```
In[268]:= MQF[f_] := \{\{
         1,0},{
         1/f, 1\}
     MQD[f_] := \{\{
         1,0},{
         -1/f, 1\}
     MDrift[s_] := {{
         1, s}, {
         0, 1}}
     MFodoHalfx[fQF_, fQD_, s1_, s2_] := MQF[fQF].MDrift[s1].MQD[fQD].MDrift[s2]
     MFodox[fQF_, fQD_, s1_, s2_] := MFodoHalfx[fQF, fQD, s1, s2].MFodoHalfx[fQF, fQD, s1, s2]
     \label{eq:mfodoHalfy} $$ MFodoHalfy[fQF_, fQD_, s1_, s2_] := MQD[fQD].MDrift[s1].MQF[fQF].MDrift[s2] $$
     MFodoy[fQF_, fQD_, s1_, s2_] := MFodoHalfy[fQF, fQD, s1, s2].MFodoHalfy[fQF, fQD, s1, s2]
      gamma[alpha_, beta_] := (1 + alpha^2) / beta
     Mbeta0[alpha_, beta_] := {{
         beta, -alpha},
        {-alpha, gamma[alpha, beta]
        }}
     MbetaHalfx[fQF_, fQD_, s1_, s2_, alpha_, beta_] :=
       (MFodoHalfx[fQF, fQD, s1, s2].Mbeta0[alpha, beta]).
        Transpose[MFodoHalfx[fQF, fQD, s1, s2]]
     Mbetax[fQF_, fQD_, s1_, s2_, alpha_, beta_] :=
       MFodox[fQF, fQD, s1, s2].Mbeta0[alpha, beta].Transpose[MFodox[fQF, fQD, s1, s2]]
     MbetaHalfy[fQF_, fQD_, s1_, s2_, alpha_, beta_] :=
       (MFodoHalfy[fQF, fQD, s1, s2].Mbeta0[alpha, beta]).
        Transpose[MFodoHalfy[fQF, fQD, s1, s2]]
     Mbetay[fQF_, fQD_, s1_, s2_, alpha_, beta_] :=
       MFodoy[fQF, fQD, s1, s2].Mbeta0[alpha, beta].Transpose[MFodoy[fQF, fQD, s1, s2]]
      alpha0 = 0;
      alphaHalf = 0;
      alphaEnd = 0;
     MbetaHalfx[fQF, fQD, s1, s2, alpha0, beta0]
     Solve[MbetaHalfx[fQF, fQD, s1, s2, alpha0, beta0] ==
        {{betaStar, 0}, {0, 1/betaStar}}, {fQF, fQD}]
     ChromX = 1/(4 * Pi) * (1/fQF * beta0 - 1/fQD * (beta0 + s1 * * 2/beta0))
```

```
Out[284]= \left\{ \left\{ beta0 \left( 1 - \frac{s1}{fOD} \right)^2 + \frac{\left( s1 + \left( 1 - \frac{s1}{fOD} \right) s2 \right)^2}{bota0} \right\} \right\}
                                         \text{beta0} \ \left(1 - \frac{\text{s1}}{\text{fQD}}\right) \ \left(\frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQE}}}{\text{fQD}}\right) + \frac{\left(\text{s1} + \left(1 - \frac{\text{s1}}{\text{fQD}}\right) \text{ s2}\right) \ \left(1 + \frac{\text{s1}}{\text{fQF}} + \left(\frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQF}}}{\text{fQD}}\right) \text{ s2}\right)}{\text{beta0}}\right\},
                                    \left\{ \text{beta0} \ \left( 1 - \frac{\text{s1}}{\text{fQD}} \right) \ \left( \frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQF}}}{\text{fQD}} \right) + \frac{\left( \text{s1} + \left( 1 - \frac{\text{s1}}{\text{fQD}} \right) \ \text{s2} \right) \ \left( 1 + \frac{\text{s1}}{\text{fQF}} + \left( \frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQF}}}{\text{fQD}} \right) \ \text{s2} \right)}{\text{beta0}} \right. \right\},
                                         \text{beta0} \left( \frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQF}}}{\text{fQD}} \right)^2 + \frac{\left(1 + \frac{\text{s1}}{\text{fQF}} + \left(\frac{1}{\text{fQF}} - \frac{1 + \frac{\text{s1}}{\text{fQF}}}{\text{fQD}}\right) \text{ s2}\right)^2}{\text{beta0}} \right\} \right\}
Out[285] = \left\{ \left\{ fQF \rightarrow \left[ -beta0^2 betaStar s1 + beta0 betaStar^2 s1 - betaStar s1^2 s2 - betaStar s1^2 s2
                                                                 betaStar\ s1\ s2^2 + \frac{beta0^4\ betaStar\ s1}{beta0^2\ -\ beta0\ betaStar\ +\ s1^2\ +\ 2\ s1\ s2\ +\ s2^2}\ -
                                                                                                                     beta0³ betaStar² s1
                                                                    beta0^2 – beta0 beta3tar + 31^2 + 2 s1 s2 + s2^2
                                                                                                          beta0<sup>2</sup> betaStar s1<sup>3</sup>
                                                                    beta0^2 - beta0 beta1 + 1^2 + 2
                                                                                                         3 beta0<sup>2</sup> betaStar s1<sup>2</sup> s2
                                                                    beta0 betaStar<sup>2</sup> s1<sup>2</sup> s2
                                                                    beta0^2 – beta0 beta3tar + 1^2 + 2 1 1 1 1 1 1
                                                                    \frac{\text{betaStar s1}^4 \text{ s2}}{\text{beta0}^2 - \text{beta0 betaStar} + \text{s1}^2 + 2 \text{ s1 s2} + \text{s2}^2} +
                                                                                                          2 beta0<sup>2</sup> betaStar s1 s2<sup>2</sup>
                                                                    beta0^2 - beta0 beta1^2 + 2 s1 s2 + s2
                                                                                                         beta0 betaStar² s1 s2²
                                                                    beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                                                    \frac{3 \text{ betaStar s1}^3 \text{ s2}^2}{\text{beta0}^2 - \text{beta0 betaStar} + \text{s1}^2 + 2 \text{ s1 s2} + \text{s2}^2} + \\
                                                                                                      3 betaStar s1<sup>2</sup> s2<sup>3</sup>
                                                                    \frac{1}{\text{beta}} beta 0 beta Star + s1<sup>2</sup> + 2 s1 s2 + s2<sup>2</sup>
                                                                                                                            betaStar s1 s2<sup>4</sup>
                                                                    beta0^2 - beta0 beta1 + 1^2 + 2
                                                                    beta0^2 beta3tar \sqrt{b}eta0^3 beta3tar 1^2 – beta0^2 1^4 + beta0 beta3tar 1^2 1^2
                                                                                                                                                beta0^{2} - beta0 betaStar + s1^{2} + 2 s1 s2 + s2^{2}
                                                                    beta0 betaStar<sup>2</sup> \sqrt{\text{beta0}^3 \text{ betaStar s1}^2 - \text{beta0}^2 \text{ s1}^4 + \text{beta0 betaStar s1}^2 \text{ s2}^2}
                                                                                                                                                beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                                                    betaStar s1^2 \sqrt{\text{beta0}^3 \text{ betaStar s1}^2 - \text{beta0}^2 \text{ s1}^4 + \text{beta0 betaStar s1}^2 \text{ s2}^2}
                                                                                                                                        beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                                                    2 betaStar s1 s2 \sqrt{\text{beta0}^3 \text{ betaStar s1}^2 - \text{beta0}^2 \text{ s1}^4 + \text{beta0 betaStar s1}^2 \text{ s2}^2}
                                                                                                                                                beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                                                    \frac{\text{betaStar s2}^2 \; \sqrt{\text{beta0}^3 \; \text{betaStar s1}^2 - \text{beta0}^2 \; \text{s1}^4 + \text{beta0 betaStar s1}^2 \; \text{s2}^2}}{\text{beta0}^2 - \text{beta0 betaStar + s1}^2 + 2 \; \text{s1 s2} + \text{s2}^2}}\right) \bigg/
                                                         (beta0<sup>2</sup> betaStar - beta0 betaStar<sup>2</sup> - beta0 s1<sup>2</sup> + betaStar s2<sup>2</sup>), fQD →
                                                 \frac{\text{beta0}^2 \; \text{s1} + \text{s1}^2 \; \text{s2} + \text{s1} \; \text{s2}^2 - \sqrt{\text{beta0}^3 \; \text{betaStar} \; \text{s1}^2 - \text{beta0}^2 \; \text{s1}^4 + \text{beta0} \; \text{betaStar} \; \text{s1}^2 \; \text{s2}^2}}{\text{beta0}^2 - \text{beta0} \; \text{betaStar} + \text{s1}^2 + 2 \; \text{s1} \; \text{s2} + \text{s2}^2}}\right\},
                                     \left\{ \text{fQF} \rightarrow \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0 betaStar}^2 \text{ s1} - \text{betaStar s1}^2 \text{ s2} - \text{betaStar s1}^2 \right] \right\} = \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0 betaStar}^2 \right] = \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0} \right] = \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0} \right] = \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0} \right] = \left[ -\text{beta0}^2 \text{ betaStar s1} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} \right] = \left[ -\text{beta0} + \text{beta0} + \text{beta0
                                                                 betaStar\ s1\ s2^2 + \frac{beta0^4\ betaStar\ s1}{beta0^2\ -\ beta0\ betaStar\ +\ s1^2\ +\ 2\ s1\ s2\ +\ s2^2}\ -
```

```
beta0<sup>3</sup> betaStar<sup>2</sup> s1
                      beta0<sup>2</sup> betaStar s1<sup>3</sup>
                      beta0^2 – beta0 beta3tar + 1^2 + 2 s1 s2 + 1^2
                                    3 beta0<sup>2</sup> betaStar s1<sup>2</sup> s2
                      beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                    beta0 betaStar<sup>2</sup> s1<sup>2</sup> s2
                      beta0<sup>2</sup> - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                           betaStar s1<sup>4</sup> s2
                      beta0^2 - beta0 beta1^2 + 2 \cdot 1 \cdot 1 \cdot 2 + 2 \cdot 1 \cdot 1 \cdot 1 = 100
                                    2 beta0<sup>2</sup> betaStar s1 s2<sup>2</sup>
                      beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                                   beta0 betaStar<sup>2</sup> s1 s2<sup>2</sup>
                      beta0^2 - beta0 beta3tar + 1^2 + 2 s1 s2 + 1^2
                                   3 betaStar s1<sup>3</sup> s2<sup>2</sup>
                      beta0^2 - beta0 beta3tar + 1^2 + 2 s1 s2 + 1^2
                                       3 betaStar s1<sup>2</sup> s2<sup>3</sup>
                      beta0^2 – beta0 beta3tar + 31^2 + 2 31 32 + 32^2 +
                                          betaStar s1 s2<sup>4</sup>
                      beta0^2 - beta0 beta3tar + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2 + 1^2
                      beta0^2 beta3^2 beta3^3 beta3^2 - beta3^2 + beta3^3 beta3^2 beta3^2
                                                beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                      beta0 betaStar<sup>2</sup> \sqrt{\text{beta0}^3 \text{ betaStar s1}^2 - \text{beta0}^2 \text{ s1}^4 + \text{beta0 betaStar s1}^2 \text{ s2}^2}
                                                beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                      betaStar s1^2 \sqrt{beta0^3 betaStar s1^2 - beta0^2 s1^4 + beta0 betaStar s1^2 s2^2}
                                              beta0^2-beta0\ betaStar+s1^2+2\ s1\ s2+s2^2
                      2 betaStar s1 s2 \sqrt{\text{beta0}^3 \text{ betaStar s1}^2 - \text{beta0}^2 \text{ s1}^4 + \text{beta0 betaStar s1}^2 \text{ s2}^2}
                                                beta0^2 - beta0 betaStar + s1^2 + 2 s1 s2 + s2^2
                      \frac{\text{betaStar s2}^2 \ \sqrt{\text{beta0}^3 \ \text{betaStar s1}^2 - \text{beta0}^2 \ \text{s1}^4 + \text{beta0 betaStar s1}^2 \ \text{s2}^2}}{\text{beta0}^2 - \text{beta0 betaStar + s1}^2 + 2 \ \text{s1 s2} + \text{s2}^2}}\right) \bigg/
                   (beta0<sup>2</sup> betaStar - beta0 betaStar<sup>2</sup> - beta0 s1<sup>2</sup> + betaStar s2<sup>2</sup>), fQD \rightarrow
                \frac{beta0^2 \; s1 + s1^2 \; s2 + s1 \; s2^2 + \sqrt{beta0^3 \; betaStar \; s1^2 - beta0^2 \; s1^4 + beta0 \; betaStar \; s1^2 \; s2^2}}{beta0^2 - beta0 \; betaStar + s1^2 + 2 \; s1 \; s2 + s2^2} \bigg\} \bigg\}
           beta0 _ beta0+ \frac{s1**2}{beta0}
Out[286]= \frac{fQF}{fQF} = \frac{fQD}{fQD}
          \left\{\left\{ \text{Cos[omega]}^2 \, \text{Cosh[omega]}, \, \frac{\text{L}^2 \, \text{Sin[omega]}^2 \, \text{Sinh[omega]}}{\text{Abs[k]}^{3/2}}, \, 0, \, 0 \right\},\right.
            \{0, Cos[omega]^2 Cosh[omega], 0, 0\},
            \left\{\texttt{0, 0, Cos[omega] Cosh[omega]^2, } \frac{\texttt{l}^2 \, \texttt{Sin[omega] Sinh[omega]^2}}{\texttt{Abs[k]}^{3/2}}\right\},
            \{0, 0, 0, Cos[omega] Cosh[omega]^2\}
```