Erratum: Lattice simulations of a gauge theory with mixed adjoint-fundamental matter [Phys. Rev. D 103, 014503 (2021)]

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Correction of the number of adjoint flavors in the numerical simulations.—In our work, we have stated that the simulations have been done with one adjoint Majorana fermion (effectively $N_f^{(A)} = \frac{1}{2}$). The presented results correspond, however, to one adjoint Dirac fermion ($N_f^{(A)} = 1$). The adjoint fermions are simulated with the rational hybrid Monte-Carlo algorithm (RHMC). Inside the RHMC, instead of a single field, two pseudofermion fields have been applied leading to a doubling of $N_f^{(A)}$ compared to the plain rational approximation parameters.[1] The two degenerate flavors in the fundamental representation ($N_f^{(F)} = 2$) were not affected since they are represented by the standard hybrid Monte-Carlo algorithm (HMC).

The corresponding theory with $N_f^{(A)} = 1$, $N_f^{(F)} = 2$ fermions has been discussed in the paper as one of the main future targets of our project. In previous literature [1,2] it has been called ultraminimal walking technicolor and suggested as a possible composite Higgs extension of the Standard Model. In these theoretical studies it has been conjectured that the theory should be near conformal, but it has never been considered in simulations so far. With $N_f^{(A)} = \frac{1}{2}$, $N_f^{(F)} = 2$ fermions, some conjectures about the infrared limit can be made based on similarities with $\mathcal{N} = 1$ supersymmetric QCD (SQCD) without scalars as discussed in the paper. There is less knowledge in case of the theory with $N_f^{(A)} = 1$, $N_f^{(F)} = 2$ fermions, which corresponds in fact to $\mathcal{N} = 2$ SQCD without scalars. From this perspective our results can provide new insights concerning the unknown infrared behavior of a theory that lies possibly very close to the conformal window.

Comments on the numerical results.—All numerical results in the paper remain correct if considered for a theory with $N_f^{(A)} = 1$. We have crosschecked the simulations also with an independent code [3].

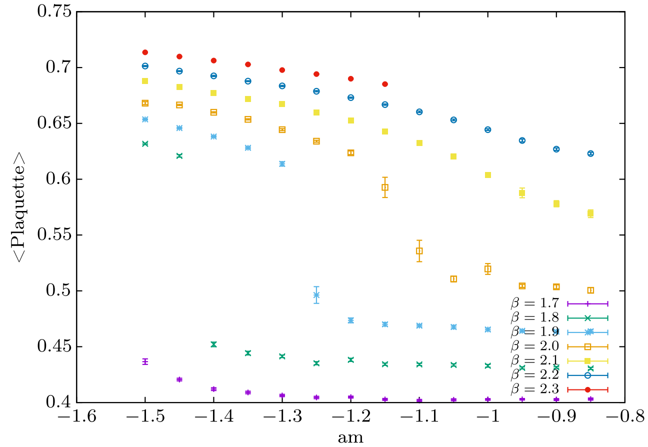
Concerning the bulk transition, we have by now obtained additional data that provide a direct comparison of different $N_f^{(A)}$. As shown in Figs. 1(a) and 1(b), the bulk transition is weaker at smaller $N_f^{(A)}$. Hence simulations at larger gauge couplings (smaller β) are possible for $N_f^{(A)} = \frac{1}{2}$ compared to $N_f^{(A)} = 1$.

In the paper, we used the chiral extrapolation of the gluino-glue particle in order to confirm consistency with $\mathcal{N} = 1$ supersymmetric Yang-Mills theory in the pure adjoint limit. This seemed to confirm $N_f^{(A)} = \frac{1}{2}$ in the simulations. However, we later observed that this is not sensitive enough to distinguish $N_f^{(A)} = 1$ from $N_f^{(A)} = \frac{1}{2}$. Recent precise data for $N_f^{(A)} = 1$ presented in Ref. [4] are now available for a better comparison of the theories. In this reference a different lattice action has been used, which prohibits a direct comparison at a given gauge coupling. Nevertheless the results can be used for a first cross-check, see Fig. 2. We have also added the values for SYM at $\beta = 1.75$. As one can observe from these data, it is difficult to distinguish the different $N_f^{(A)}$ just based on the gluino-glue mass. Our numerical data for the gluino-glue mass are therefore consistent with $N_f^{(A)} = 1$ and $N_f^{(A)} = \frac{1}{2}$.

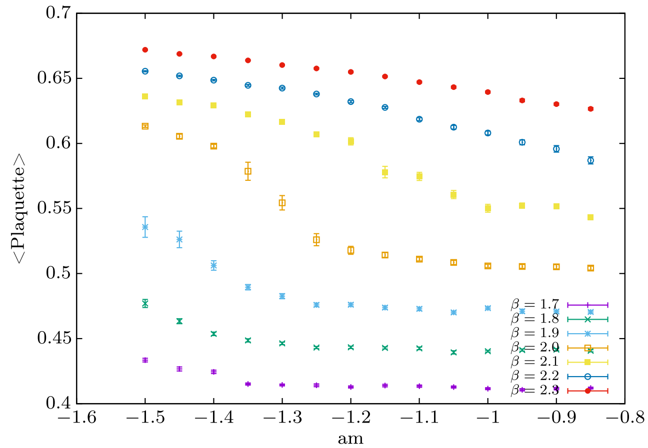
Our final conclusion remains the same: we observe that our data are more consistent with a chiral symmetry breaking than a conformal scenario for SU(2) Yang-Mills theory coupled $N_f^{(A)} = 1$, $N_f^{(F)} = 2$ fermions. The mass ratios indicate, however, a close to conformal scaling.

Implications and comparison to other studies.—Our study provides the first numerical data of an SU(2) gauge theory coupled to two fundamental Dirac fermions and one adjoint Dirac fermion. This theory has been considered as a composite

[1]The number of fields is an open parameter in order to include determinant breakup to improve the rational approximation. Our simulations correspond to $N_f^{(A)} = 1$ with a determinant breakup of two.



(a) $N_f^{(A)} = 1$



(b) $N_f^{(A)} = \frac{1}{2}$

FIG. 1. The strong coupling phase transitions shown by discontinuity of the average plaquette as a function of the bare mass parameter. Pure adjoint limit on a 4^4 lattice with (a) $N_f^{(A)} = 1$ and (b) $N_f^{(A)} = \frac{1}{2}$ adjoint fermions.

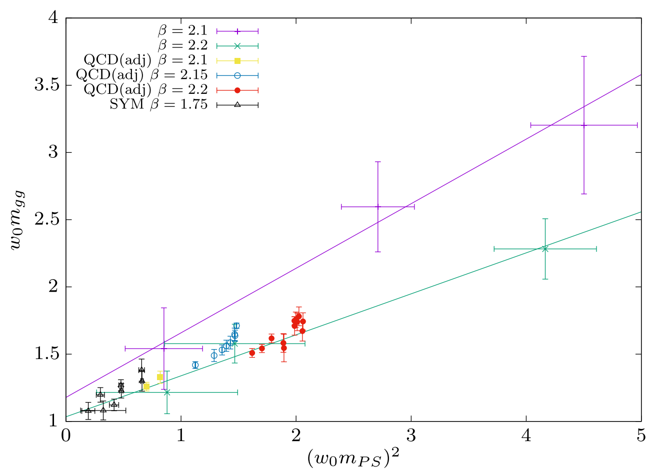


FIG. 2. The mass of the gluino-glue in units of $w_{0\chi}$ is shown in the pure adjoint limit with a linear chiral extrapolation like in the paper. Additional data for the theories with $N_f^{(A)} = \frac{1}{2}$ and $N_f^{(A)} = 1$ have been added for comparison. The reference data for supersymmetric Yang-Mills theory have been published in [5] and for $N_f^{(A)} = 1$ adjoint QCD in [4]. In case of $N_f^{(A)} = 1$ masses are shown in units of w_0 instead of the extrapolated value $w_{0\chi}$. Note that different lattice actions have been used: in [4] an unimproved Wilson action and in the paper a tree-level Symanzik improved gauge and stout smeared fermion action.

Higgs extension of the Standard Model. In these extensions, a near conformal scaling, but still with chiral symmetry breaking in the deep infrared, has been conjectured. Our results are consistent with this prediction, but more precise data are needed to confirm it. New insights might also be obtained from studies of the pure adjoint limit like Ref. [4]. If this limit turns out to be a conformal theory, the same is expected to hold for the theory with additional fundamental flavors.

A more complete study of the landscape of different $N_f^{(F)}$, $N_f^{(A)}$ combinations will follow, providing a direct comparison of the theory considered here and $\mathcal{N} = 1$ supersymmetric QCD without scalar fields.

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