The order analysis for the two loop corrections to lepton MDM

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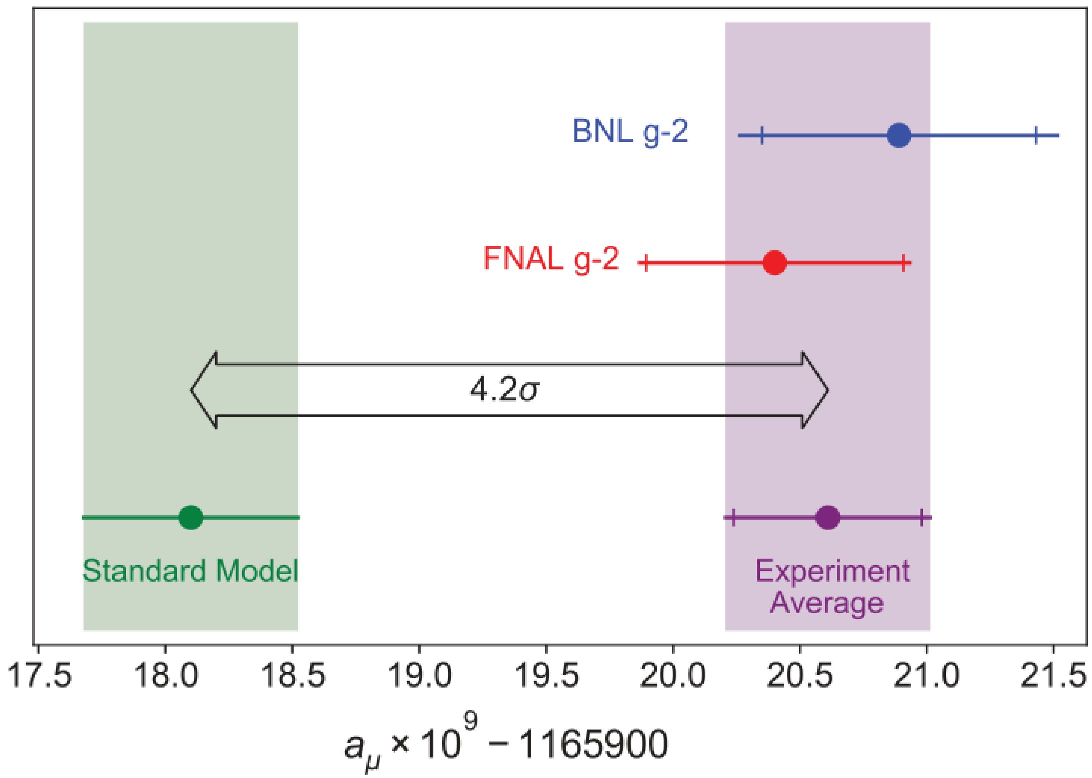
1、 muon 的反常磁矩

$a_\mu(\text{FNAL}) = 116\,592\,040(54) \times 10^{-11}$ (0.46 ppm) 3.3 standard deviations

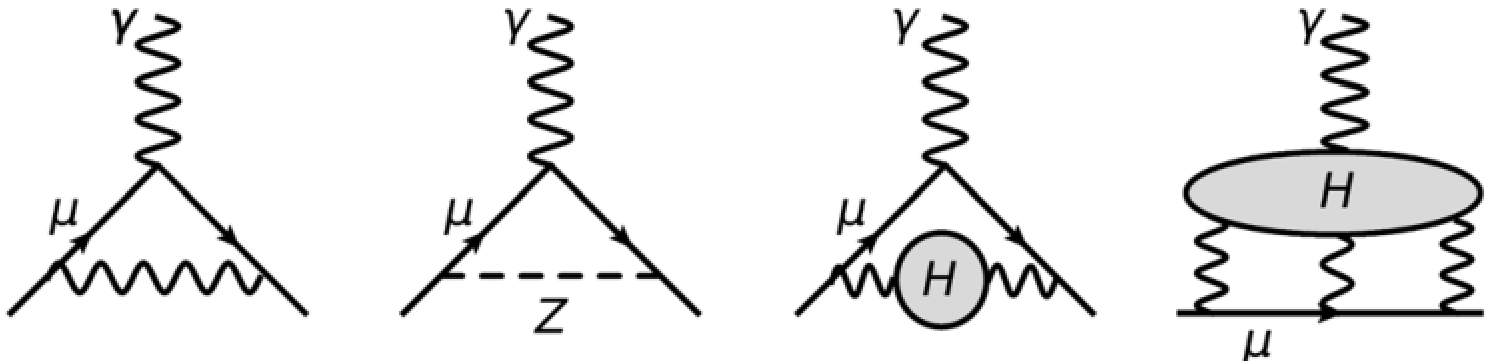
new experimental average

$a_\mu(\text{Exp}) = 116\,592\,061(41) \times 10^{-11}$ (0.35 ppm) 4.2 standard deviations.

$a_\mu(\text{Exp}) - a_\mu(\text{SM}) = (251 \pm 59) \times 10^{-11}$, a significance of 4.2σ

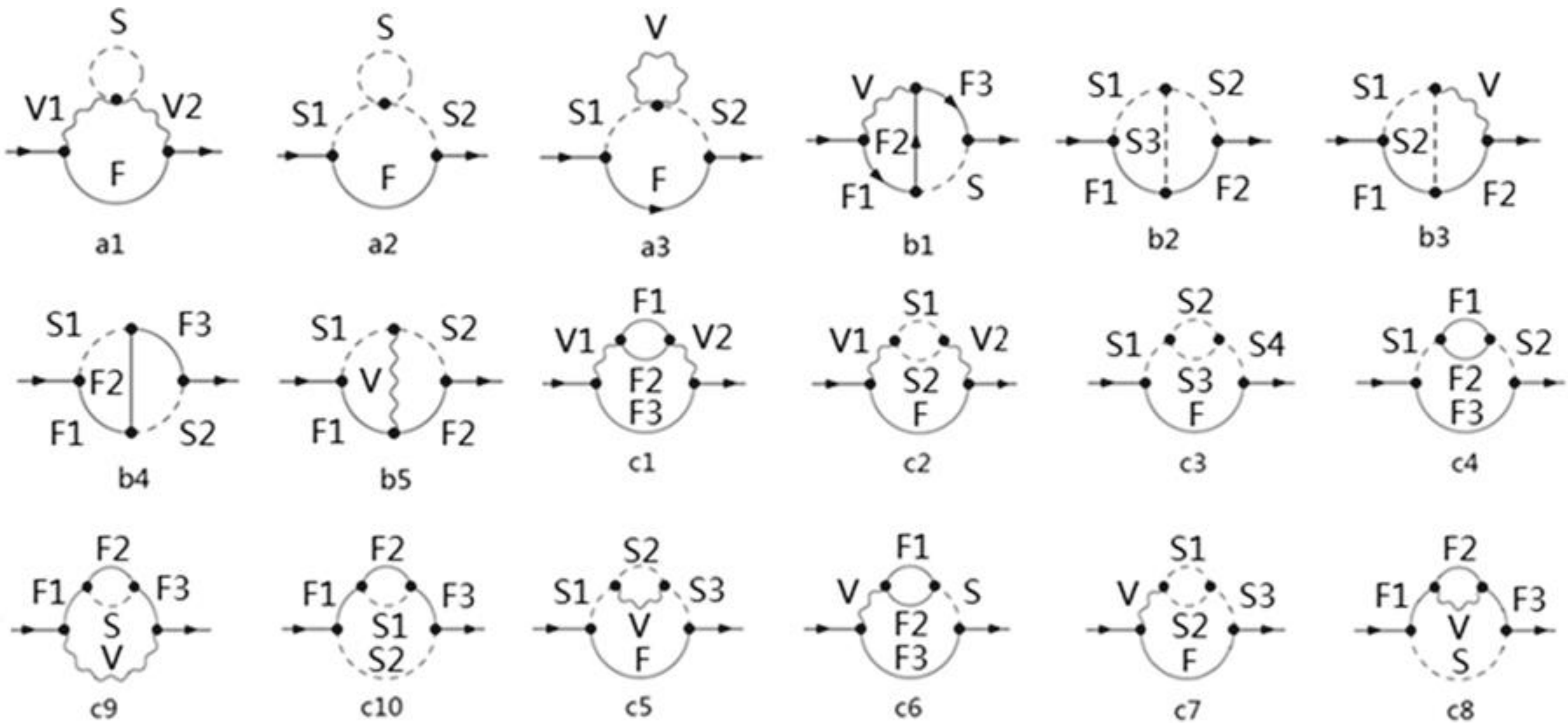


The anomalous magnetic moment receives contributions from all sectors of the SM, and possibly from New Physics (NP): $a_\mu = a_\mu^{\mathrm{QED}} + a_\mu^{\mathrm{EW}} + a_\mu^{\mathrm{hadronic}} + a_\mu^{\mathrm{NP?}}$.



$$a_\mu(\mathrm{SM}) = 116\,591\,810(43) \times 10^{-11} \ (0.37 \ \mathrm{ppm}).$$

2、双圈图量级分析



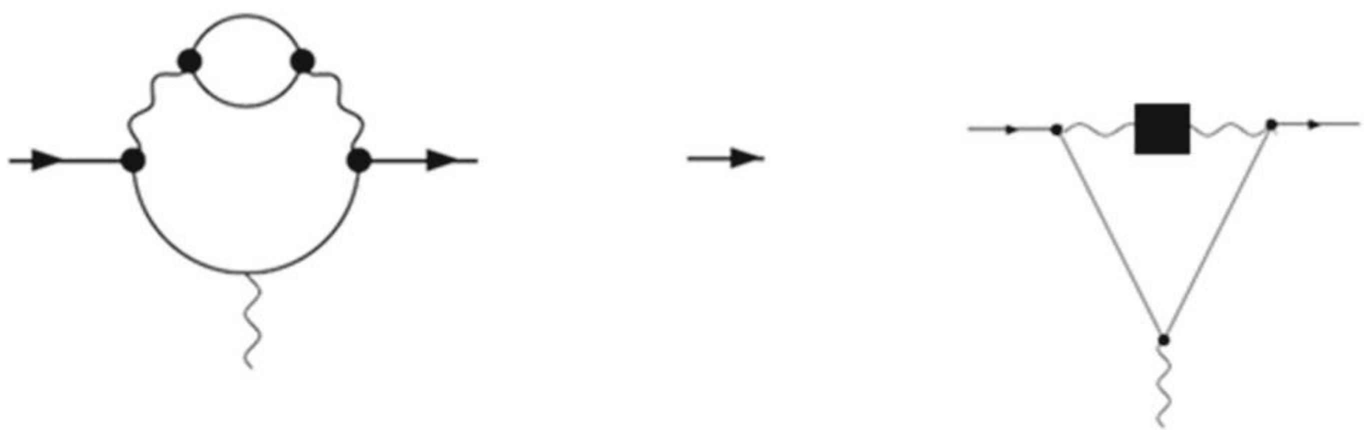
以MSSM为例对双圈图对muon MDM的量级进行分析

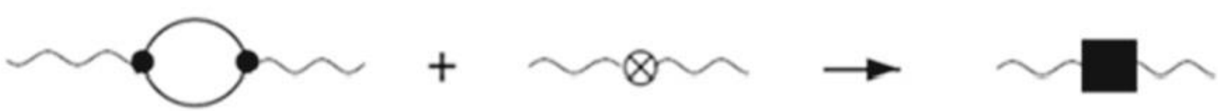
We use two mass scales M and M_{SH} for the SUSY particles' masses.

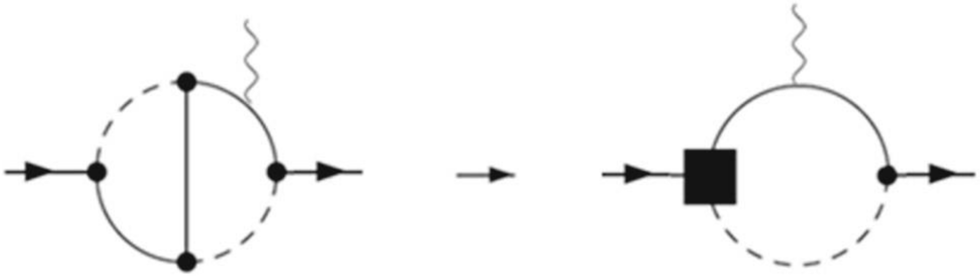
M_{SH} represents heavy SUSY particles mass scale, and squarks masses belong to M_{SH}.

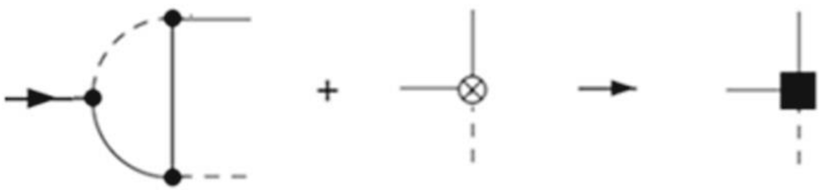
M is the light SUSY particle mass scale, the masses of the SUSY particles except squarks are supposed as M. M_{SH} is much larger than M.

$m_Z \simeq m_W$, we use m_V to represent the masses of Z boson and W boson.



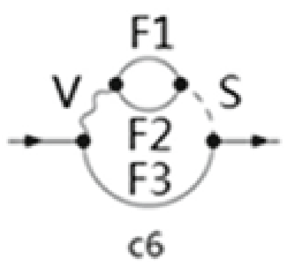






1. The two loop Barr–Zee type diagrams

c6 $[\chi^{\pm};\ \chi^{\pm};\ \mu;\ (\gamma, Z);\ H^0]$ and c6 $[\chi^0;\ \chi^{\pm};\ \nu;\ W^{\pm};\ H^{\pm}]$

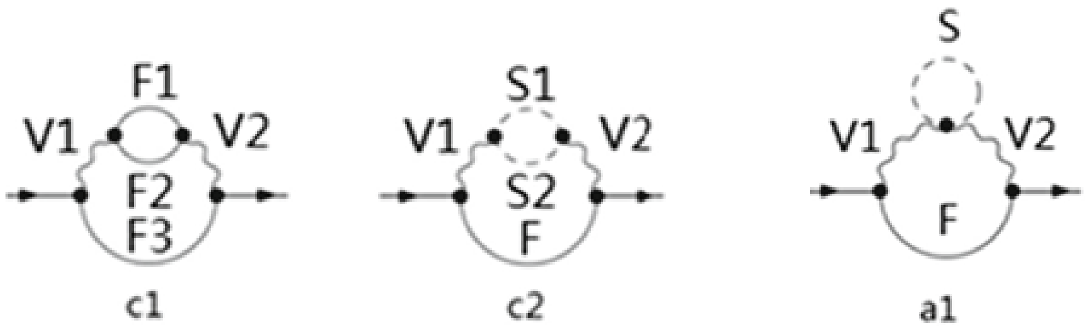


The factor is $\frac{x_l}{x_M^{1/2} x_V^{1/2}}$ **, which is not large!**

2. The factor $\frac{x_l}{x_M}$.

c1 $[\chi^{\pm};\ \chi^{\pm};\ \mu;\ \gamma;\ (\gamma,\ Z)]$, c2 $[S;\ S;\ \gamma;\ (\gamma,\ Z);\ \mu]$, a1 $[\gamma;\ S;\ (\gamma,\ Z);\ \mu]$

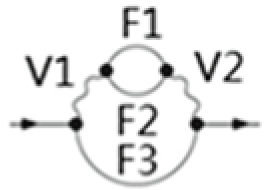
with S denoting the charged scalar particles $(\tilde{L},\ H^{\pm})$



This factor $\frac{x_l}{x_M}$ is smaller than the factor $\frac{x_l}{x_M^{1/2} x_V^{1/2}}$ from Barr-Zee type diagrams. These two loop diagrams can be neglected!

3. The factor $\frac{x_l}{x_V}$

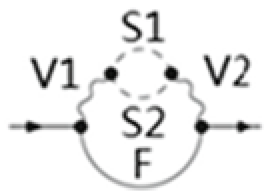
c1 $[\chi^{\pm};\ \chi^{\pm};\ \mu;\ Z;\ Z]$, c1 $[\chi^{0};\ \chi^{\pm};\ \nu;\ W;\ W]$,



c1

c2 $[S;\ S;\ Z;\ Z;\ \mu]$, c2 $[S1;\ S2;\ W;\ W;\ \nu]$

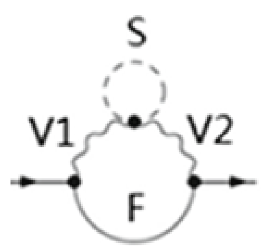
with $(S1,\ S2) = (\tilde{\nu},\ \tilde{L});\ (H^0,\ H^{\pm})$,



c2

a1 $[Z;\ S;\ Z;\ \mu]$ with $S = (\tilde{L},\ H^{\pm},\ H^0,\ \tilde{\nu})$

a1 $[W;\ S;\ W;\ \nu]$ with $S = (\tilde{L},\ H^{\pm},\ H^0,\ \tilde{\nu})$

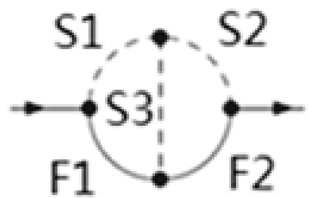


a1

4. The factor $\frac{x_l^{1/2}\lambda_{HSS}}{x_M^{1/2}M}$, which is smaller than $\frac{x_l^{1/2}}{x_M^{1/2}}$, because $\frac{\lambda_{HSS}}{M} \le 1$.

b2 $[\chi^\pm;\ \chi^\pm;\ \tilde{\nu};\ \tilde{\nu};\ H^0]$, b2 $[\chi^0;\ \chi^0;\ \tilde{L};\ \tilde{L};\ H^0]$, b2 $[\chi^0;\ \chi^\pm;\ \tilde{L};\ \tilde{\nu};\ H^\pm]$)

have the vertex $S-H-S$ possessing mass dimension, which is supposed as λ_{HSS}.



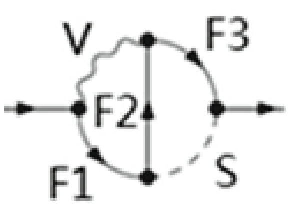
b2

5. There are many two loop diagrams contributing to muon MDM with the factor $\frac{x_l^{1/2}}{x_M^{1/2}}$.

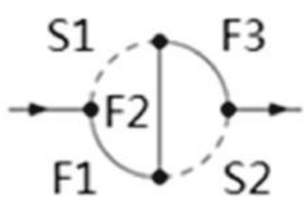
甲 The sub-loop is triangular diagram

b1 $[\mu;\ \chi^0;\ \chi^0;\ Z;\ \tilde{L}]$, b4 $[\chi^0;\ \nu;\ \chi^\pm;\ \tilde{L};\ \tilde{\nu}]$,

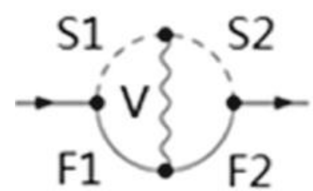
b5 $[\chi^\pm;\ \chi^\pm;\ \tilde{\nu};\ \tilde{\nu};\ Z]$, b5 $[\chi^0;\ \chi^0;\ \tilde{L};\ \tilde{L};\ Z]$, b5 $[\chi^0;\ \chi^\pm;\ \tilde{L};\ \tilde{\nu};\ W]$)



b1



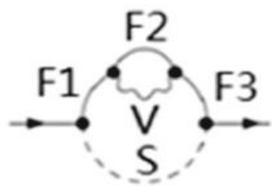
b4



b5

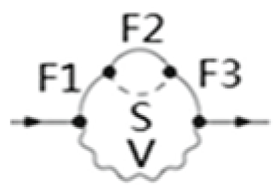
乙 The sub-loop is the self-energy diagram of fermion

c8 [$\chi^{\pm}$; $\chi^{\pm}$; $\chi^{\pm}$; (γ, Z); $\tilde{\nu}$], c8 [χ^{0}; χ^{0}; χ^{0}; Z; $\tilde{L}$],
c8 [$\chi^{\pm}$; χ^{0}; $\chi^{\pm}$; W; $\tilde{\nu}$], c8 [χ^{0}; $\chi^{\pm}$; χ^{0}; W; $\tilde{L}$],



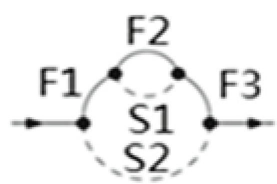
c8

c9 [μ; $\chi^{\pm}$; μ; $\tilde{\nu}$; (γ, Z)], c9 [μ; χ^{0}; μ; $\tilde{L}$; (γ, Z)],
c9 [ν; $\chi^{\pm}$; ν; $\tilde{L}$; W], c9 [ν; χ^{0}; ν; $\tilde{\nu}$; W],



c9

c10 [$\chi^{\pm}$; $\chi^{\pm}$; $\chi^{\pm}$; H^{0}; $\tilde{\nu}$], c10 [$\chi^{\pm}$; χ^{0}; $\chi^{\pm}$; $H^{\pm}$; $\tilde{\nu}$],
c10 [χ^{0}; χ^{0}; χ^{0}; H^{0}; $\tilde{L}$], c10 [χ^{0}; $\chi^{\pm}$; χ^{0}; $H^{\pm}$; $\tilde{L}$]

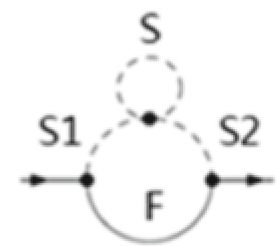


c10

丙 The sub-loop is the self-energy diagram of scalar boson

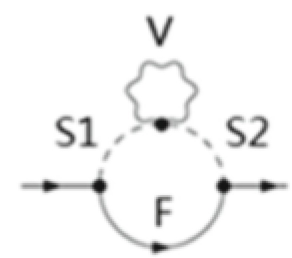
a2 $[\tilde{L};\ (\tilde{\nu},\ \tilde{L},\ H^0,\ H^{\pm});\ \tilde{L};\ \chi^{\pm}]$,

a2 $[\tilde{\nu};\ (\tilde{\nu},\ \tilde{L},\ H^0,\ H^{\pm});\ \tilde{\nu};\ \chi^0]$,



a2

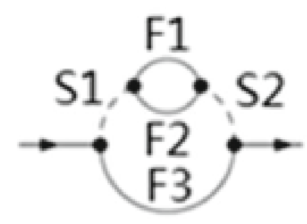
a3 $[\tilde{L};\ \tilde{L};\ (\gamma,\ Z,\ W);\ \chi^0]$, a3 $[\tilde{\nu};\ \tilde{\nu};\ (Z,\ W);\ \chi^{\pm}]$,



a3

c4 $[\nu;\ \chi^0;\ \chi^{\pm};\ \tilde{\nu};\ \tilde{\nu}]$, c4 $[\mu;\ \chi^{\pm};\ \chi^{\pm};\ \tilde{\nu};\ \tilde{\nu}]$,

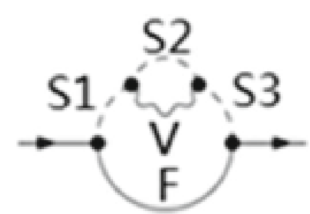
c4 $[\mu;\ \chi^0;\ \chi^0;\ \tilde{L};\ \tilde{L}]$, c4 $[\nu;\ \chi^{\pm};\ \chi^0;\ \tilde{L};\ \tilde{L}]$,



c4

c5 $[\tilde{L};\ \tilde{L};\ \tilde{L};\ (\gamma,\ Z);\ \chi^0]$, c5 $[\tilde{L};\ \tilde{\nu};\ \tilde{L};\ W;\ \chi^0]$

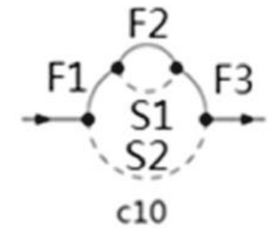
c5 $[\tilde{\nu};\ \tilde{\nu};\ \tilde{\nu};\ Z;\ \chi^{\pm}]$, c5 $[\tilde{\nu};\ \tilde{L};\ \tilde{\nu};\ W;\ \chi^{\pm}]$



c5

6. $\frac{m_F}{M} \le 1$ and the factor $\frac{x_l^{1/2}}{x_M^{1/2}} \frac{m_F}{M} \le \frac{x_l^{1/2}}{x_M^{1/2}}$.

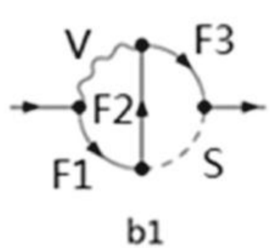
(c10[χ^0; F; χ^0; $\tilde{S}$; $\tilde{L}$] with $(F,\ \tilde{S}) = (\nu,\ \tilde{\nu}),\ (l,\ \tilde{L})$
c10[$\chi^\pm$; F; $\chi^\pm$; $\tilde{S}$; $\tilde{\nu}$] with $(F,\ \tilde{S}) = (\nu,\ \tilde{L}),\ (l,\ \tilde{\nu})$)

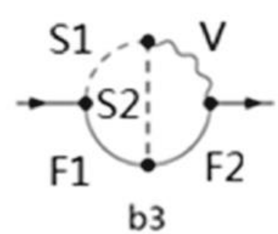


Here, m_F represents the mass of virtual fermion including SM fermion, $\chi^\pm$ and χ^0 in the two loop diagram.

7. $\frac{x_l^{1/2}}{x_M^{1/2}}$ and $\frac{x_l}{x_V}$

(b1[μ; $\chi^\pm$; $\chi^\pm$; $(\gamma,\ Z)$; $\tilde{\nu}$], b1[ν; χ^0; $\chi^\pm$; W; $\tilde{\nu}$], b1[ν; $\chi^\pm$; χ^0; W; $\tilde{L}$], b3[$\chi^\pm$; μ; $\tilde{\nu}$; $\tilde{\nu}$; Z], b3[χ^0; μ; $\tilde{L}$; $\tilde{L}$; $(\gamma,\ Z)$], b3[χ^0; ν; $\tilde{L}$; $\tilde{\nu}$; W], b3 [$\chi^\pm$; ν; $\tilde{\nu}$; $\tilde{L}$; W]), some parts have the factor $\frac{x_l^{1/2}}{x_M^{1/2}}$ and the other parts have the factor $\frac{x_l}{x_V}$ after our expansion.

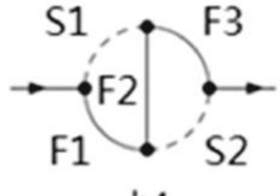




8. $\frac{x_l}{x_M^{1/2} x_V^{1/2}}$ and $\frac{x_l^{3/2}}{x_H x_V^{1/2}}$

This type diagrams (b4 $[\mu;\ \chi^{\pm};\ \chi^{\pm};\ H^0;\ \tilde{\nu}]$, b4 $[\mu;\ \chi^0;\ \chi^0;\ H^0;\ \tilde{L}]$, b4 $[\nu;\ \chi^0;\ \chi^{\pm};\ H^{\pm};\ \tilde{\nu}]$, b4 $[\nu;\ \chi^{\pm};\ \chi^0;\ H^{\pm};\ \tilde{L}]$)

Here $x_H = \frac{m_H^2}{\Lambda^2}$, and m_H is heavy Higgs mass.

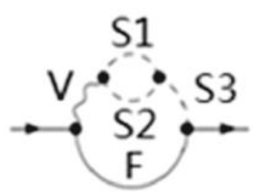


b4

9. $\frac{x_l \lambda_{HSS}}{x_V^{1/2} x_M^{1/2} M}$ and $\frac{x_l \lambda_{HSS}}{x_V^{1/2} x_H^{1/2} m_H}$. In rough estimation, $\frac{\lambda_{HSS}}{m_H} \lesssim 1$.

c7 $[H^0;\ H^0;\ H^0;\ (\gamma,\ Z);\ \mu]$, c7 $[\tilde{\nu};\ \tilde{\nu};\ H^0;\ Z;\ \mu]$, c7 $[S;\ S;\ H^0;\ (\gamma,\ Z);\ \mu]$ with $S = \tilde{L},\ H^{\pm}$

c7 $[S1;\ S2;\ H^{\pm};\ W;\ \nu]$ with $(S1,\ S2) = (\tilde{\nu},\ \tilde{L});\ (H^{\pm},\ H^0)$

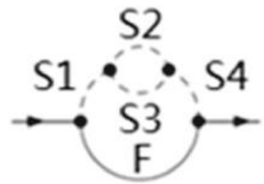


c7

10. $\frac{x_l^{1/2}\lambda_{HSS}^2}{x_M^{1/2}M^2}$ and $\frac{x_l^{1/2}\lambda_{HSS}^2}{x_M^{1/2}m_H^2}$

c3 $[\tilde{\nu};\ H^0;\ \tilde{\nu};\ \tilde{\nu};\ \chi^{\pm}]$, c3$[\tilde{L};\ H^{\pm};\ \tilde{\nu};\ \tilde{L};\ \chi^0]$,

c3 $[\tilde{\nu};\ H^{\pm};\ \tilde{L};\ \tilde{\nu};\ \chi^{\pm}]$, c3 $[\tilde{L};\ H^0;\ \tilde{L};\ \tilde{L};\ \chi^0]$



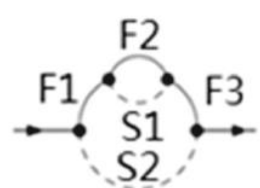
c3

11. $\frac{x_l^{1/2}}{x_M^{1/2}}\frac{m_F}{M}\log x_{SH}$ with $x_{SH}=\frac{M_{SH}^2}{\Lambda^2}$ $M_{SH}\gg M$.

c10$[\chi^0;\ F;\ \chi^0;\ \tilde{S};\ \tilde{L}]$ with $(F,\ \tilde{S})=(u,\ \tilde{U}),\ (d,\ \tilde{D})$

c10$[\chi^{\pm};\ F;\ \chi^{\pm};\ \tilde{S};\ \tilde{\nu}]$ with $(F,\ \tilde{S})=(u,\ \tilde{D}),\ (d,\ \tilde{U})$

They possess heavy squarks, and the factor include large logarithm function.



c10

比较一下量级

1 The large factors $\frac{x_l^{1/2}}{x_M^{1/2}}$ and $\frac{x_l}{x_V}$.

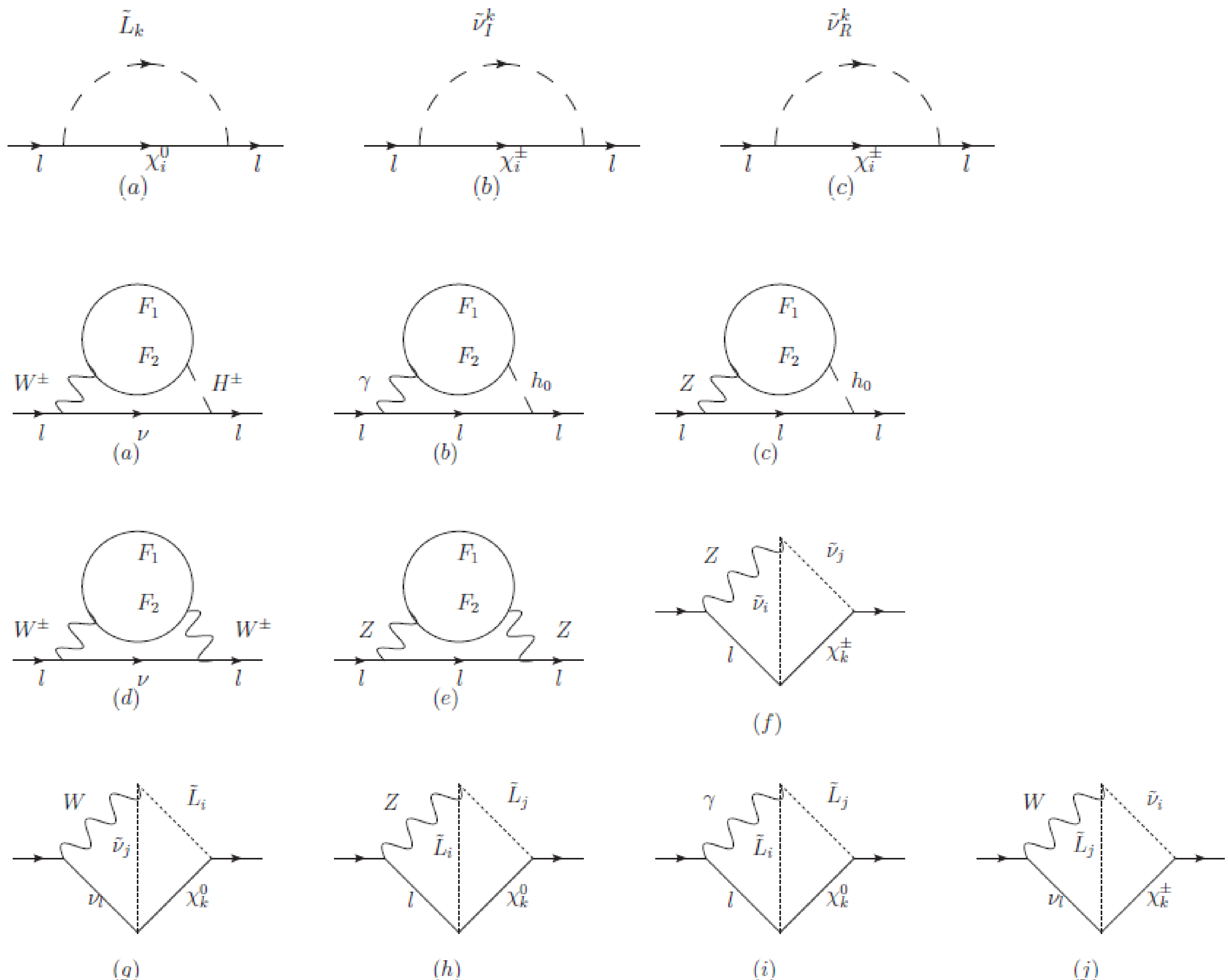
2 Because $\frac{\lambda_{HSS}}{M}$, $\frac{\lambda_{HSS}^2}{M^2}$, $\frac{\lambda_{HSS}^2}{m_H^2}$ and $\frac{m_F}{M}$ are not more than 1, ($\frac{x_l^{1/2}\lambda_{HSS}}{x_M^{1/2}M}$, $\frac{x_l^{1/2}\lambda_{HSS}^2}{x_M^{1/2}M^2}$, $\frac{x_l^{1/2}\lambda_{HSS}^2}{x_M^{1/2}m_H^2}$, $\frac{x_l^{1/2}}{x_M^{1/2}}\frac{m_F}{M}$) should not be bigger than the factor $\frac{x_l^{1/2}}{x_M^{1/2}}$.

3 The middle factors $\frac{x_l}{x_M^{1/2}x_V^{1/2}}$ $\frac{x_l\lambda_{HSS}}{x_V^{1/2}x_M^{1/2}M}$ and $\frac{x_l\lambda_{HSS}}{x_V^{1/2}x_H^{1/2}m_H}$.

4 The small factors $\frac{x_l}{x_M}$ and $\frac{x_l^{3/2}}{x_H x_V^{1/2}}$.

5 The non-decoupling factor $\frac{x_l^{1/2}}{x_M^{1/2}}\frac{m_F}{M}\log x_{SH}$ is special.

3. Muon g-2 in U(1)XSSM



1. The corrections from neutralinos and scalar leptons

$$a_\mu^{1L,\ \tilde{L}\chi^0} = -\sum_{k=1}^{6}\sum_{j=1}^{8}\Big[\Re(A_L^* A_R)\sqrt{x_{\chi_j^0} x_\mu}\, x_{\tilde{L}_k}\frac{\partial^2 \mathcal{B}(x_{\chi_j^0}, x_{\tilde{L}_k})}{\partial x_{\tilde{L}_k}^2}$$
$$+\frac{1}{3}(|A_L|^2 + |A_R|^2)x_{\tilde{L}_k} x_\mu \frac{\partial \mathcal{B}_1(x_{\chi_j^0}, x_{\tilde{L}_k})}{\partial x_{\tilde{L}_k}}\Big].$$

2. The corrections from chargino and CP-odd scalar neutrino

$$a_\mu^{1L,\ \tilde{\nu}^I\chi^\pm} = \sum_{i=1}^{2}\sum_{k=1}^{6}\Big[-2\Re(B_L^* B_R)\sqrt{x_{\chi_i^-} x_\mu}\,\mathcal{B}_1(x_{\tilde{\nu}_k^I}, x_{\chi_i^-})$$
$$+\frac{1}{3}(|B_L|^2 + |B_R|^2)x_\mu x_{\chi_i^-}\frac{\partial \mathcal{B}_1(x_{\tilde{\nu}_k^I}, x_{\chi_i^-})}{\partial x_{\chi_i^-}}\Big].$$

3. The corrections from chargino and CP-even scalar neutrino

$$a_\mu^{1L,\ \tilde{\nu}^R\chi^\pm} = \sum_{i=1}^{2}\sum_{k=1}^{6}\Big[-2\Re(C_L^* C_R)\sqrt{x_{\chi_i^-} x_\mu}\,\mathcal{B}_1(x_{\tilde{\nu}_k^R}, x_{\chi_i^-})$$
$$+\frac{1}{3}(|C_L|^2 + |C_R|^2)x_\mu x_{\chi_i^-}\frac{\partial \mathcal{B}_1(x_{\tilde{\nu}_k^R}, x_{\chi_i^-})}{\partial x_{\chi_i^-}}\Big].$$

4. The corrections from the new vector boson Z' and lepton. The mass of Z' are very heavy, and we take $m_{Z'}$ larger than 4.5 TeV. Comparing with Z-lepton one loop contribution, the corresponding contribution from Z'-lepton are suppressed by the factor $\frac{m_Z^2}{m_{Z'}^2} \sim 4 \times 10^{-4}$. Therefore, we neglect Z'-lepton one loop contribution.

5. The neutral Higgs-lepton and charged Higgs-neutrino contributions are suppressed by the square of the Higgs-lepton coupling $\frac{m_\mu^2}{m_W^2} \sim 10^{-6}$. As discussed in Ref. [36], these type contributions are neglected.

The one loop contributions to muon g-2 can be expressed as

$$a_\mu^{1L} = a_\mu^{1L,\ \tilde{L}\chi^0} + a_\mu^{1L,\ \tilde{\nu}^R\chi^\pm} + a_\mu^{1L,\ \tilde{\nu}^I\chi^\pm}.$$

$$a_\mu^{2L,\,WH} = \frac{eH^L_{\bar{\mu}H\nu}}{512\sqrt{2}\pi^4 s_W} \sum_{F_1=\chi^\pm} \sum_{F_2=\chi^0} \frac{x_\mu^{1/2}}{x_{F_1}^{1/2}} \Big\{ \frac{199}{36} \Re(H^L_{H\bar{F}_1F_2} H^L_{W\bar{F}_2F_1} + H^R_{H\bar{F}_1F_2} H^R_{W\bar{F}_2F_1}) + \cdots \Big\}$$

$$a_\mu^{2L,\,\gamma h^0} = \frac{e^2}{64\sqrt{2}\pi^4} H_{h^0\bar{\mu}\mu} \sum_{F_1=F_2=\chi^\pm} \frac{x_\mu^{1/2}}{x_{F_1}^{1/2}} \Re(H^L_{h^0\bar{F}_1F_2}) \Big[1 + \ln\frac{x_{F_1}}{x_{h^0}}\Big],$$

$$a_\mu^{2L,\,Zh^0} = \frac{\sqrt{2}}{512\pi^4} \sum_{F_1=F_2=\chi^\pm,\chi^0} H_{h^0\bar{\mu}\mu} \frac{x_\mu^{1/2}}{x_{F_1}^{1/2}} \Big[\varrho_{1,1}(x_Z, x_{h^0}) - \ln x_{F_1} - 1\Big]$$
$$\times (H^L_{Z\bar{\mu}\mu} - H^R_{Z\bar{\mu}\mu}) \Re(H^L_{h^0\bar{F}_1F_2} H^L_{Z\bar{F}_2F_1} + H^R_{h^0\bar{F}_1F_2} H^R_{Z\bar{F}_2F_1}).$$

$$a_\mu^{2L,\,WW} = \frac{e^2}{1536\pi^4 s_W^2} \frac{x_\mu}{x_W} \sum_{F_1=\chi^\pm} \sum_{F_2=\chi^0} \Big\{ -31(|H^L_{W\bar{F}_1F_2}|^2 + |H^R_{W\bar{F}_1F_2}|^2)$$
$$-12(|H^L_{W\bar{F}_1F_2}|^2 - |H^R_{W\bar{F}_1F_2}|^2) + 11\Re(H^{R*}_{W\bar{F}_1F_2} H^L_{W\bar{F}_1F_2}) \Big\}.$$

$$a_\mu^{2L,\,ZZ} = \frac{1}{1024\pi^4} \frac{x_\mu}{x_Z} \sum_{F_1=F_2=\chi^\pm} \Big\{ -6\Big(|H^L_{Z\bar{F}_1F_2}|^2 + |H^R_{Z\bar{F}_1F_2}|^2\Big)\Big(|H^L_{Z\bar{\mu}\mu}|^2 + |H^R_{Z\bar{\mu}\mu}|^2\Big)$$
$$\times(2\ln x_{F_1} + 5) + 16\Big(|H^L_{Z\bar{F}_1F_2}|^2 + |H^R_{Z\bar{F}_1F_2}|^2\Big) H^L_{Z\bar{\mu}\mu} H^R_{Z\bar{\mu}\mu}[(\ln x_{F_1} + 2)\ln\frac{x_{F_1}}{x_Z} + 2]\Big\}.$$

$$a_\mu^{2L,\, Z\tilde{\nu}\chi^\pm} = \frac{1}{768\pi^4}\sum_{i=1}^{2}\sum_{j,k=1}^{6} G_{Z\tilde{\nu}_j^I\tilde{\nu}_k^R}\Big\{\frac{x_\mu}{x_Z}\Big[-4\Re\Big(H^L_{Z\bar{\mu}\mu}H^L_{\mu\bar{\chi}_i^\pm\tilde{\nu}_j^I}H^{L*}_{\mu\bar{\chi}_i^\pm\tilde{\nu}_k^R}+H^R_{Z\bar{\mu}\mu}H^R_{\mu\bar{\chi}_i^\pm\tilde{\nu}_j^I}H^{R*}_{\mu\bar{\chi}_i^\pm\tilde{\nu}_k^R}$$

$$-\Re\Big(H^L_{Z\bar{\mu}\mu}H^R_{\mu\bar{\chi}_i^\pm\tilde{\nu}_j^I}H^{R*}_{\mu\bar{\chi}_i^\pm\tilde{\nu}_k^R}+H^R_{Z\bar{\mu}\mu}H^L_{\mu\bar{\chi}_i^\pm\tilde{\nu}_j^I}H^{L*}_{\mu\bar{\chi}_i^\pm\tilde{\nu}_k^R}\Big)(6\ln x_\mu-10)\Big]$$

$$+(H^L_{Z\bar{\mu}\mu}+H^R_{Z\bar{\mu}\mu})\Re\Big(H^R_{\mu\bar{\chi}_i^\pm\tilde{\nu}_j^I}H^{L*}_{\mu\bar{\chi}_i^\pm\tilde{\nu}_k^R}\Big)\frac{x_\mu^{1/2}}{x_{\chi_i^\pm}^{1/2}}\Big(\ln x_{\chi_i^\pm}-2\ln x_Z-\frac{35}{12}\Big)\Big\}+(\tilde{\nu}^I\leftrightarrow\tilde{\nu}^R)\,,$$

$$a_\mu^{2L,\, Z\tilde{L}\chi^0} = \frac{-1}{1536\pi^4}\sum_{s,t=1}^{6}\sum_{j=1}^{8}\Big\{4\Re\Big(H^{R*}_{\mu\bar{\chi}_j^0\tilde{L}_t}G_{Z\tilde{L}_t\tilde{L}_s}H^R_{\mu\bar{\chi}_j^0\tilde{L}_s}\Big)\frac{x_\mu}{x_Z}\Big[4H^R_{Z\bar{\mu}\mu}+H^L_{Z\bar{\mu}\mu}(3\ln x_\mu-5)\Big]$$

$$+4\Re\Big(H^{L*}_{\mu\bar{\chi}_j^0\tilde{L}_t}G_{Z\tilde{L}_t\tilde{L}_s}H^L_{\mu\bar{\chi}_j^0\tilde{L}_s}\Big)\frac{x_\mu}{x_Z}\Big[4H^L_{Z\bar{\mu}\mu}+H^R_{Z\bar{\mu}\mu}(3\ln x_\mu-5)\Big]$$

$$-\Re\Big(H^{R*}_{\mu\bar{\chi}_j^0\tilde{L}_t}G_{Z\tilde{L}_t\tilde{L}_s}H^L_{\mu\bar{\chi}_j^0\tilde{L}_s}+H^{L*}_{\mu\bar{\chi}_j^0\tilde{L}_t}G_{Z\tilde{L}_t\tilde{L}_s}H^R_{\mu\bar{\chi}_j^0\tilde{L}_s}\Big)$$

$$\times(H^L_{Z\bar{\mu}\mu}+H^R_{Z\bar{\mu}\mu})\frac{x_\mu^{1/2}}{x_{\chi_j^0}^{1/2}}\Big(8\ln x_{\chi_j^0}-10\ln x_Z+\frac{287}{12}\Big)\Big\},$$

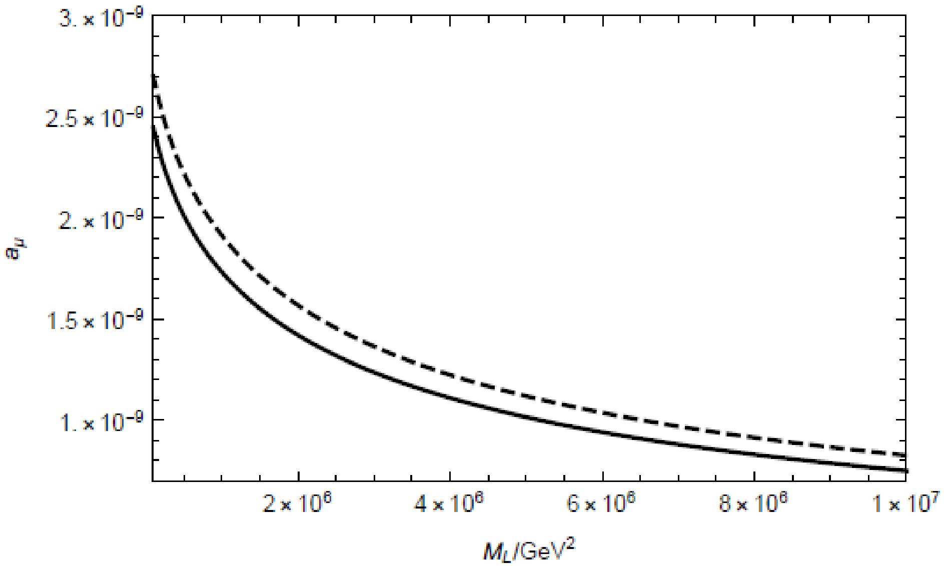
$$a_\mu^{2L,\, \gamma\tilde{L}\chi^0} = \frac{e^2}{384\pi^4}\sum_{s=1}^{6}\sum_{j=1}^{8}\Re\Big(H^{R*}_{\mu\bar{\chi}_j^0\tilde{L}_s}H^L_{\mu\bar{\chi}_j^0\tilde{L}_s}\Big)\frac{x_\mu^{1/2}}{x_{\chi_j^0}^{1/2}}\Big[10\log x_\mu-8\log x_{\chi_j^0}-\frac{289}{12}\Big],$$

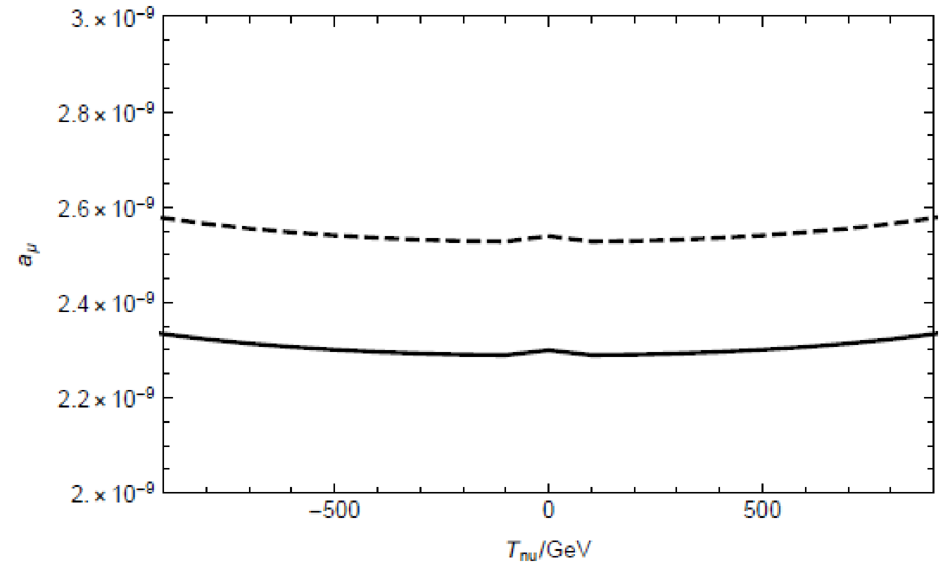
$$a_\mu^{2L,W\tilde{L}\tilde{\nu}\chi^0} = \frac{1}{768\pi^4}\sum_{j=1}^{8}\sum_{i,k=1}^{6} H^L_{W\bar{\nu}\mu}\Big\{-15\frac{x_\mu}{x_W}\Re\Big(H^{L*}_{\mu\bar{\chi}_j^0\tilde{L}_k}H^L_{\nu\bar{\chi}_j^0\tilde{\nu}_i^I}G_{W\tilde{L}_k\tilde{\nu}_i^I}\Big)$$

$$+\Re\Big(H^{R*}_{\mu\bar{\chi}_j^0\tilde{L}_k}H^L_{\nu\bar{\chi}_j^0\tilde{\nu}_i^I}G_{W\tilde{L}_k\tilde{\nu}_i^I}\Big)\frac{x_\mu^{1/2}}{x_{\chi_j^0}^{1/2}}\Big(\frac{29}{12}-2\ln x_W+4\ln x_{\chi_j^0}\Big)\Big\}+(\tilde{\nu}^I\leftrightarrow\tilde{\nu}^R),$$

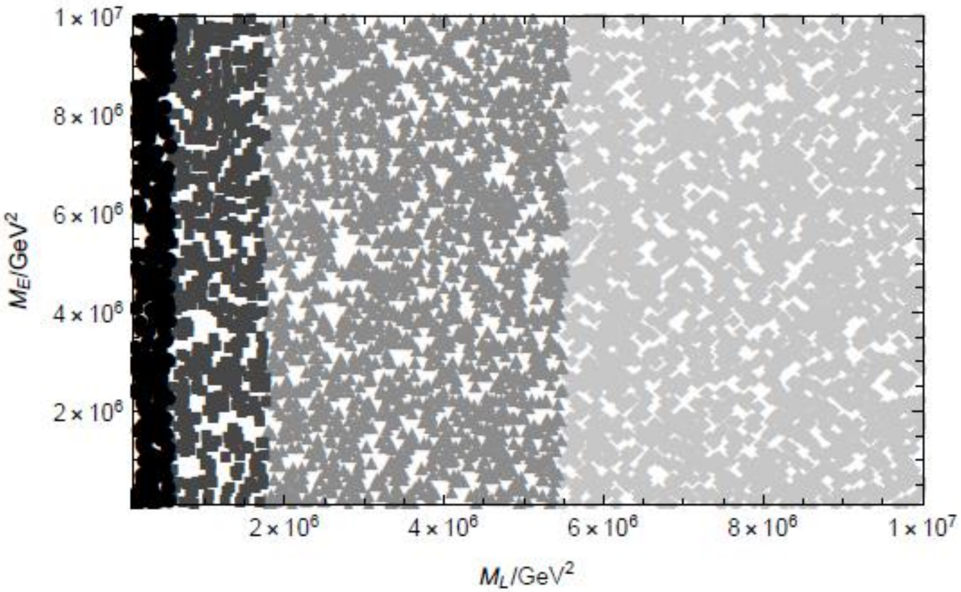
$$a_\mu^{2L,W\tilde{L}\tilde{\nu}\chi^-} = -\frac{1}{1536\pi^4}\sum_{j=1}^{2}\sum_{i,k=1}^{6} H^L_{W\bar{\nu}\mu}\Big\{-18\frac{x_\mu}{x_W}\Re\Big(H^{L*}_{\mu\bar{\chi}_j^\pm\tilde{\nu}_i^I}H^L_{\nu\bar{\chi}_j^\pm\tilde{L}_k}G_{W\tilde{L}_k\tilde{\nu}_i^I}\Big)$$

$$+\Re\Big(H^{R*}_{\mu\bar{\chi}_j^\pm\tilde{\nu}_i^I}H^L_{\nu\bar{\chi}_j^\pm\tilde{L}_k}G_{W\tilde{L}_k\tilde{\nu}_i^I}\Big)\frac{x_\mu^{1/2}}{x_{\chi_j^\pm}^{1/2}}\Big(2\ln x_{\chi_j^\pm}-4\ln x_W-\frac{7}{6}\Big)\Big\}+(\tilde{\nu}^I\leftrightarrow\tilde{\nu}^R).$$

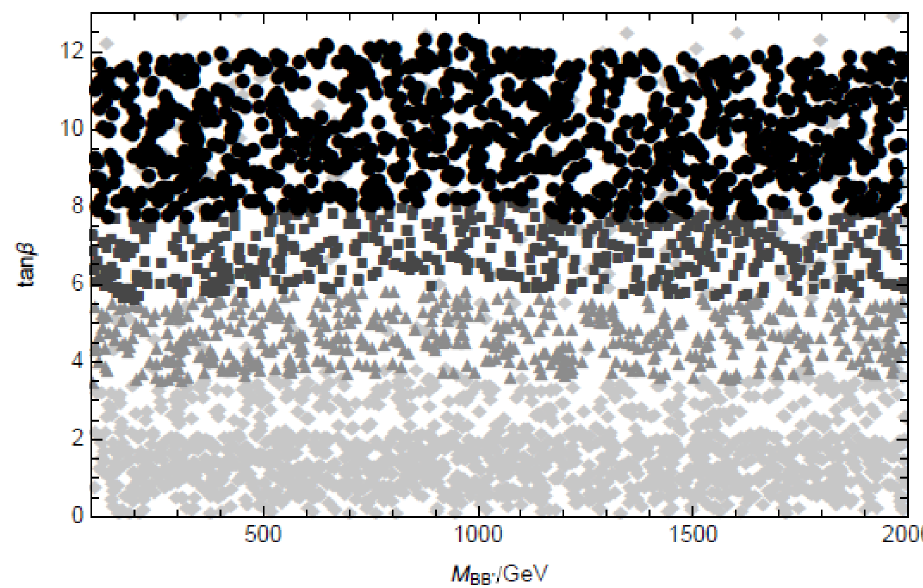




The solid (dashed) line corresponds to the results with $\tan\beta = 9$ (10).



a_μ in the plane of M_L versus M_E.



a_μ in the plane of $\tan\beta$ versus $M_{BB'}$.

The light-gray lozenge ◊ represents $0 < a_\mu < 10 \times 10^{-10}$.

The gray triangle ▲ denotes $10^{-9} \le a_\mu < 1.5 \times 10^{-9}$.

The dark-gray square ■ denotes $1.5 \times 10^{-9} \le a_\mu < 2 \times 10^{-9}$.

The filled circle • represents $2 \times 10^{-9} \le a_\mu < 3 \times 10^{-9}$.

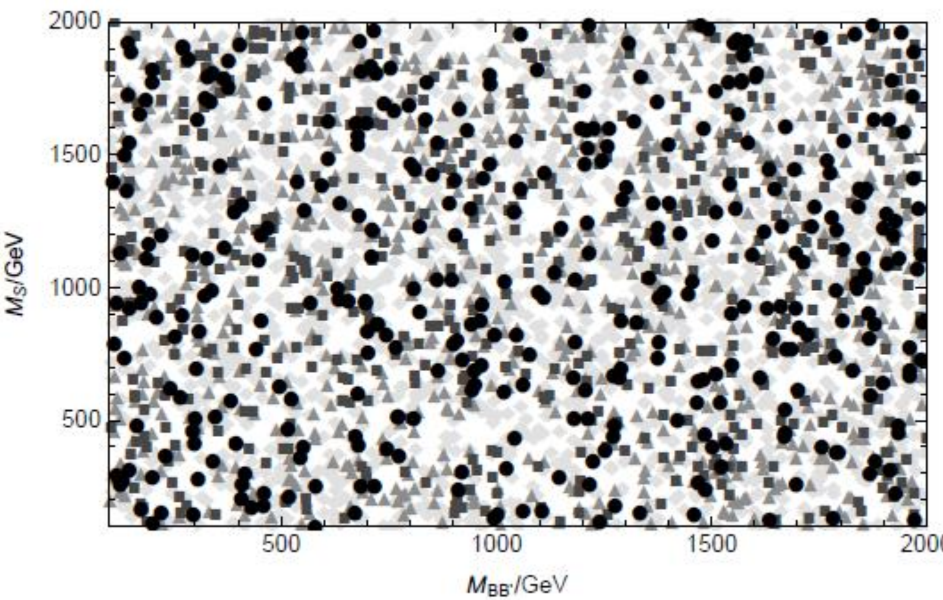
In order to analyse the results more extensively, we calculate a_μ numerically as

$$0.1 \text{ TeV} \le M_1 \le 2 \text{ TeV},\ 0.1 \text{ TeV} \le M_{BL} \le 2 \text{ TeV},\ 0.1 \text{ TeV} \le M_{BB'} \le 2 \text{ TeV},$$

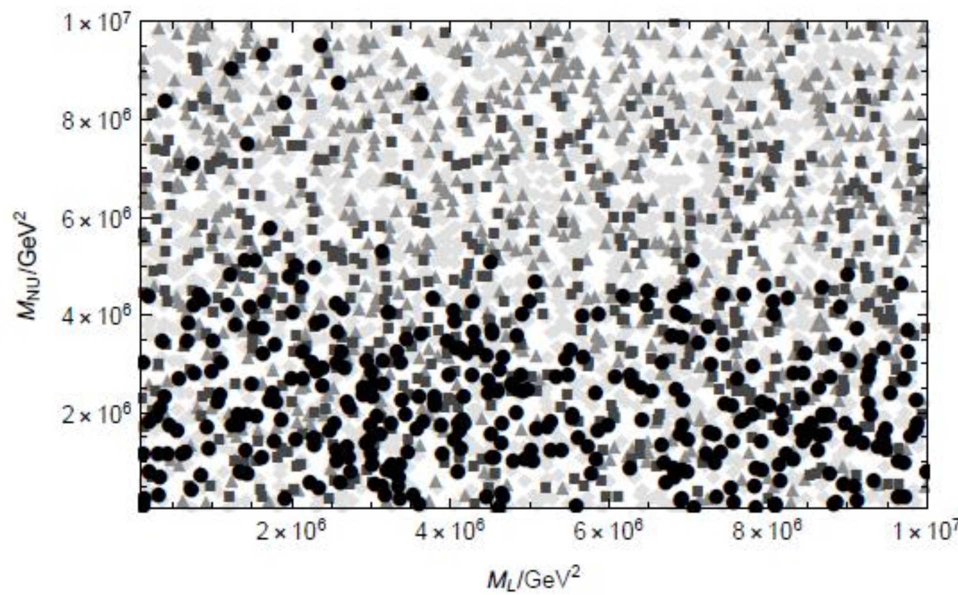
$$0.1 \text{ TeV} \le M_S \le 2 \text{ TeV},\ \ 1 \le \tan\beta \le 20,\ \ 0.1 \text{ TeV}^2 \le M_L \le 10 \text{ TeV}^2,$$

$$0.1 \text{ TeV}^2 \le M_E \le 10 \text{ TeV}^2,\ 0.05 \text{ TeV}^2 \le M_{NU} \le 10 \text{ TeV}^2,$$

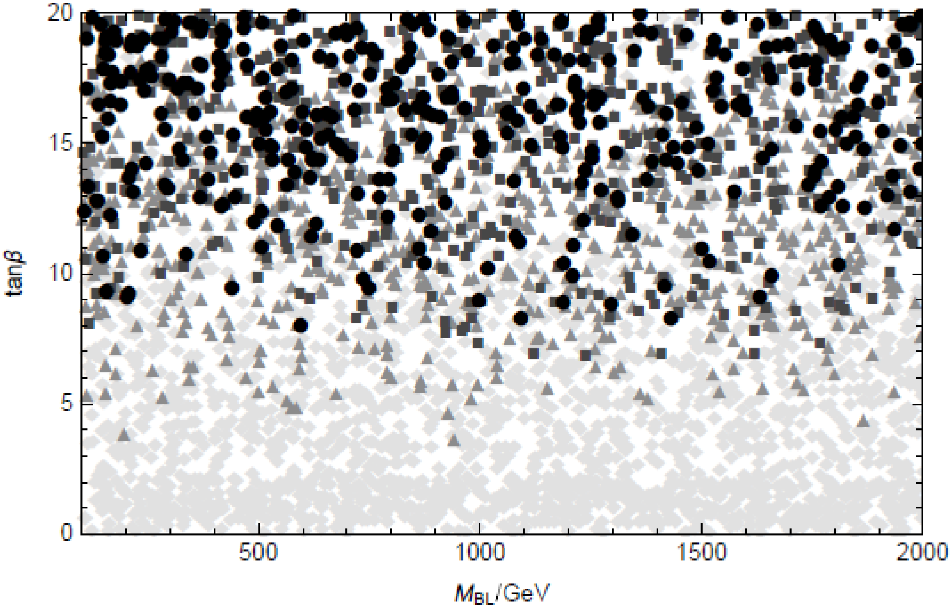
$$-1 \text{ TeV} \le T_e \le 1 \text{ TeV},\ \ -1 \text{ TeV} \le T_{nu} \le 1 \text{ TeV}.$$



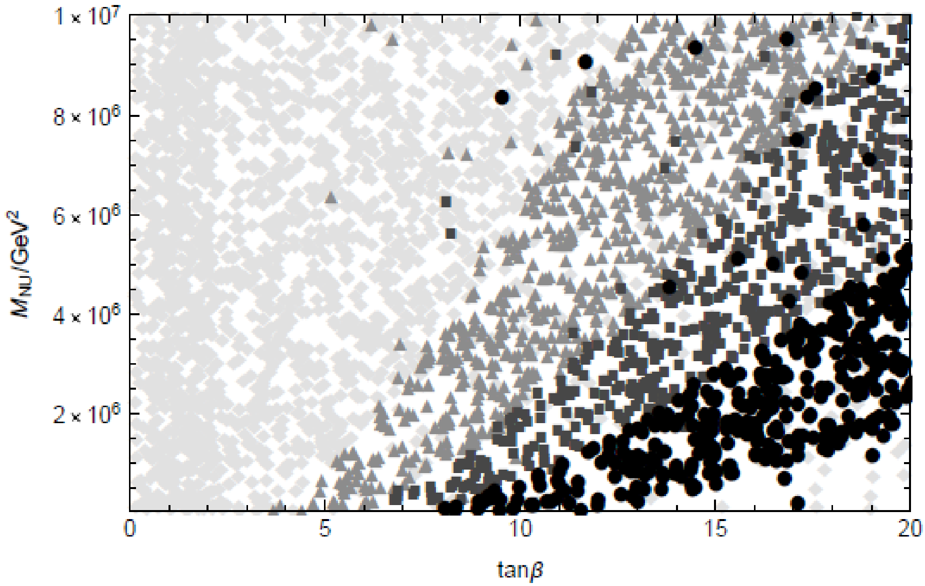
a_μ in the plane of M_S versus $M_{BB'}$



a_μ in the plane of M_L versus M_{NU}



a_μ in the plane of M_{BL} versus $\tan\beta$



a_μ in the plane of M_{NU} versus $\tan\beta$

Summary

1 If the SUSY particles are very heavy, the loop corrections are tiny.

2 In our used parameter spaces, the ratio a_μ^{2L}/a_μ^{1L} of just two loop results to the one loop results is in the region $3\% \sim 15\%$.

3 The corrections from Barr-Zee type diagrams are at the order of $10^{-11} \sim 10^{-12}$.

The diamond type diagrams have large factor $\frac{\sqrt{x_\mu}}{\sqrt{x_M}}$, whose numerical results can reach the order of 10^{-10}.

Therefore, we can obtain the relation of the three type two loop diagrams:

$a_\mu^{Barr-Zee} \lesssim a_\mu^{rainbow} \lesssim a_\mu^{diamond}$.

4 The best numerical result of a_μ is around 25×10^{-10}, which can well compensate the departure between the experiment data and SM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