No-go Theorem for R Symmetries in 4D GUTs

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MF, Ratz and Vaudrevange, *Phys. Lett.* B **705** (2011).

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The set-up

Four-dimensional

supersymmetric **SU(5) GUT** Georgi and Glashow (1974).

with an ***R*** **symmetry** and

only a **finite number of multiplets**.

We would like to...

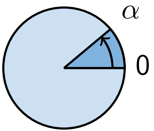
...break SU(5) $\to G_{\mathrm{SM}}$.

...**keep the *R* symmetry unbroken.**

...arrive at the MSSM spectrum.

R symmetries

R symmetries distinguish between superpartners.

- $\mathrm{U}(1)_R$: 

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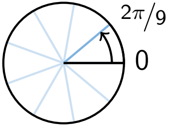
- $\mathbb{Z}_M^R$, **$M \geq 3$**: 

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⇒ R parity is not a real R symmetry.
(it is equivalent to non-R matter parity)

- the superpotential is charged under an R symmetry:

$$q_R(W) \neq 0.$$

The theorem

In supersymmetric SU(5) GUTs with a low-energy R symmetry and a finite number of multiplets…

> …there are always
> **charged massless states**
> **beyond the MSSM spectrum**.

- underlying reason: mass term of GUT-breaking Higgs forbidden,

$$\cancel{\mathrm{m}\, H_0\, H_0}\,.$$

$\Rightarrow$ no low-energy *R* symmetries in conventional SU(5) GUTs.

Thank you!

Bibliography

1. M. Fallbacher, M. Ratz and P. K. S. Vaudrevange, 'No-go theorems for R symmetries in four-dimensional GUTs', *Phys. Lett.* B **705** (2011), 503–506, arXiv: 1109.4797 [hep-ph].
2. H. Georgi and S. L. Glashow, 'Unity of All Elementary-Particle Forces', *Phys. Rev. Lett.* **32** (1974), 438–441.
3. H. M. Lee, S. Raby, M. Ratz, G. G. Ross, R. Schieren, K. Schmidt-Hoberg and P. K. S. Vaudrevange, 'Discrete R symmetries for the MSSM and its singlet extensions', *Nucl. Phys.* B **850** (2011), 1–30, arXiv: 1102.3595 [hep-ph].

An application: the μ problem

- Assume MSSM with SU(5) GUT relations for matter charges:

What symmetries are

anomaly-free and

forbid the μ term ~~$\mu H_u H_d$~~ ?

$\Rightarrow$ **only *R* symmetries!** Lee et al. (2011).

- in SU(5) GUTs:

$\Rightarrow$ no R symmetries at low energies.

$\Rightarrow$ no symmetry that forbids the μ term.

$\Rightarrow$ **no natural solution to the μ problem.**