

# The Electroweak Sphaleron in a strong magnetic field

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# Motivations

- Sphaleron has a magnetic dipole moment
- Magnetic field can lower sphaleron energy
- Could magnetic fields in e.g. heavy-ion collisions lower energy enough to make sphaleron observable?

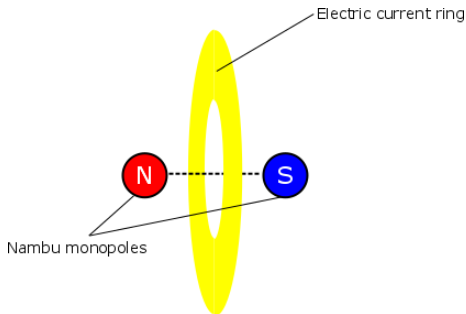


Figure: Schematic cartoon of an Electroweak sphaleron

# Strong magnetic fields in Electroweak Theory

- Constant magnetic field becomes unstable at

$$B_{\text{crit}}^{(1)} = \frac{m_W^2}{e}$$

- Stable solution becomes lattice of vortices.
- At second critical field

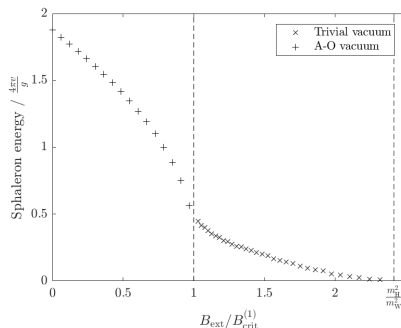
$$B_{\text{crit}}^{(2)} = \frac{m_H^2}{e}$$

Higgs symmetry is restored.

- Expect sphaleron energy to be zero at this point, but what happens before then?

# Our results

- Computed the sphaleron solution numerically in lattice Electroweak theory
- External field strength from  $B_{\text{ext}} = 0$  to  $B_{\text{ext}} = B_{\text{crit}}^{(2)}$
- Sphaleron becomes increasingly prolate for stronger fields.
- For  $B_{\text{crit}}^{(1)} < B_{\text{ext}} < B_{\text{crit}}^{(2)}$  we have a sphaleron against an Ambjørn-Olesen vortex background.



# Implications

- Critical field strength where sphaleron energy vanishes is

$$B_{\text{crit}}^{(2)} = \frac{m_{\text{H}}^2}{e} \approx 5.2 \times 10^4 \text{ GeV} \approx 2.7 \times 10^{20} \text{ T}$$

- Magnetic fields in LHC heavy-ion collisions  $\sim 1 \text{ GeV}^2$  and scale linearly with energy, so  $\sqrt{s} \sim 10^5 \text{ TeV}$  required.
- 10 TeV Pb-Pb collisions lower sphaleron energy by  $\sim 0.1\%$ .
- Unsuppressed sphaleron production due to magnetic fields not feasible in foreseeable future.
- Potential cosmological/astrophysical sources:
  - ▶ Superconducting cosmic strings
  - ▶ Magnetically charged black holes
  - ▶ Inflation produced large scale magnetic fields