Model Building?

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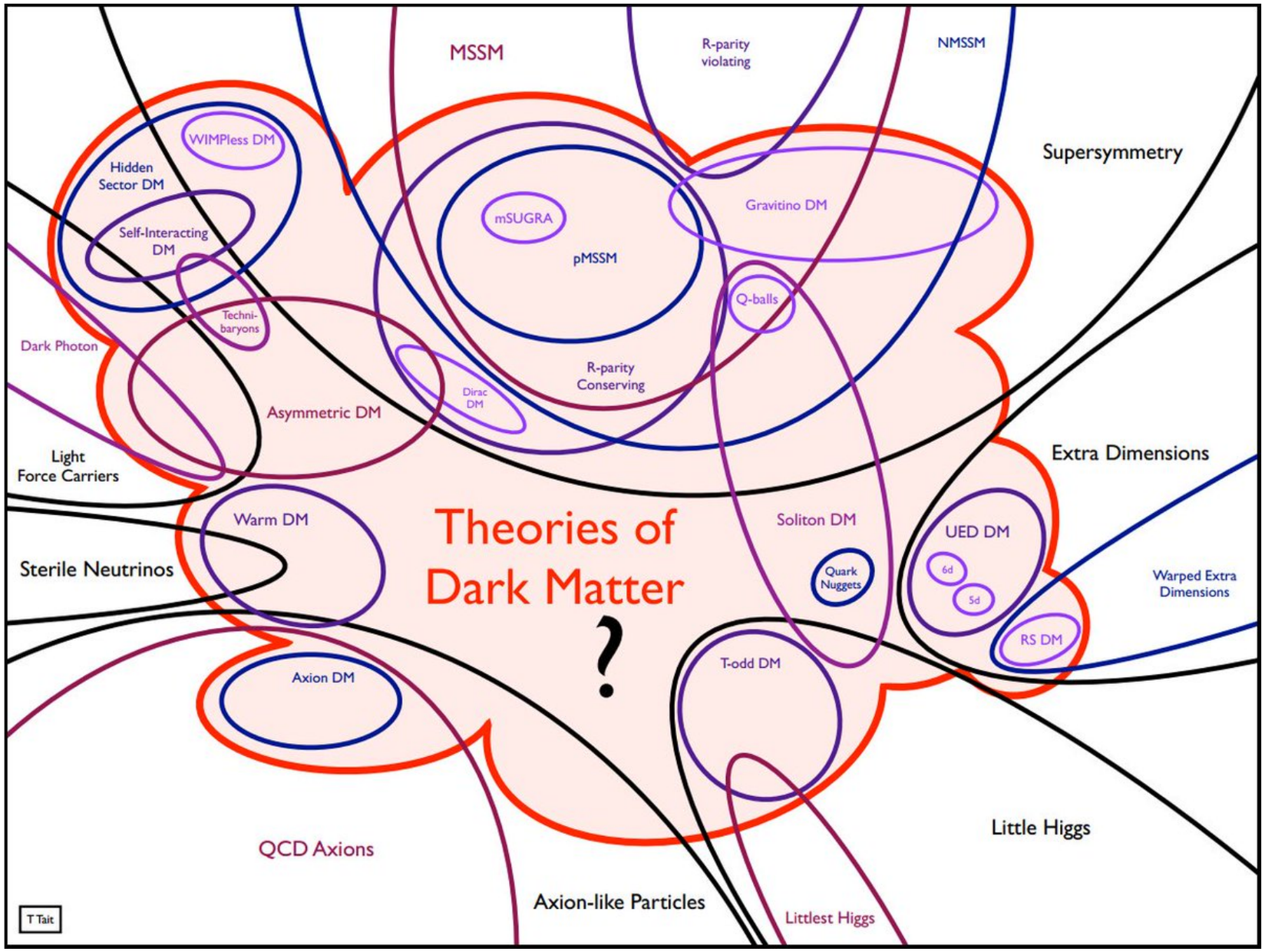
Pollica, June 2022

DM LANDSCAPE



Too many models!

Michele Redi, INFN Florence

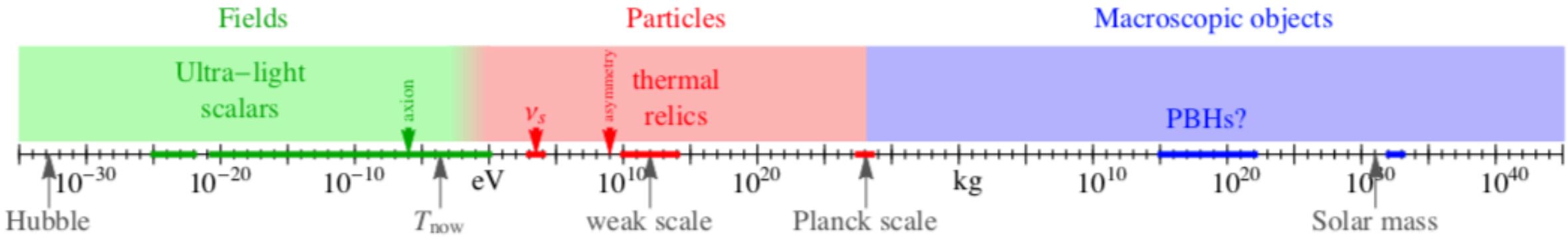
- DM Identikit

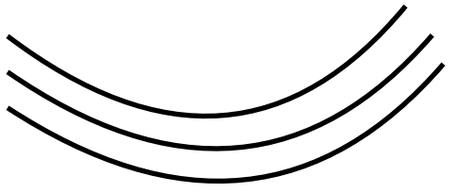
1. Stable

2. Neutral

3. Cold

4. Collisionless



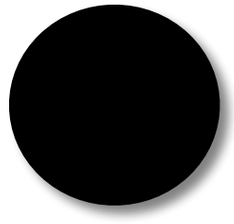


Fields

(Axion)

Particles

(WIMP)



Macroscopic

(Black holes)

What should be our theory guide?

BEST MODELS

QCD Axion:

Solves strong CP problem

Predicts DM candidate

So far weakly constrained

WIMP:

Motivated by the electro-weak scale

Experimentally observable

Secluded dark sector:

DM candidates are ubiquitous in dark sectors

No reason to be coupled to SM

Primordial Black Holes:

Excellent DM candidate in SM

Non trivial to obtain the abundance

Constrained experimentally

Others?

Scalar singlet, fermion singlet, dark photon, ALPs, MACHOs, solitons, monopoles, wimpzillas...

QUESTIONS

PQ quality:

The Peccei-Quinn global symmetry of the axion must be of exceptional quality:

$$\bar{\theta} \sim \frac{1}{m_\pi^2 f_\pi^2} \frac{\langle O_d \rangle}{M_p^{d-4}} \longrightarrow d > 12$$

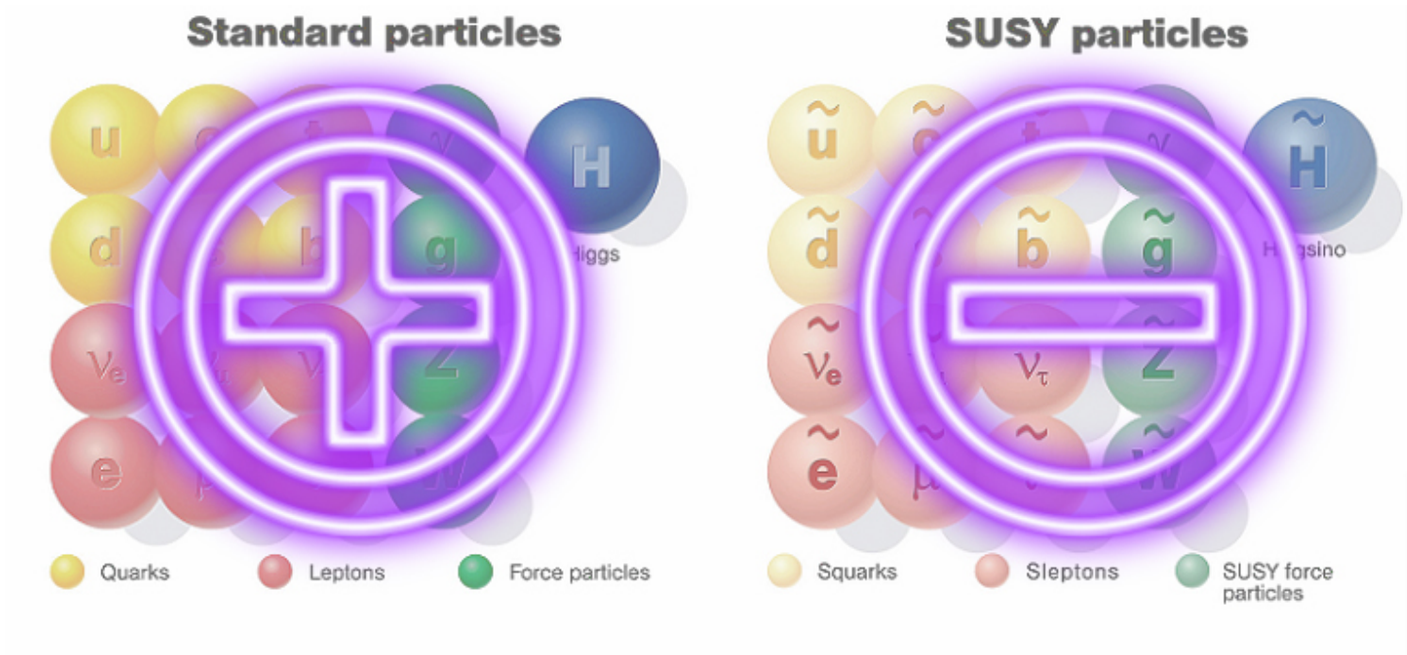
At fundamental level no exact global symmetries exist. Moreover in many models the symmetry is imposed by hand. This is similar to mu=0 solution of strong CP and at odds with SM philosophy.

Should we worry about PQ quality?

- DM STABILITY:

Cosmological stability of DM is often obtained imposing ad hoc global symmetries. In supersymmetry:

R-parity:



Proton stability nicely follows from accidental baryon number conservation of SM lagrangian.

Should DM be accidentally stable as the proton?

- New accidental symmetries:

Accidental symmetry follow from gauge symmetries:

1) A fermion quintuplet of SU(2)L

2) New ``dark" gauge forces

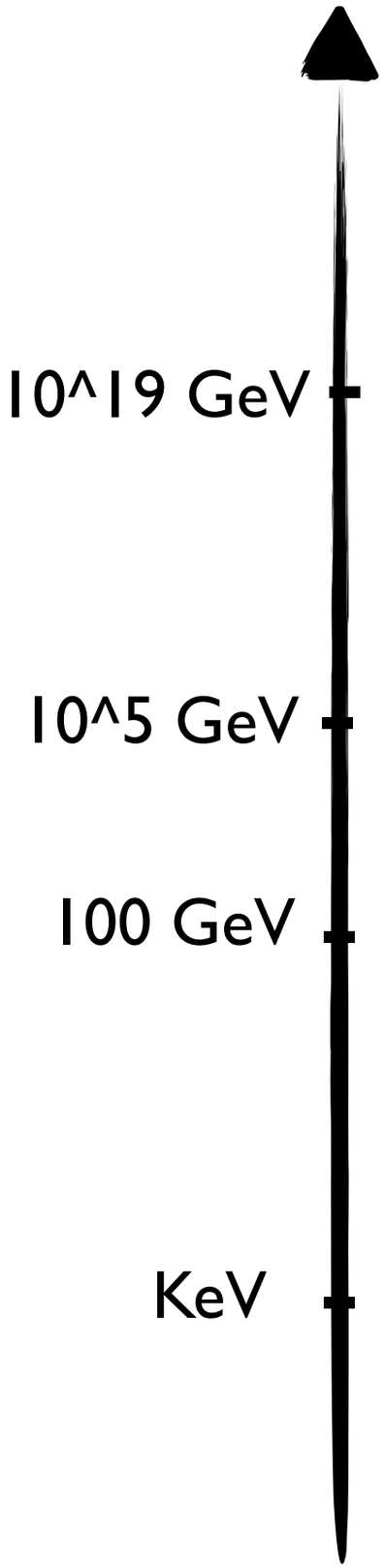
Non abelian gauge forces lead to hadron-like DM

- DM is black hole:

$$\tau \sim \frac{1}{\hbar} \frac{M^3}{M_p^4}$$

A classical object is stable

Should we care about DM production?



Phase transitions, features in primordial power spectrum...

Freeze-out in cold dark sectors. Inflationary production.
More difficult to justify stability.

thermal freeze-out. Interactions with SM guaranteed.

non minimal thermal freeze-out, freeze-in, asymmetric.
No guaranteed signals.

Misalignment mechanism. Signals mostly cosmological.
No particular reason to interact with SM.