

# Pedro Schwaller

## Current and recent interests

- Mechanism of EWSB (Higgs physics & naturalness)
- Dark Matter model building
- Baryon Asymmetry of the Universe

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- Baryon Asymmetry of the Universe

The scale of  
Dark QCD

arxiv:1306.4676  
with Yang Bai

# Asymmetric DM

- Motivated by

$$\rho_{\text{DM}} \approx 5\rho_{\text{B}}$$

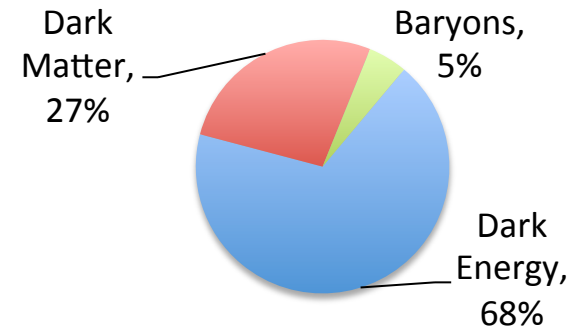
- Many mechanism to relate number densities:  $n_{\text{DM}} \approx n_{\text{B}}$

- Only doing half of the job!

$$\rho_{\text{DM}} = n_{\text{DM}} \times M_{\text{DM}}$$

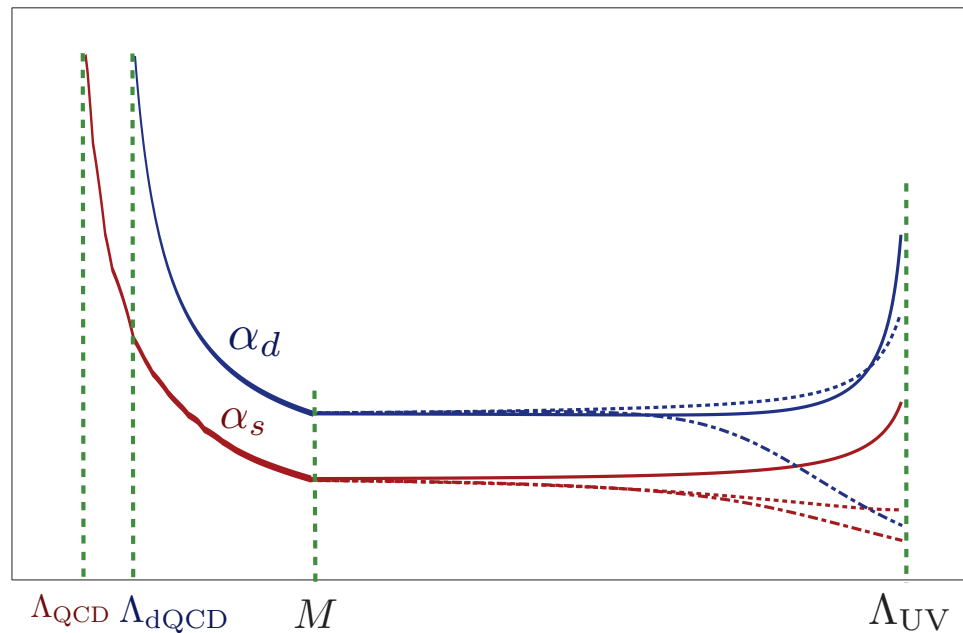
- Look for dynamical explanation of

$$M_{\text{DM}} \sim M_p$$



Nussinov; Barr; Barr, Chivukula, Farhi; Gudnason, Kouvaris, Sannino; Kitano, Low; Luty, Kaplan, Zurek; Buckley, Randall; Davoudiasl, Morrissey, Sigurdson, Tulin; Shelton, Zurek; Falkowski, Rudermann, Volanski; N. Rius et al; S. Davidson et al; Kim, Zurek;

# Running - Schematic



- FP predicts ratio of couplings at intermediate scale  $M$
- Joint fields decouple at  $M$
- Independent running, but similar confinement scales

$$\Lambda_{dQCD} \sim \Lambda_{QCD}$$

# Model

$SU(3)_{\text{QCD}}$

$\times$

$SU(3)_{\text{dQCD}}$

Fermions:

$Q_{\text{SM}} (3, 1)$

SM quarks

$Y_i (3, 3)$

$X_i (1, 3)$

Dark quarks

Scalars:

$\tilde{Q}_i (3, 1)$

$\Phi_i (3, 3)$

$\tilde{X}_i (1, 3)$

Decouple at scale  $M$

# Specific Model

$SU(3)_{\text{QCD}}$

$\times$

$SU(3)_{\text{dQCD}}$

Fermions:

$Q_{\text{SM}} (3, 1)^7$   
SM quarks

$Y_i (3, 3)^2$

$X_i (1, 3)^7$   
Dark quarks

Scalars:

$\tilde{Q}_i (3, 1)^2$

$\Phi_i (3, 3)^1$

$\tilde{X}_i (1, 3)^1$

Decouple at scale  $M$

Fixed points:

$$\alpha_s^* = 0.090 \quad \alpha_d^* = 0.168$$

$$M = 870 \text{ GeV}$$

DM mass:

$$M_{DM} \approx 3.5 \text{ GeV}$$

# Asymmetry

- From decay of a heavy Majorana fermion

$$\mathcal{L} \supset k_i \bar{Y}_1 \Phi N_i + \text{h.c.}$$



- Asymmetry in bi-fundamental fields  $Y_1$ ,  $\Phi$
- Decay to SM, dark quarks:  $B$  and  $D$  asymmetry

$$\frac{\rho_{DM}}{\rho_B} = \frac{7}{5} \frac{3.5 \text{ GeV}}{0.94 \text{ GeV}} \approx 5$$

# Pheno / Outlook

- Direct detection
  - Mediated by bi-fundamental fields
  - Order  $10^{-40} \text{ cm}^2$  (still ok after LUX!!!)
  - No indirect detection!
- Collider:
  - Pair production of bi-fundamentals
  - Jets + missing energy, or exotic jets
- Future:
  - Improved models (weak scale / SUSY relation?)
  - Pheno: collider studies, (dark) flavor, DM dynamics
  - Generic composite ADM studies



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## Current and recent interests

- Mechanism of EWSB
  - Vector-like leptons, di-photon rate & vacuum stability (w. Joglekar, Wagner, 2012-13)
  - Higgs CP violation (w. A. Freitas, 2012), Baryogenesis relation? (...)
- Dark Matter model building
  - Dark QCD (this talk)
  - V-leptons and DM (w. Tait, Vega-Morales, 2013; Joglekar, Wagner (in progress))
  - Searches for co-annihilating DM (...)
- Baryon Asymmetry of the Universe
  - Finite temperature interaction rates, phenomenology (w. Garbrecht, 2013, ...)
  - Lower scale models, collider/flavour tests, neutrino physics (...)