Reply to "Comment on 'Infrared fixed point structure in the minimal supersymmetric standard model with baryon and lepton number violation'"

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Infrared fixed points in the minimal supersymmetric standard model with baryon and lepton number violation were studied and their structure elucidated by us [Phys. Rev. D **63**, 076008 (2001)]. Here we reply to the previous Comment on this paper. We emphasize that our paper concentrates on the case of the only true infrared fixed point in the model, i.e., the stable nontrivial fixed point for the top- and bottom-quark Yukawa couplings and the baryon number violating coupling. For this case the Comment does not affect in any manner the numerical results and conclusions derived in our paper.

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One of the main weaknesses of the standard model (SM) and its supersymmetric extensions is that the masses of the matter particles—the quarks and leptons—are free parameters of the theory. This problem arises from the presence of many unknown dimensionless Yukawa couplings. Considerable attention has, therefore, recently been focused on the renormalization-group (RG) evolution of the various dimensionless Yukawa couplings in the SM and its minimal supersymmetric extension, the minimal supersymmetric standard model (MSSM). Through the RG evolution, one can relate the Yukawa couplings to the gauge couplings via the Pendelton-Ross infrared stable fixed point (IRSFP) for the top-quark Yukawa coupling, or via the quasi-fixed-point behavior [1]. The predictive power of different models can, thus, be enhanced if the RG running of the parameters is dominated by the infrared stable fixed points.

In the minimal supersymmetric standard model, besides the Yukawa interactions and their supersymmetric counterparts, there are Yukawa couplings which violate baryon and lepton number conservation. This is in contrast to the situation that one obtains in the SM, where gauge invariance, particle content, and renormalizability forbid baryon and lepton number violation at the level of renormalizable operators. In [2], following [3], we have carried out a detailed analysis of the infrared fixed point structure of the third-generation Yukawa couplings and the highest generation baryon and lepton number violating couplings in the minimal supersymmetric standard model. Having shown in [3] that the only stable infrared fixed point of the model is the one with nontrivial fixed point values for the top- and bottom-quark Yukawa couplings, the baryon number violating coupling λ''_{233}, and trivial fixed point values for the rest of the couplings, the purpose of [2] was to obtain exact as well as approximate analytical solutions for these Yukawa couplings and the baryon number violating coupling, as well as the corresponding soft supersymmetry breaking trilinear couplings at the weak scale given their values at the ultraviolet scale. In [2], we also studied the renormalization-group flow of such a system, and numerically determined the quasi-infrared-fixed surfaces and the quasi-infrared-fixed points toward which the RG flow is attracted.

The main point of the authors of the Comment [4] is that the statement "in the regime where the Yukawa couplings $\tilde{Y}_t(0), \ldots, \tilde{Y}''(0) \rightarrow \infty$ with their ratios fixed, it is legitimate to drop 1 in the denominators of Eqs. (16) and (18)–(23) ..." in [2] is not always correct.

As stated above, in our paper [2] we consider the quasi-infrared-fixed points for the top- and bottom-quark Yukawa couplings and the baryon number violating coupling only, corresponding to the stable nontrivial true fixed point for these couplings. In this case, we have numerically obtained the quasi-fixed-point solution in our paper. For the case of these couplings, neglecting 1 in the denominator of Eq. (16) and the associated Eqs. (18), (19), and (23) of [2] in the quasi-fixed-point limit is correct. Furthermore, since we have not used Eqs. (39) and (40)–(45) in [2] to obtain the infrared point values for the case treated in our paper, but rather obtained them directly by a numerical solution of the RG equations, the 1 is included in our study, i.e., the question of dropping 1 does not arise. In particular, *the solutions for the relevant couplings* around the true fixed point values, Eqs. (52)–(61), and the quasifixed values for these couplings, (63) and (64); *obtained in our paper* [2] *are correct*.

Although the case of all the couplings being large was mentioned in our paper [2], we did not study the general case of quasi-infrared-fixed points where all the Yukawa couplings go to infinity. We concentrated on the case of top- and bottom-quark Yukawa couplings and the baryon number violating coupling, since only these have been shown to have nontrivial true infrared fixed points [3]. For this case our analysis is correct. For the rest of the couplings, whose quasi-infrared-fixed-point behavior has not been studied in our paper, a separate study might be needed, as pointed out in [4].

In view of the above, the Comment [4] is a technical statement about the validity of Eq. (39) of our paper [2] for the general case in which all the Yukawa couplings become large. Although this equation was stated in our paper, it was not used in the derivation of our results, since our focus was on a different case. As such, the Comment [4] does not alter the main results and conclusions of our paper [2].

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[1] For a review and references, see, e.g., B. Schrempp and M. Wimmer, Prog. Part. Nucl. Phys. **37**, 1 (1996).
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[3] B. Ananthanarayan and P.N. Pandita, Phys. Rev. D **62**, 036009 (2000); **63**, 099901(E) (2001).
[4] Y. Mambrini and G. Moultaka, preceding Comment, Phys. Rev. D **65**, 058901 (2002).