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UNIVERSITÀ DI PISA

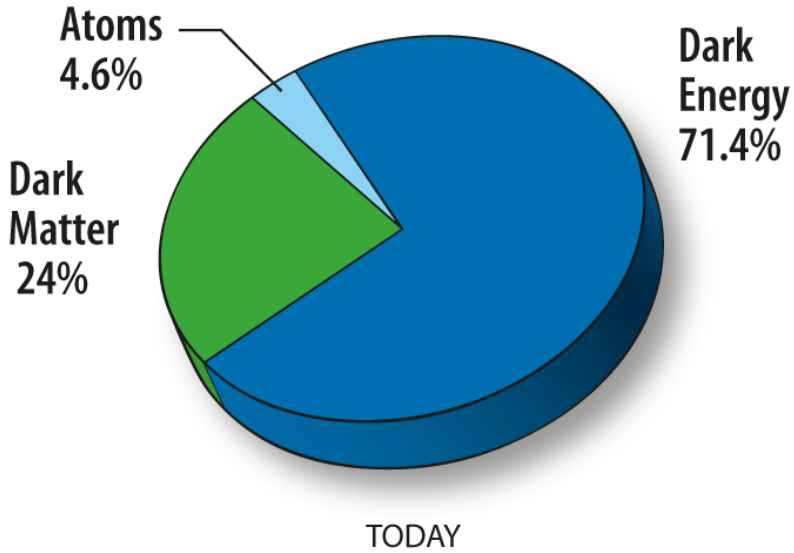
# Accidental Dark Matter models

Giacomo Landini

Invisibles 2021 Workshop

# Overview

Astrophysical and cosmological evidence for DM : $\boxed{\Omega_{\rm DM} \approx 0.26}$




**DM properties**

- neutral
- stable (or $\tau_{\rm DM} \gg t_{\rm U}$)
- cold
- weakly interacting with the Standard model particles

None of the Standard Model particles is a good DM candidate: **physics Beyond the Standard Model is required!**

# Accidental symmetries and DM stability

- The proton is stable or very long-lived: $\tau_p > 10^{34}$ years
- Consequence of the *accidental* baryon number symmetry of the renormalizable SM Lagrangian $\mathrm{U}(1)_B : q \to e^{i\theta} q$
- $\mathrm{U}(1)_B$ broken by dimension-6 operators: $\tau_p \sim \Lambda_{\mathrm{UV}}^4 / m_p^5$

## Accidental DM models

Can DM be accidentally stable as the proton?

- dark sector: confining and/or spontaneously broken dark *gauge theory*

$$\Downarrow$$

- set of accidental global symmetries of the action up to dimension $d \geq 4$ ( $\mathrm{U}(1)$ numbers, discrete $Z_2$ group parities/charge conjugations...)

  $\Rightarrow$ DM is the lightest state with non-trivial transformation properties

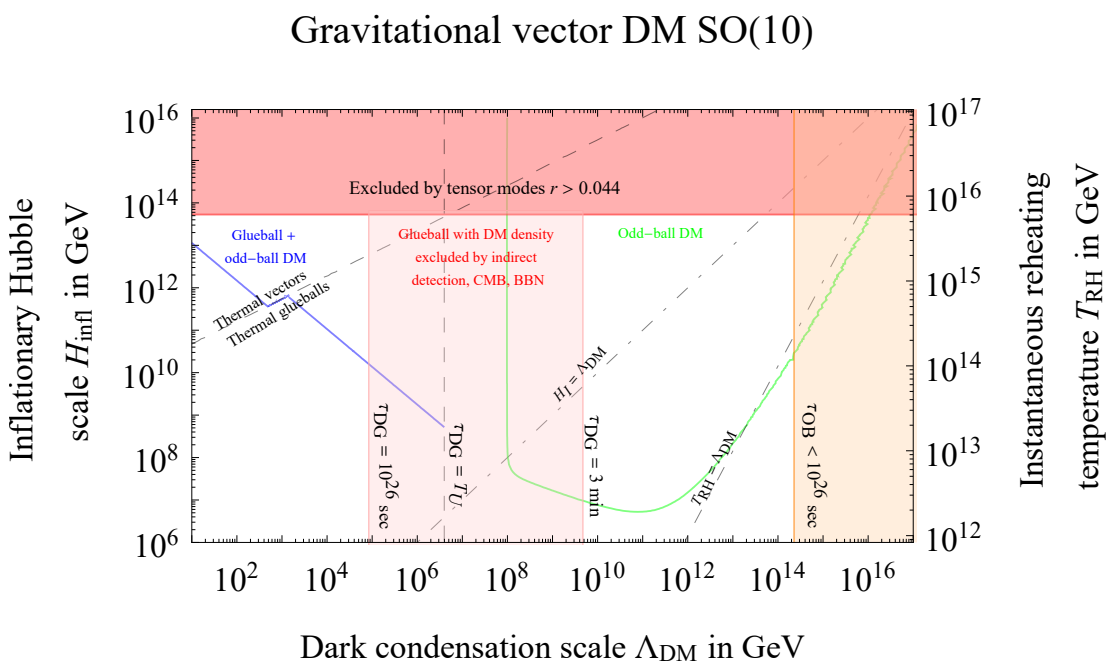
$$\Downarrow$$

- Higher dimensional operators can break the accidental symmetries but are suppressed by powers of $\Lambda_{\mathrm{UV}} \Rightarrow \tau_{\mathrm{DM}} \gg t_U$.

# Gravitational vector DM in $\mathrm{SO}(N)$ gauge theory

- Pure $\mathrm{SO}(N)$ gauge theory coupled to gravity;
- Accidental $Z_2$ group parity (*O-parity*): $\mathcal{G}_{ij} \to (-1)^{\delta_{1i}+\delta_{1j}}\mathcal{G}_{ij}$;
- Special glueballs odd under O-parity decay only through dimension-$N$ operators $\Rightarrow$ they are long lived if $M_{OB} \lesssim 10^{14}$ GeV for $N = 10$;

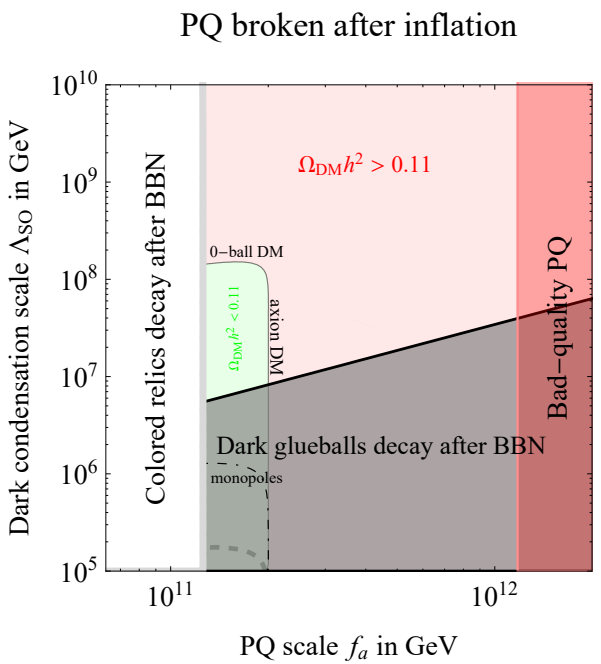
DM is produced via *gravitational freeze-in*



# Axion DM in $\mathrm{SU}(N) \to \mathrm{SO}(N)$ gauge theory

- $\mathrm{SU}(N)$ gauge group with a scalar in the symmetric representation + heavy fermions provide an accidental $\mathrm{U}(1)_{\mathrm{PQ}}$ symmetry, automatically preserved by higher-order operators up to dimension $N$;
- $\mathrm{SU}(N) \otimes \mathrm{U}(1)_{\mathrm{PQ}} \to \mathrm{SO}(N)$ by scalar vev at $f_a$ ;
- extra *accidental* $Z_2$ group parity preserved by $\mathrm{SO}(N)$ dynamics (O-parity)

Multicomponent DM: *axions* (VRM) + $Z_2$-odd bound (freeze out/freeze-in)



# Conclusions

- A dark confining/spontaneously broken gauge sector gives rise to a set of accidental global symmetries;
- automatically stable (or long-lived) DM candidates
- gauge dynamics is interesting by itself (Peccei-Quinn quality, confinement/Higgs duality, phase transitions,...)

**Poster**

Find more details in my poster!