Minimal Supersymmetric Standard Model
within CompHEP software package

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Abstract

The Minimal Supersymmetric Standard Model is presented as a model for the CompHEP
software package as a set of files containing the complete Lagrangian of the MSSM, particle
contents and parameters. All resources of CompHEP with a user-friendly interface are now
available for the phenomenological study of the MSSM. Various special features of the model
are discussed.

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1 Introduction

Supersymmetry (SUSY) is one of the most promising theoretical ideas pretending to solve some problems of the Standard Model (SM) and Grand Unified Theories (GUT). The simplest supersymmetric extension of the SM is the Minimal Supersymmetric Standard Model (MSSM). The phenomenological study of the MSSM in relation to colliders of TeV energies is an important task for understanding the SUSY discovery potential of existing and forthcoming accelerators.

One of the important points for the phenomenological study of different models of particle physics is the possibility for automatic calculations. There are several software packages (GRACE [1], DILL [2], XLOOPS [3], PHYSICA [4], SHELL2 [5], TLAMM [6], HECAS [7], etc.) which allow users to perform analytic and numerical calculations of high energy physics processes. Among them is the CompHEP software package [8] which was developed by High Energy Physics Group of Skobeltsin Institute for Nuclear Physics of Moscow State University. It allows to pass automatically from the Lagrangian of a model to event distribution and performs complete tree level calculations in the framework of any fed model. One of the main advantages of CompHEP is that it allows to perform the calculations within any user defined model. In comparison with the previous packages we present the complete version of the MSSM as a CompHEP model. Some technical details of implementing the MSSM into the package are discussed as well.

Files containing the MSSM Lagrangian, particles and parameters are available from the following WWW sites:

http://theory.npi.msu.su/~comphep/comphep-susy.Z
or
http://thsun1.jinr.ru/~comphep/comphep-susy.Z

2 MSSM in the CompHEP package: Lagrangian, particles and parameters

The general structure of the CompHEP software package as well as its main features is described in Ref. [8], and we will not repeat it here. We just note that in order to specify a model for performing calculations within CompHEP, one has to create the following set of files (this can be done also within the CompHEP package itself by choosing the menu item NEW MODEL):

lgrngN.mdl the table containing the Feynman rules of the model
prtclsN.mdl the table with the particles of the model
varsN.mdl the table of the model parameters
funcN.mdl the table with parameter dependences, which allows to have only independent parameters for the final calculation

Here $N$ is an integer number, the number of the model.

We skip here the description of constructing the supersymmetric extension of the SM, since a number of excellent reviews are available, see e.g. [9, 10]. The Yukawa interactions are determined by the superpotential which in the case of the MSSM reads

$$W = \epsilon_{ij} \left( h^{1L}_i L^c_i H^1 E^c_j + h^{1D}_i Q^1_i H^1 H^2_j + h^{1U}_i Q^1_i H^2 H^2_j + \mu H^1_j H^2_j \right).$$

Here $h^{IJ}$ are the Yukawa coupling constants, $L$ and $Q$ are the $SU(2)$ doublet lepton and quark superfields, $E^c$, $U^c$ and $D^c$ are the $SU(2)$ singlet charge-conjugated superfields of leptons and up-
and down-type quarks, $H_{1,2}$ are the $SU(2)$ doublet Higgs superfields, $i, j$ are the $SU(2)$ indices and $I, J$ are generation indices.

We follow the Feynman rules of the MSSM according to the Ref. [11]. Besides we have generated the Feynman rules by ourselves using the general form of the Lagrangian [11] for double check. It has been done by means of the LanHEP program [12].

The MSSM particle spectrum is the following:

- **Standard Model particles:**
  - photon $\gamma$, $W^\pm$ and $Z$ bosons and gluon $g$
  - quarks $u, d, s, c, b, t$
  - leptons $e, \nu_e, \mu, \nu_\mu, \tau, \nu_\tau$

- **Higgs bosons** $H_1$ and $H_2$ (the physical states are two neutral $CP$-even Higgses $h$ and $H$, neutral $CP$-odd Higgs $A$ and a pair of charged Higgs bosons $H^{\pm}$)

- **Superpartners**
  - superpartners of the gauge bosons (gaugino) and Higgs bosons (higgsino) whose mass eigenstates are two charginos $\tilde{\chi}^+_1, \tilde{\chi}^+_2$ and four neutralinos $\tilde{\chi}^0_1, \tilde{\chi}^0_2, \tilde{\chi}^0_3, \tilde{\chi}^0_4$
  - superpartners of the matter fields (squarks and sleptons); the physical eigenstates are mixtures of the superpartners of the left-handed and right-handed quarks and leptons.

The part of file `prtclsN.mdl` is presented in Table 1 in the CompHEP notations. It contains all the particles mentioned above. The rest part of `prtclsN.mdl` contains auxiliary fields and is discussed later.

The meaning of the table contents is the following:

| Full name | full particle name for the particular model; |
| P,AP | particle and anti-particle notations; |
| 2*spin | doubled spin of a particle; |
| mass | mass of a particle; |
| width | width of a particle; |
| color | transformation properties of a particle under the $SU(3)_{colour}$ gauge group: 8 – octet, 3 – triplet and 1 – singlet; |
| aux | some specific properties of a particle. |

The detailed explanation can be found in Ref. [8]

The MSSM contains, in general, many parameters:

- **$SU(3)$, $SU(2)$ and $U(1)$ gauge couplings;**

- **Yukawa couplings** $h_L$, $h_U$, $h_D$ (they are, in general, 3-dimensional matrices in the generation space);

- **gaugino masses** $M_1, M_2, M_3$;

- **trilinear soft supersymmetry breaking parameters** $A_L, A_U, A_D$ (they are, in general, 3-dimensional matrices in the generation space);
• Higgs mixing parameter $\mu$ and the corresponding bilinear soft supersymmetry breaking parameter $B$ (the last can be re-expressed through the ratio of vacuum expectation values of the Higgs fields $\tan \beta = v_2/v_1$);

• a number of rotating matrices $Z_{ij}$ of squark, slepton, Higgs, chargino and neutralino sectors, as well as the CKM mixing matrix.

However, after the appropriate simplifying assumptions (unification of the gauge coupling constants, universality of the soft supersymmetry breaking parameters at the GUT scale, the diagonal form of the Yukawa matrices, etc.) are made, only few independent parameters are left. Below we discuss our assumptions and model parameters.

• matrices of Yukawa couplings and corresponding trilinear soft supersymmetry breaking parameters $A$ are diagonal

• superpartners of the left-handed and right-handed fermions of two light generations do not mix; mixing takes place only for the third generation sfermions. This turns to be rather accurate approximation, since the off-diagonal entries of the sfermion mass-squared-matrices are of the form $m_f(A_f - \mu \tan \beta)$. This assumption also fixes the form of the rotating matrices $Z_{ij}$ in squark and slepton sectors, for which we have also neglected the intergenerational mixing

• we accept also some theoretical motivations, namely, the gauge coupling constant unification and the universality of the soft supersymmetry breaking parameters at the GUT scale, which is natural in, e.g. supergravity inspired models. This, however, affects only on numerical values of sparticle and Higgs masses and mixings which are presented below as an example. The last assumption can be relaxed and even rejected if one is interested in studying models beyond MSSM or effects of non-universal SUSY breaking terms, etc.

Under the above mentioned assumptions, in addition to the SM parameters one has the following set of parameters all taken at the Grand Unification scale (the corresponding model is often referred to as Minimal Supergravity):

• $m_0$ – the common mass of scalar particles

• $m_{1/2}$ – the common mass of fermions

• $\mu_0$ – the initial value of the Higgs mixing parameter

• $A_0$ – the initial value of trilinear soft supersymmetry breaking parameters

The soft supersymmetry breaking part of the Lagrangian then takes the form:

$$-L_{SB} = m_0^2 \sum_i |\varphi_i|^2 + \left( m_{1/2} \sum_\alpha \lambda_\alpha \lambda_\alpha + A_0 (h_L \tilde{L} \tilde{H}_1 \tilde{E}^c + h_D Q \tilde{H}_1 \tilde{D}^c + h_U Q \tilde{H}_2 \tilde{U}^c) + B \mu \tilde{H}_1 \tilde{H}_2 + h.c. \right),$$

$\varphi_i$ are the scalar particles, $\lambda_\alpha$ are gauginos, the tilde denotes the scalar component of the corresponding superfield, $SU(2)$ contraction being understood.

And the last parameter is

• $\tan \beta$ (the value of this parameter determines two different scenarios, the so called high and low $\tan \beta$ scenarios [13])
The numerical values of the parameters can be chosen in different ways. However, if one wants to perform a self-consistent analysis one has to be careful since many restrictions have to be satisfied simultaneously. We follow here the strategy of the global fit analysis \cite{13} in the framework of which one can predict values of parameters satisfying some common conditions and present experimental data.

We use the following values of the input MSSM parameters obtained from the global fit analysis for high $\tan\beta$ scenario (as an example) at the GUT scale:

| $m_0$ | $m_{1/2}$ | $\mu$ | $\tan\beta$ | $Y_t$ | $Y_b$ | $Y_\tau$ | $M_{\text{GUT}}$ | $1/\alpha_{\text{GUT}}$ | $A_0$ |
|-------|------------|-------|--------------|-------|-------|-----------|----------------|----------------|-------|
| 800   | 88         | -270  | 41.2         | 0.0014| 0.0011| 0.0011    | $2.5 \cdot 10^{16}$ | 24.3           | 0     |

where $Y_t = h_t^2/16\pi^2$.

To calculate the numerical values of the soft SUSY breaking parameters and masses of superparticles we run one-loop renormalization group equations from the unification point down to the scale of the $Z$-boson mass. After that the values of the elements of rotating matrices $Z_{ij}$ can be also calculated.

The input parameters of the MSSM in the CompHEP notations are presented in Table 2 (the file `varsN.mdl`).

It should be stressed that widths of the particles have been calculated by means of CompHEP itself for this particular set of particle masses. One should keep the right widths of the particles for the calculation of different processes (especially, resonant ones) and recalculate widths for any new set of parameters.

The table of the MSSM Lagrangian (the file `lgrngN.mdl`) exactly corresponds to the order of the Feynman rules in Ref. \cite{13}, but the section 14. All four-scalar vertices from section 14 and gluon-gluon-squark-squark vertices from section 15 are converted into three-particle vertices and given in the end of the table.

The four-scalar vertices originate from the scalar potential which is the sum of the $F$- and $D$-term parts:

$$V = \frac{1}{2}(D_G^a D_G^a + D_W^a D_W^a + D_B^a D_B^a) + F_i^* F_i,$$

where

$$D_G^a = g_s(\tilde{Q}'^* \lambda^a \tilde{Q}' + \tilde{D}'^* \lambda^a \tilde{D}' + \tilde{U}'^* \lambda^a \tilde{U}')$$
$$D_W^a = \frac{g}{2}(\tilde{Q}'^* \tau^a \tilde{Q}' + \tilde{L}'^* \tau^a \tilde{L}' + H_1^* \tau^a H_1 + H_2^* \tau^a H_2)$$
$$D_B^a = g'(\frac{1}{6} \tilde{Q}'^* \tilde{Q}' + \frac{1}{3} \tilde{D}'^* \tilde{D}' - \frac{2}{3} \tilde{U}'^* \tilde{U}' + \frac{1}{2} \tilde{L}'^* \tilde{L}' + \tilde{E}'^* \tilde{E}' - \frac{1}{2} H_1^* H_1 + \frac{1}{2} H_2^* H_2)$$
$$F_{H_1^* F_{H_1}} = \mu^2 H_1^* H_1 + h_{1t}^2 \tilde{L}^* \tilde{L} \tilde{E}'^* \tilde{E}' + h_{D}^2 h_{D}^2 \tilde{Q}'^* \tilde{Q}' \tilde{D}'^* \tilde{D}' + \left[ h_{1t}^2 H_1^* \tilde{L}^* \tilde{E}' + h_{1t}^2 H_1^* \tilde{Q}'^* \tilde{Q}' \tilde{D}'^* \tilde{D}' + h_{1t}^2 H_1^* \tilde{L}^* C^{JK} \tilde{Q}'^* \tilde{E}' \tilde{D}'^* \tilde{D}' + H.c. \right]$$
$$F_{H_2^* F_{H_2}} = \mu^2 H_1^* H_1 + h_{1t}^2 \tilde{Q}'^* \tilde{Q}' \tilde{D}'^* \tilde{D}' + \left[ h_{1t}^2 H_1^* \tilde{Q}'^* \tilde{Q}' \tilde{D}'^* \tilde{D}' + H.c. \right]$$

$$F_{L^* F_{L}} = \left( h_{L}^2 \right)^2 H_1^* H_1 \tilde{E}'^* \tilde{E}'$$
\[
F_{E E}^* F_E = \left( h_{t L}^I \right)^2 \epsilon_{ij} \epsilon_{kl} H_{1k}^I H_{1k} \bar{L}_j^I \bar{L}_l^I \\
F_{Q Q}^* F_Q = \left( h_{t D}^I \right)^2 H_1^I H_1 \bar{D}_j^I \bar{D}_l + \left( h_{t U}^I \right)^2 H_2^I H_2 \bar{U}_l^I \bar{U}_l + \left[ h_{t U}^I h_{t D}^I H_1^I H_2^I C^{IJ} \bar{U}^I \bar{D}^J + H.c. \right] \\
F_{U U}^* F_U = \left( m_{a t}^I \right)^2 \epsilon_{ij} \epsilon_{kl} H_{2a}^I H_{2k} \bar{Q}_j^I \bar{Q}_l^I \\
F_{D D}^* F_D = \left( m_{b t}^I \right)^2 \epsilon_{ij} \epsilon_{kl} H_{1k}^I H_{1k} \bar{Q}_j^I \bar{Q}_l^I \\
\]

\( \lambda^a(a = 1, \ldots, 8) \) and \( \tau^a(a = 1, 2, 3) \) are Gell-Mann and Pauli matrices, \( C^{IJ} \) is the Cabbibo-Kobayashi-Maskawa mixing matrix, \( Q_1^I = Q_1^I, Q_2^I = C^{IJ} Q_2^I \) and \( Q_1^I = C^{IJ} Q_1^I, Q_2^I = Q_2^I \).

In order to reduce the enormous number of four-scalar vertices due to flavour permutations we split each vertex to a pair of three-particle ones and introduce a number of auxiliary fields. The other reason of doing this is that 4-colour vertices cannot be implemented directly into CompHEP due to conventions about the colour structure. The way we introduced such vertices is clearly seen from the structure of \( F \)-terms which can be written as follows:

\[
F_{H_1 H_1}^* F_{H_1} = |h_{D}^{IJ} \bar{Q}_j^I \bar{D}_j + h_{L}^{IJ} \bar{E}_j^I + \mu \bar{H}_2|^2 \\
F_{H_2 H_2}^* F_{H_2} = |h_{D}^{IJ} \bar{Q}_j^I \bar{U}_j + \mu \bar{H}_1|^2 \\
F_{L L}^* F_{L} = |h_{L}^{IJ} \bar{H}_j^I \bar{E}_j|^2 \\
F_{E E}^* F_{E} = |h_{L}^{IJ} \epsilon_{ij} \bar{H}_j^I \bar{L}_j|^2 \\
F_{Q Q}^* F_{Q} = |C^{IJ} h_{D}^{JK} \bar{D}_j^K \bar{H}_1 + h_{L}^{IJ} \bar{U}_j^I \bar{H}_2|^2 \\
F_{U U}^* F_{U} = |h_{U}^{IJ} \epsilon_{ij} \bar{H}_j^I \bar{Q}_j|^2 \\
F_{D D}^* F_{D} = |h_{D}^{IJ} \epsilon_{ij} \bar{H}_j^I \bar{Q}_j|^2 \\
\]

For example, the four-scalar vertices coming from terms \( F_{H_1 H_1}^* F_{H_1} \) and \( F_{H_2 H_2}^* F_{H_2} \) can be introduced through two doublets of the auxiliary fields \( (\xi_1, \xi_2) \) with a constant propagator \( 1/M_\xi^2 \). To cancel the dependence of the results on the mass of the auxiliary fields we multiply each vertex containing the latter by the factor \( M_\xi \), however, it is necessary for CompHEP to define it and assign a numerical value for it (we put \( M_\xi = 1 \)).

These auxiliary fields are defined in the CompHEP particle table (the file \( \text{prtclsN.mdl} \)). The part of the file with the definition of new auxiliary fields is presented in Table 3.

Some part of the CompHEP table of the MSSM Lagrangian with auxiliary fields is presented in Table 4 as an example (the vertices containing sparticles of the first and second generation, and conjugated vertices are skipped).
3 Test of the model and conclusions

In the paper we have presented the Minimal Supersymmetric Standard Model as a model implemented into the CompHEP package. The model has been already used for the study of the chargino pair production at LEP [14]. Chargino sector has been tested by comparison of the analytical results obtained by means of CompHEP with those presented in [15, 16]. In Ref. [15] the chargino pair production at high energy $\gamma\gamma$ colliders has been studied ($\gamma\gamma \rightarrow \tilde{\chi}_j^- \tilde{\chi}_j^+$ process). The paper [16] is devoted to the study of chargino and sneutrino production in electron-photon collisions ($e^-\gamma \rightarrow \tilde{\chi}_j^- \tilde{\nu}_e$ process). CompHEP results are in agreement with the results obtained in these papers. The charged Higgs sector has been also tested. We have an agreement with the results of Ref. [17] where the study of the charged Higgs pair production in $e^+e^-$ collisions has been performed.

People from High Energy Physics community are welcome to study the MSSM within the CompHEP software package. Any remarks or suggestions are appreciated.

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| Full name      | P | aP | 2*spin | mass | width | color | aux |
|---------------|---|----|--------|------|-------|-------|-----|
| photon        | A | A  | 2      | 0    | 0     | 1     | G   |
| Z boson       | Z | Z  | 2      | MZ   | wZ    | 1     | G   |
| gluon         | G | G  | 2      | 0    | 0     | 8     | G   |
| W boson       | W+| W- | 2      | MW   | wW    | 1     | G   |
| neutrino n1   | n1| N1 | 1      | 0    | 0     | 1     | L   |
| mu-neutrino n2| n2| N2 | 1      | 0    | 0     | 1     | L   |
| muon          | e2| E2 | 1      | Mm   | 0     | 1     |     |
| tau-neutrino n3| n3| N3 | 1      | 0    | 0     | 1     | L   |
| tau-lepton e3  | E3| 1  |        | Mt   | 0     | 1     |     |
| u-quark       | u | U  | 1      | 0    | 0     | 3     |     |
| d-quark       | d | D  | 1      | 0    | 0     | 3     |     |
| c-quark       | c | C  | 1      | Mc   | 0     | 3     |     |
| s-quark       | s | S  | 1      | Ms   | 0     | 3     |     |
| t-quark       | t | T  | 1      | Mtop | wtop  | 3     |     |
| b-quark       | b | B  | 1      | Mb   | 0     | 3     |     |
| Light Higgs   | h | h  | 0      | Mh   | wh    | 1     |     |
| Heavy higgs   | H | H  | 0      | MHH  | wHh   | 1     |     |
| 3rd Higgs     | H3| H3 | 0      | MH3  | wH3   | 1     |     |
| Charged Higgs | H+| H- | 0      | MHc  | wHc   | 1     |     |
| chargino 1    | "1+| "1-| 1      | MC1  | wC1   | 1     |     |
| chargino 2    | "2+| "2-| 1      | MC2  | wC2   | 1     |     |
| neutralino 1  | "o1| "o1| 1      | MNE1 | wNE1  | 1     |     |
| neutralino 2  | "o2| "o2| 1      | MNE2 | wNE2  | 1     |     |
| neutralino 3  | "o3| "o3| 1      | MNE3 | wNE3  | 1     |     |
| neutralino 4  | "o4| "o4| 1      | MNE4 | wNE4  | 1     |     |
| gluino        | g | g  | 1      | MSG  | wSG   | 8     |     |
| 1st selectron | "e1| "E1| 0      | MSe1 | wSe1  | 1     |     |
| 2nd selectron | "e4| "E4| 0      | MSe2 | wSe2  | 1     |     |
| 1st smuon     | "e2| "E2| 0      | MSmu1| wSmu1 | 1     |     |
| 2nd smuon     | "e5| "E5| 0      | MSmu2| wSmu2 | 1     |     |
| 1st stau      | "e3| "E3| 0      | MStau1| wStau1| 1    |     |
| 2nd stau      | "e6| "E6| 0      | MStau2| wStau2| 1    |     |
| e-sneutrino   | "n1| "N1| 0      | MSne | wSne  | 1     |     |
| m-sneutrino   | "n2| "N2| 0      | MSnmu| wSnmu | 1     |     |
| t-sneutrino   | "n3| "N3| 0      | MSntau| wSntau| 1    |     |
| u-squark 1    | "u1| "U1| 0      | MSu1 | wSu1  | 3     |     |
| u-squark 2    | "u2| "U2| 0      | MSu2 | wSu2  | 3     |     |
| d-squark 1    | "d1| "D1| 0      | MSD1 | wSd1  | 3     |     |
| d-squark 2    | "d2| "D2| 0      | MSd2 | wSd2  | 3     |     |
| c-squark 1    | "c1| "C1| 0      | MSc1 | wSc1  | 3     |     |
| c-squark 2    | "c2| "C2| 0      | MSc2 | wSc2  | 3     |     |
| s-squark 1    | "s1| "S1| 0      | MSs1 | wSs1  | 3     |     |
| s-squark 2    | "s2| "S2| 0      | MSs2 | wSs2  | 3     |     |
| t-squark 1    | "t1| "T1| 0      | MStop1| wStop1| 3    |     |
| t-squark 2    | "t2| "T2| 0      | MStop2| wStop2| 3    |     |
| b-squark 1    | "b1| "B1| 0      | MSbot1| wSbot1| 3   |     |
| b-squark 2    | "b2| "B2| 0      | MSbot2| wSbot2| 3   |     |

Table 1: MSSM particles table in the CompHEP notations.
| Name  | Value  | Comment | Name  | Value  | Comment | Name  | Value  | Comment |
|-------|--------|---------|-------|--------|---------|-------|--------|---------|
| EE    | 0.31333|         | TB    | 41.2   |         | tan β |         |         |
| GG    | 1.117  |         | hx    | -220   |         | μ     |         |         |
| SW    | 0.474  | sinθ_W | ls1   | 0      |         | A_L^1 |         |         |
| s12   | 0.221  |         | ls2   | 0      |         | A_L^2 |         |         |
| s23   | 0.04   |         | ls3   | 4.62   |         | A_t   |         |         |
| s13   | 0.0035 |         | us1   | 0      |         | A_U^1 |         |         |
| MZ    | 91.187 |         | us2   | 0      |         | A_U^2 |         |         |
| Zn11  | 0.152  |         | us3   | 106    |         | A_D^1 |         |         |
| Zn12  | 0.060  |         | ds1   | 0      |         | A_D^2 |         |         |
| Zn13  | -0.953 |         | ds2   | 0      |         | MStop^1 |         |         |
| Zn14  | -0.255 |         | ds3   | 3.32   |         | MStop^2 |         |         |
| Zn21  | 0.681  |         | wZ    | 2.502  |         | MStop^3 |         |         |
| Zn22  | -0.172 |         | wW    | 2.094  |         | MStop^4 |         |         |
| Zn23  | 0.274  |         | Mm    | 0.1057 |         | MSn1  |         |         |
| Zn24  | -0.657 |         | Mt    | 1.777  |         | MSn2  |         |         |
| Zn31  | -0.992 |         | Mm    | 1.3    |         | MSn3  |         |         |
| Zn32  | -0.983 |         | Ms    | 0.2    |         | MSntau |         |         |
| Zn33  | -0.107 |         | Mtop  | 175    |         | MSntau |         |         |
| Zn34  | 0.117  |         | wtop  | 1.442  |         | MSntau |         |         |
| Zn41  | 0.710  |         | Mm    | 4.3    |         | MS1   |         |         |
| Zn42  | 0.025  |         | Mh    | 110    |         | MS2   |         |         |
| Zn43  | -0.072 |         | wh    | 0.088  |         | MSd1  |         |         |
| Zn44  | 0.700  |         | MHH   | 273    |         | MSd2  |         |         |
| Zm11  | 0.918  |         | wHh   | 18.6   |         | MSd2  |         |         |
| Zm12  | 0.397  |         | MH3   | 273    |         | MSc1  |         |         |
| Zm21  | -0.397 |         | MH3   | 18.8   |         | MSc1  |         |         |
| Zm22  | 0.918  |         | MHc   | 285    |         | MSc2  |         |         |
| Zp11  | 0.994  |         | MhC   | 9.73   |         | MSc2  |         |         |
| Zp12  | 0.106  |         | MC1   | 65     |         | MSc2  |         |         |
| Zp21  | -0.106 |         | wC1   | 0.00003|         | MSc2  |         |         |
| Zp22  | 0.994  |         | MC2   | 254    |         | MSc2  |         |         |
| Zd33  | -0.978 |         | wC2   | 7.26   |         | MSc2  |         |         |
| Zd36  | -0.206 |         | MNE1  | 35     |         | MNE1  |         |         |
| Zd63  | -0.206 |         | wNE1  | 0      |         | MNE1  |         |         |
| Zd66  | 0.978  |         | MNE2  | 65     |         | MNE2  |         |         |
| Zu33  | 0.158  |         | wNE2  | 0      |         | MNE2  |         |         |
| Zu36  | -0.987 |         | MNE3  | 240    |         | MNE3  |         |         |
| Zu63  | 0.987  |         | wNE3  | 1.91   |         | MNE3  |         |         |
| Zu66  | 0.158  |         | MNE4  | 248    |         | MNE4  |         |         |
| Z133  | -0.733 |         | wNE4  | 11.5   |         | MNE4  |         |         |
| Z136  | -0.680 |         | MSG   | 236    |         | MSG   |         |         |
| Z163  | -0.680 |         | wSG   | 0.000258|         | wSG   |         |         |
| Z166  | 0.733  |         | MSe1  | 804    |         | MSe1  |         |         |

Table 2: The input parameters of the MSSM in the CompHEP notations.
| imprt | GGU1U1 | ~00 | ~01 | 2 | Maux | 0 | 3 | *  |
| imprt | GGU2U2 | ~02 | ~03 | 2 | Maux | 0 | 3 | *  |
| imprt | GGD1D1 | ~04 | ~05 | 2 | Maux | 0 | 3 | *  |
| imprt | GGD2D2 | ~06 | ~07 | 2 | Maux | 0 | 3 | *  |
| imprt | GGC1C1 | ~08 | ~09 | 2 | Maux | 0 | 3 | *  |
| imprt | GGC2C2 | ~0A | ~0B | 2 | Maux | 0 | 3 | *  |
| imprt | GGS1S1 | ~0C | ~0D | 2 | Maux | 0 | 3 | *  |
| imprt | GGS2S2 | ~0E | ~0F | 2 | Maux | 0 | 3 | *  |
| imprt | GGT1T1 | ~0G | ~0H | 2 | Maux | 0 | 3 | *  |
| imprt | GGT2T2 | ~0I | ~0J | 2 | Maux | 0 | 3 | *  |
| imprt | GGB1B1 | ~0K | ~0L | 2 | Maux | 0 | 3 | *  |
| imprt | GGB2B2 | ~0M | ~0N | 2 | Maux | 0 | 3 | *  |
| imprt | DD-SU3 | ~0O | ~0P | 0 | Maux | 0 | 8 | *  |
| imprt | SU2-1 | ~0Q | ~0P | 0 | Maux | 0 | 1 | *  |
| imprt | SU2-2 | ~0Q | ~0Q | 0 | Maux | 0 | 1 | *  |
| imprt | SU2-3 | ~0R | ~0R | 0 | Maux | 0 | 1 | *  |
| imprt | U1    | ~0S | ~0S | 0 | Maux | 0 | 1 | *  |
| imprt | xi11  | ~0T | ~0U | 0 | Maux | 0 | 1 | *  |
| imprt | xi12  | ~0V | ~0V | 0 | Maux | 0 | 1 | *  |
| imprt | xi21  | ~0X | ~0Y | 0 | Maux | 0 | 1 | *  |
| imprt | xi22  | ~0Z | ~0a | 0 | Maux | 0 | 1 | *  |

Table 3: The part of the CompHEP table of particles with the definition of new auxiliary fields.
Table 4: The part of the CompHEP table of the MSSM Lagrangian with auxiliary fields

| P1 | P2 | P3 | P4 | Factor                  | Lorentz part |
|----|----|----|----|-------------------------|--------------|
| G  | ~ON | ~b2 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OM | ~B2 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OL | ~b1 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OK | ~B1 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OJ | ~t2 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OI | ~T2 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OH | ~t1 |    | Sq rt 2*GG*Maux         | m1.m2        |
| G  | ~OG | ~T1 |    | Sq rt 2*GG*Maux         | m1.m2        |
| ~0O| ~B1 | ~b1 | i*2*GG/2*Maux            | 1            |
| ~0O| ~T1 | ~t1 | i*2*GG/2*Maux            | 1            |
| ~0R| ~E6 | ~e6 | -i*2*EE/(4*SW)*Maux      | ZL36**2      |
| ~0O| ~E6 | ~n3 | -2*EE/(4*SW)*Maux        | ZL36         |
| ~0P| ~E6 | ~n3 | i*2*EE/(4*SW)*Maux       | ZL361        |
| ~0R| ~N3 | ~n3 | i*2*EE/(4*SW)*Maux       | 1            |
| ~0R| ~T1 | ~t1 | i*2*EE/(4*SW)*Maux       | ZU33**2      |
| ~0Q| ~C1 | ~b1 | 2*EE/(4*SW)*Maux         | Vcb*ZD33*ZU22|
| ~0P| ~C1 | ~b1 | i*2*EE/(4*SW)*Maux       | Vcb*ZD33*ZU22|
| ~0S| ~E6 | ~e6 | i*2*EE/(4*SW)*Maux       | 2*ZL66**2-ZL36**2|
| ~0S| ~N3 | ~n3 | -i*2*EE/(4*SW)*Maux      | 1            |
| ~0S| ~B2 | ~b2 | i*2*EE/(12*CW)*Maux      | 2*ZD66**2+ZD36**2|
| ~0S| ~T2 | ~t2 | -i*2*EE/(12*CW)*Maux     | 4*ZU66**2-ZU36**2|
| ~0W| ~E6 | ~e6 | -Maux                    | ZL36*ZL66*13|
| ~0U| ~E3 | ~n3 | -Maux                    | ZL63*13      |
| ~0W| ~B1 | ~b1 | -Maux                    | ZD33*ZD63*d3 |
| ~0U| ~B1 | ~t1 | -Maux                    | Vtb*ZD63*ZU33*d3 |
| ~0V| ~E6 | ~e6 | Maux                     | ZL36*ZL66*13|
| ~0T| ~N3 | ~e3 | Maux                     | ZL63*13      |
| ~0V| ~B2 | ~b2 | Maux                     | ZD36*ZD66*d3 |
| ~0T| ~T2 | ~b2 | Maux                     | Vtb*ZD66*ZU36*d3 |
| ~0a| ~T1 | ~b1 | -Maux                    | Vtb*ZD33*ZU63*u3 |
| ~0Y| ~T2 | ~t2 | -Maux                    | ZU36*ZU66*u3  |
| ~0Z| ~B2 | ~t2 | Maux                     | Vtb*ZD36*ZU66*u3 |
| ~0X| ~T2 | ~t2 | Maux                     | ZU36*ZU66*u3  |
References

[1] T.Kaneko, H.Tanaka, Tokyo U. ICRR-238-91-7;
Minami-Tateya Collaboration (T.Ishikawa et al.), KEK-92-19;
Minami-Tateya Collaboration (M.Jimbo et al.), TMCP-95-1, hep-ph/9503363;
Minami-Tateya Collaboration (M.Jimbo et al.), TMCP-95-3, hep-ph/9503365.

[2] V.Lucic, Comp. Phys. Commun. 92 (1995) 90, hep-ph/9412298.

[3] L.Brucher, Nucl. Instrum. Meth. A389 (1997) 327, hep-ph/9611378.

[4] J.Beringer, Bern U. BUTP-92-07, In: La Londe-les-Maures 1992, Proceedings, New computing
techniques in physics research II, p.703.

[5] J.Fleischer, O.V.Tarasov, Comp. Phys. Commun. 71 (1992) 193.

[6] L.V.Avdeev, J.Fleischer, M.Yu.Kalmykov, M.N.Tentyukov, Nucl. Instrum. Meth. A389 (1997) 343, hep-ph/9610467;
L.V.Avdeev, J.Fleischer, M.Yu.Kalmykov, M.N.Tentyukov, hep-ph/9710222, accepted for publication in Comp. Phys. Comm.

[7] V.N.Larin, F.F.Tikhonin, Serpukhov, IFVE-90-75 (in Russian).

[8] E.E.Boos, M.N.Dubinin, V.A.Ilyin, A.E.Pukhov, V.I.Savrin, SNUTP-94-116, INP-MSU-94-36/358, hep-ph/9503280;
P.A.Baikov et al., Proc. of X Workshop on HEP and QFT (QFTHEP-95), ed. by B.Levtchenko,
V.Savrin, p.101, hep-ph/9701412.

[9] H.P.Nilles, Phys. Rep. 110 (1984) 1.

[10] H.E.Haber, G.L.Kane, Phys. Rep. 117 (1985) 75.

[11] J.Rosiek, Phys. Rev. D41 (1990) 3464;
J.Rosiek, Karlsruhe U. KA-TP-8-1995, hep-ph/9511250.

[12] A.V.Semenov, Moscow State U. INP-MSU-96-24-431, hep-ph/9608488.

[13] W. de Boer, R.Ehret, D.I.Kazakov, Z. Phys. C67 (1995) 647, hep-ph/9405342;
W. de Boer et al., Z. Phys. C71 (1996) 415, hep-ph/9603350.

[14] A.S.Belyaev, A.V.Gladyshev, JINR-E2-97-76, hep-ph/9703251.

[15] M.Koike, T.Nonaka, T.Kon, Phys. Lett. B357 (1995) 232, hep-ph/9504309.

[16] S.Hesselbach, H.Fraas, Phys. Rev. D55 (1997) 1343, hep-ph/9604439.

[17] A.Arhib, M.C.Peyranere, G.Moultaka, Phys. Lett. B341 (1995) 313, hep-ph/9406357.