon\,\omega]$$

Out[∘]=

$$\frac{2\,k^2\,mp\,mpi\,(\alpha 1 + \alpha 2 + \beta 1 + \beta 2 - \gamma 1 - \gamma 2)}{M\,(mp + mpi)} + \frac{(mp + mpi)\,(2\,mp\,mpi + mpi^2 - 4\,k\,\omega)}{k} == 0$$