

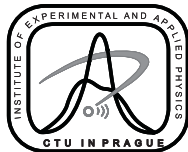
# BPS Cho–Maison magnetic monopole

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# Magnetic monopole in the Standard Model?

Two main paradigms for a field theoretical description of a magnetic monopole:

- 't Hooft–Polyakov monopole:

- Traditional paradigm (1974)
- Based on topology of the vacuum manifold  $G/H$
- In order that it exist, it must be  $\pi_2(G/H) \neq \{1\}$
- This is, however, not the case in SM:  $\pi_2(SU(2) \times U(1)/U(1)) = \{1\}$
- $\Rightarrow$  no 't Hooft–Polyakov monopole in SM!



- Cho–Maison monopole:

- Alternative paradigm (1996)
- Desired non-trivial topology is found in the target space of the normalized Higgs field  $H = \frac{1}{\sqrt{2}}(v + \sigma)\xi$ , where  $\xi^\dagger \xi = 1$
- Set of all  $\xi$  form the complex projective space  $\mathbb{CP}^1$  (due to  $U(1)_Y$  invariance)
- But  $\pi_2(\mathbb{CP}^1) = \pi_2(S^2) = \mathbb{Z}$
- $\Rightarrow$  Cho–Maison monopole can exist SM!



# Infinite monopole mass and the solution

Indeed, magnetic monopole solution can be found!

- But there's a problem: It has infinite mass!
- However, this can be cured by going beyond SM and modifying the  $U(1)_Y$  kinetic term (Cho, Kim, Yoon, 1997) as

$$-\frac{1}{4}B_{\mu\nu}B^{\mu\nu} \longrightarrow -\frac{1}{4}\epsilon B_{\mu\nu}B^{\mu\nu}$$

where  $\epsilon$  is some positive function of  $|H|^2$

- If  $\epsilon(0) = 0$ , the mass of the monopole comes out finite!

However, since  $\epsilon$  is in principle arbitrary, is the monopole mass also arbitrary?

- This type of questions is solved by BPS limit of a given theory:
  - Equations of motions are of the first order
  - The solutions satisfy the lower energy (Bogomolny) bound
- For the 't Hooft–Polyakov monopole obtaining a BPS limit is easy
- What about the BPS limit of the Cho–Maison monopole?

# The result

We derived a whole class of BPS theories that support Cho–Maison monopole:

- Turns out that, in contrast to 't Hooft–Polyakov monopole, it is not enough just to switch off the scalar potential, but also the gauge sector has to be non-trivially modified:

$$\begin{aligned}\mathcal{L}_{\text{BPS}} = & |D_\mu H|^2 - \frac{v^2}{4g^2|H|^2} h^2 \left( \text{Tr} [F_{\mu\nu}^2] - \frac{2}{|H|^4} \text{Tr} [F_{\mu\nu} H H^\dagger]^2 \right) \\ & - \frac{1}{4} \left( \frac{h'}{g|H|^2} \text{Tr} [F_{\mu\nu} H H^\dagger] + \frac{f'}{g'} B_{\mu\nu} \right)^2\end{aligned}$$

where  $h, f'$  are some function of  $|H|^2$

- We were able to find exact solutions
- Most importantly, we found the universal lower mass bound for the Cho–Maison monopole:

$$M \geq \frac{2\pi v}{g} \approx 2.37 \text{ TeV}$$

Based on:

P. B., F. Blaschke, PTEP 2018 (2018) no.7, 073B03, arXiv:1711.04842