Baryogenesis & dark matter from *B* mesons: a supersymmetric story

Gonzalo Alonso-Álvarez

Work with: Gilly Elor, Ann Nelson, Huagyu Xiao, arXiv:1907.10612

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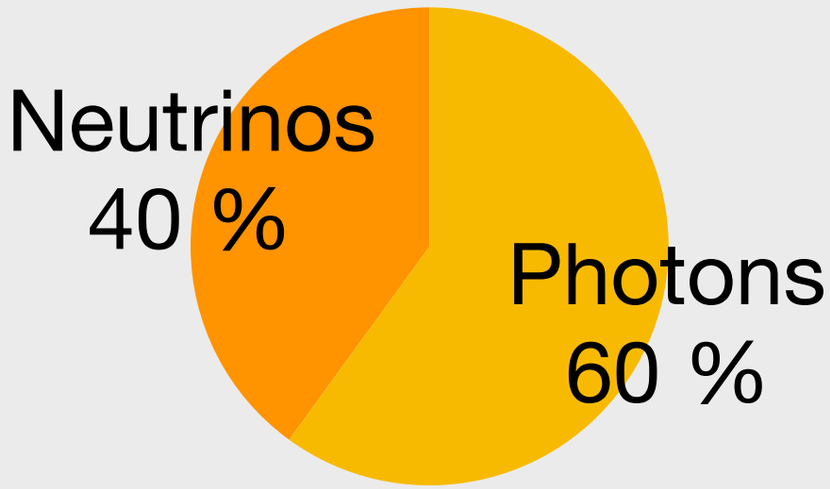
elusives
neutrinos, dark matter & dark energy physics
Horizon 2020

UNIVERSITÄT HEIDELBERG
ZUKUNFT SEIT 1386

"la Caixa" Foundation

Motivation

We expect:



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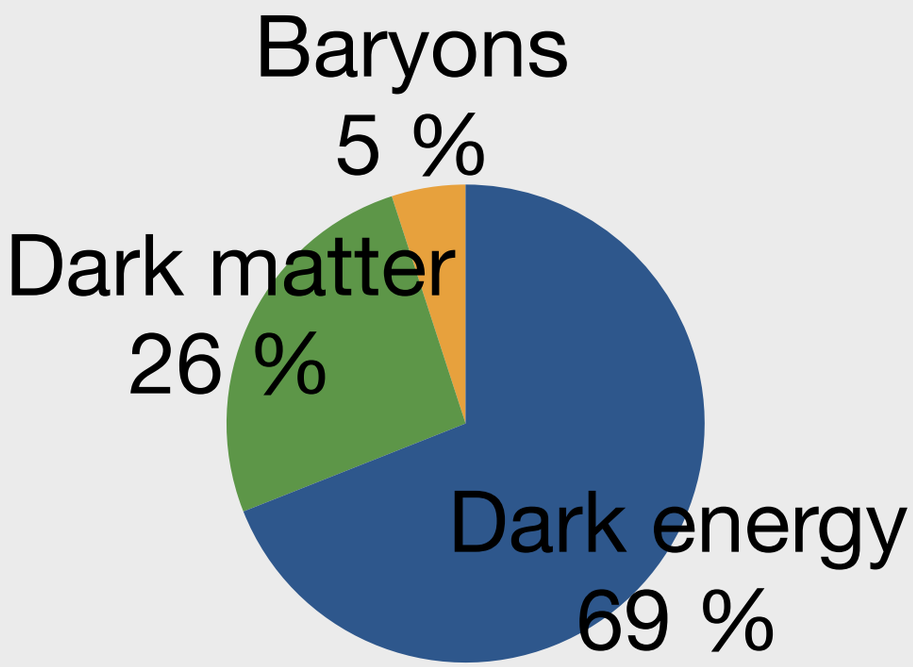

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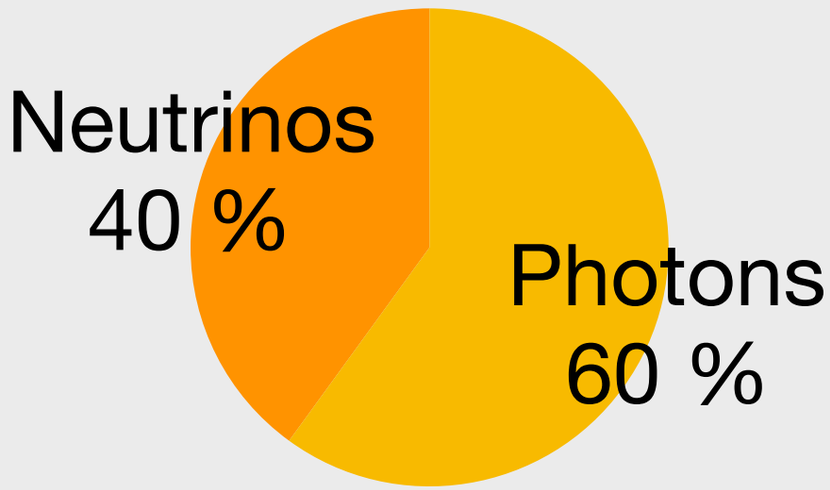

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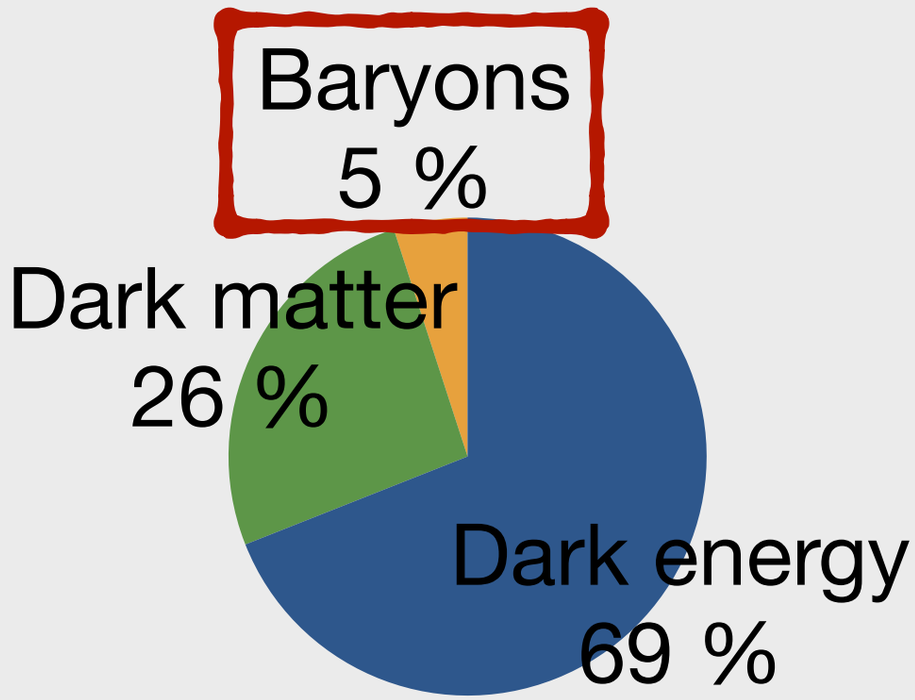

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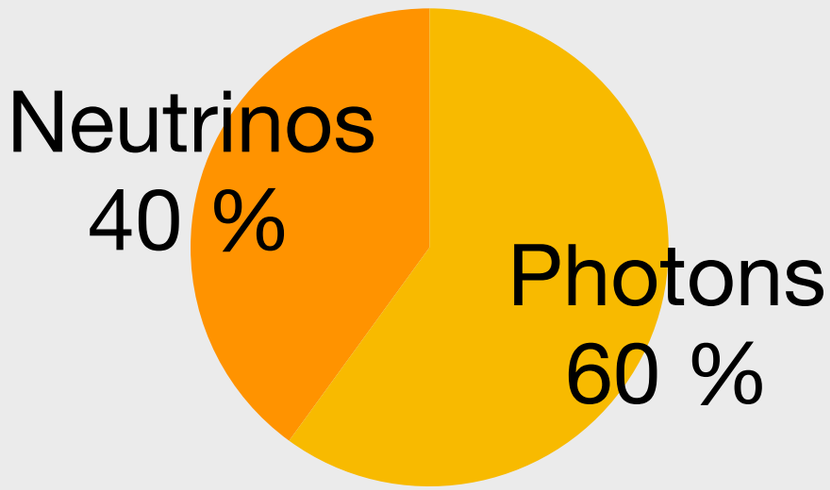

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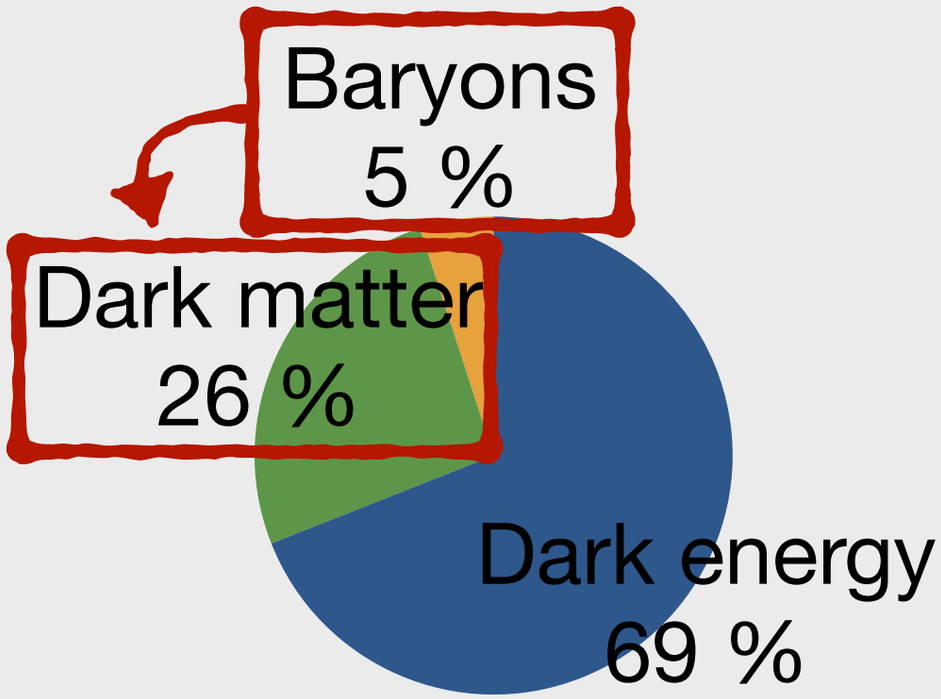

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Peter Paul Rubens, Jan Brueghel the Elder

- Baryon asymmetry of the visible Universe.

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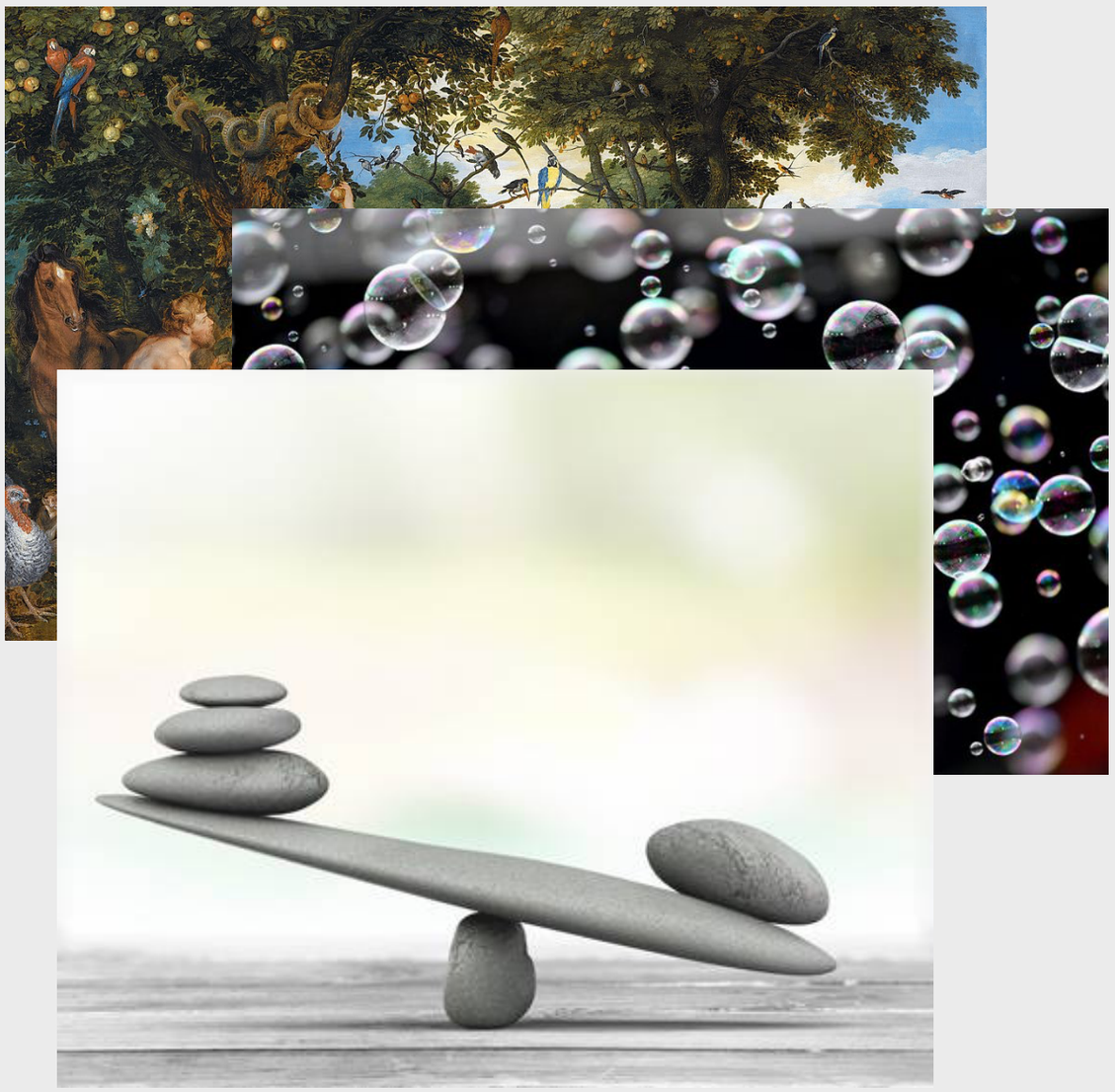

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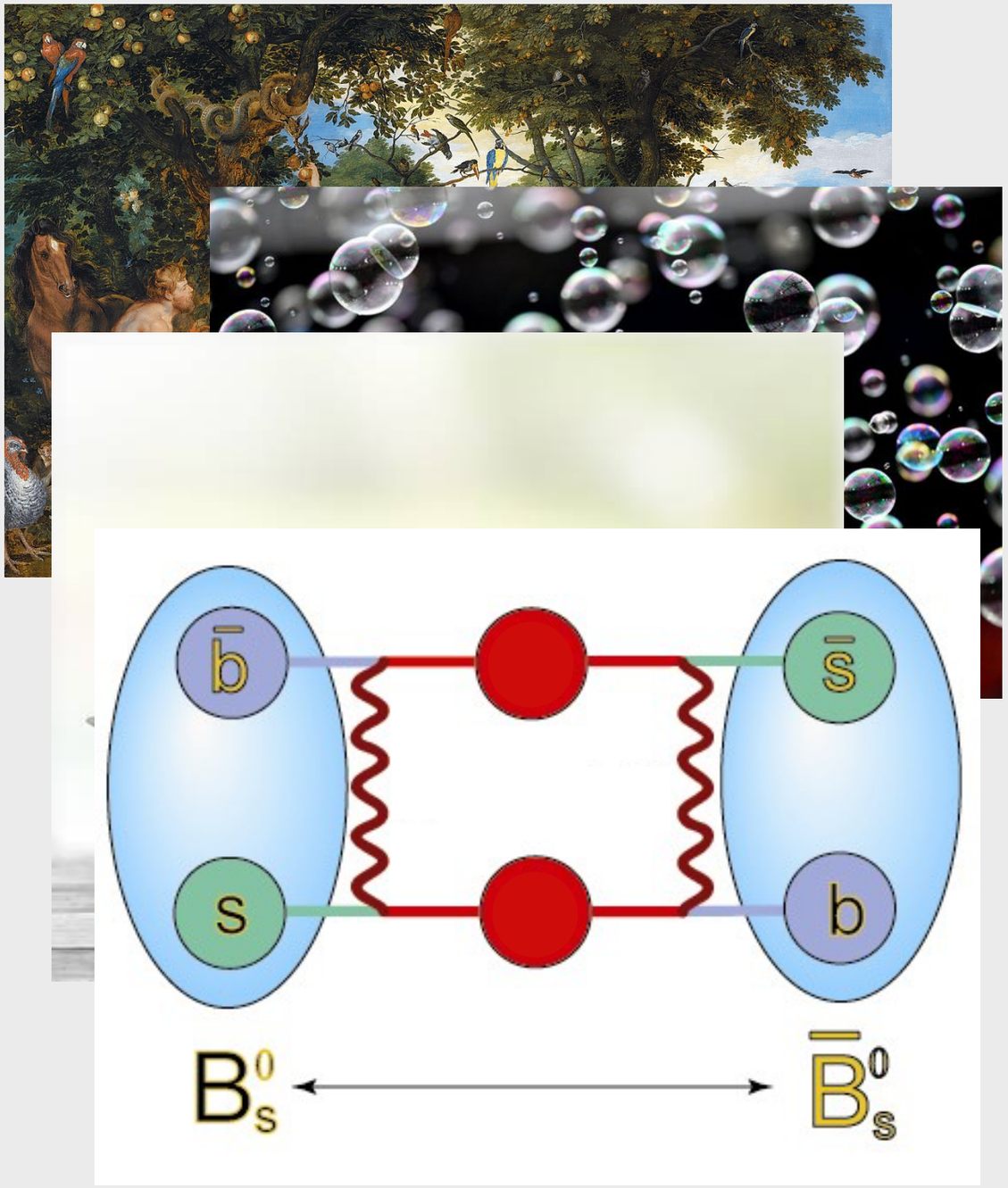

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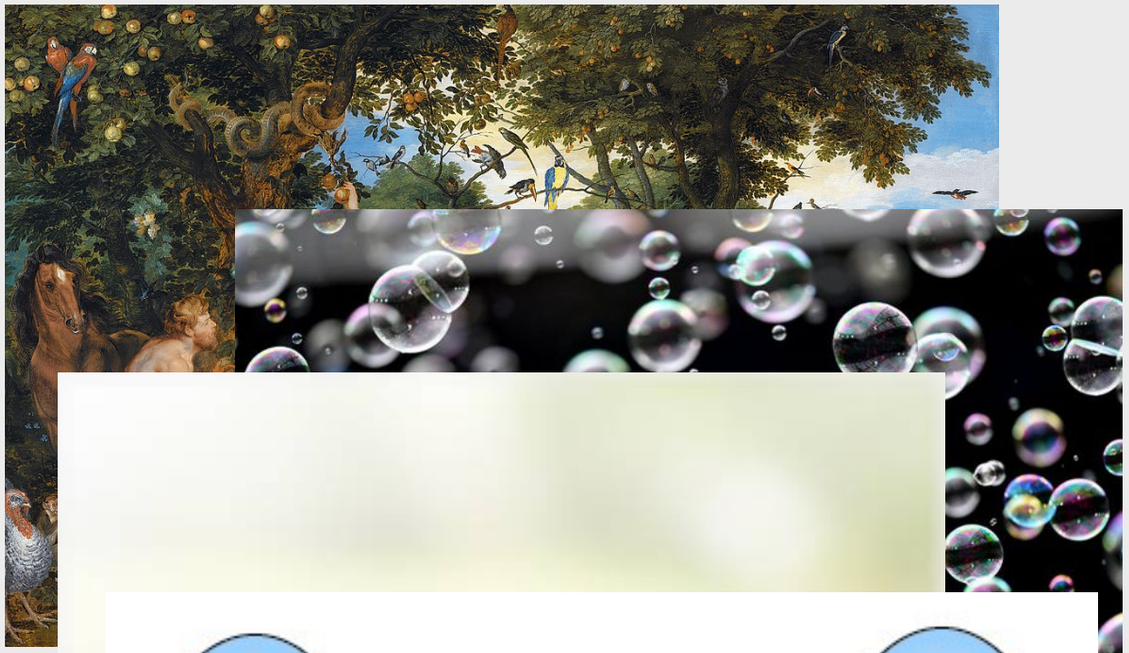

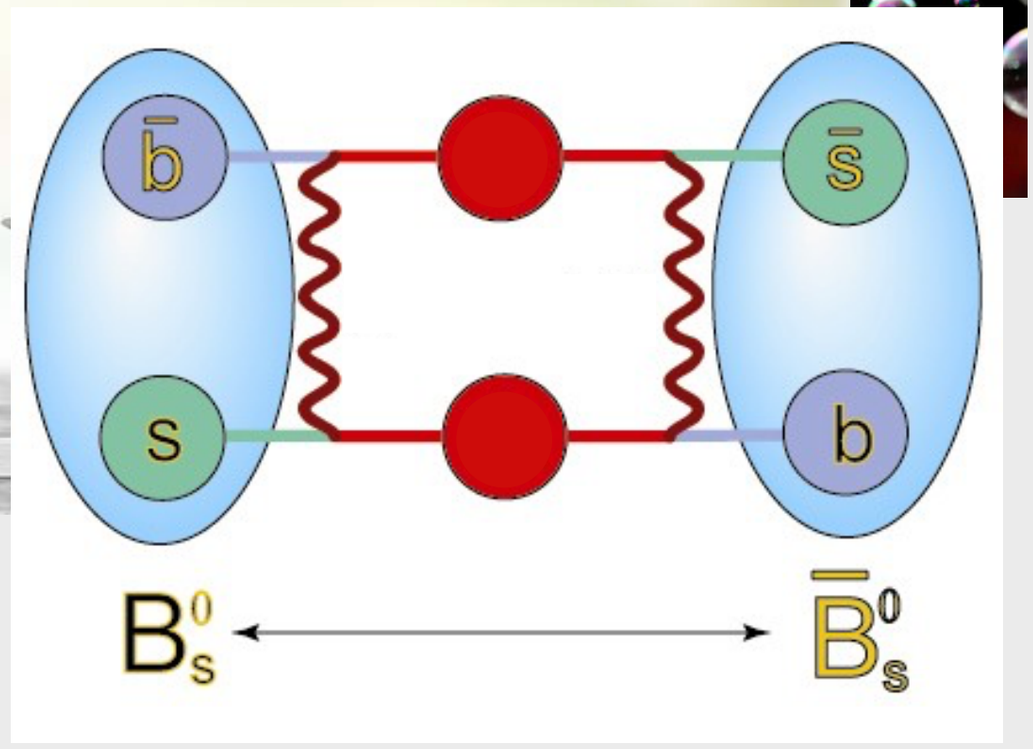

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- Baryogenesis from B meson oscillations:

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- Self-contained model (SUSY)
  - Full flavor structure
  - DM = RH sneutrino

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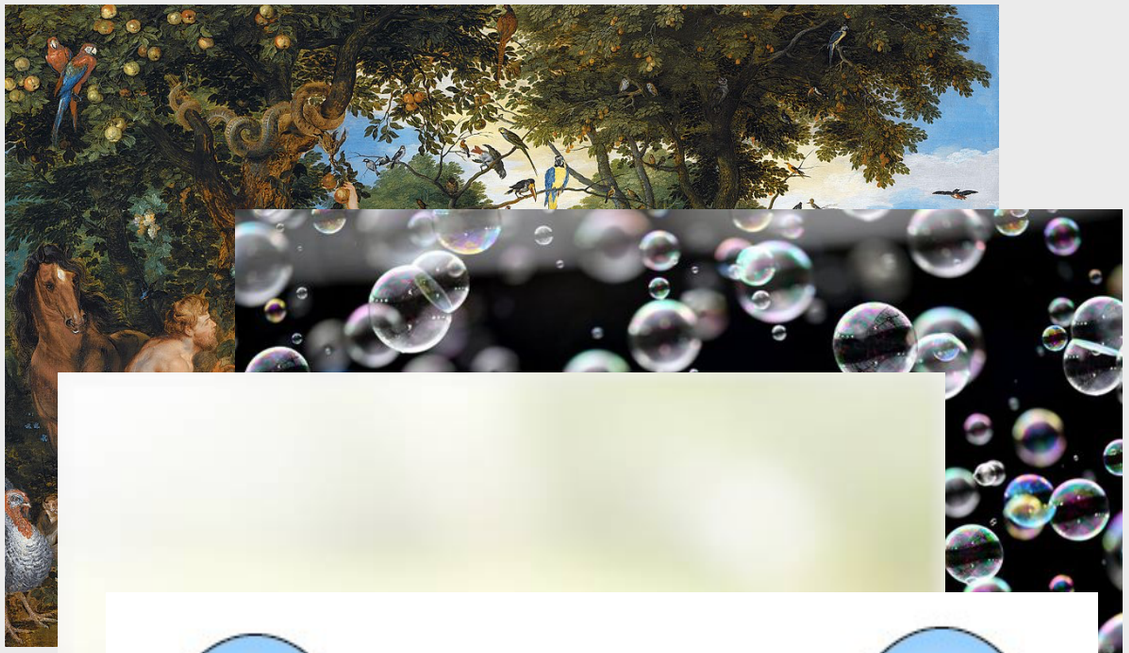

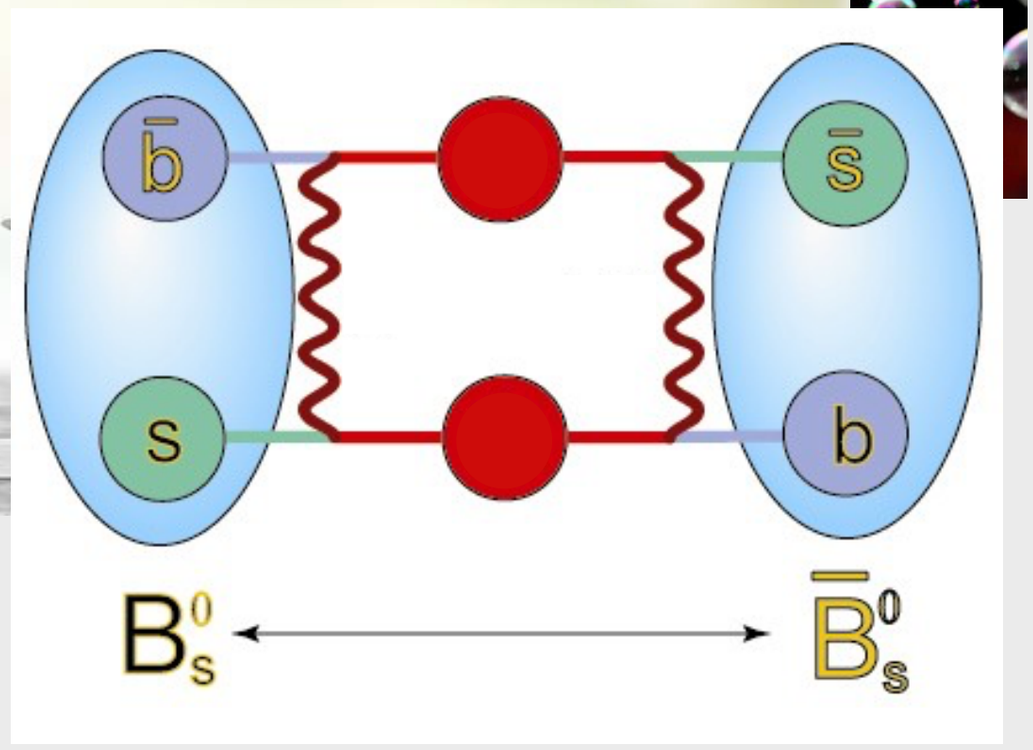

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- **Very testable scenario.**

Main ideas

1. Baryogenesis and dark matter are linked.

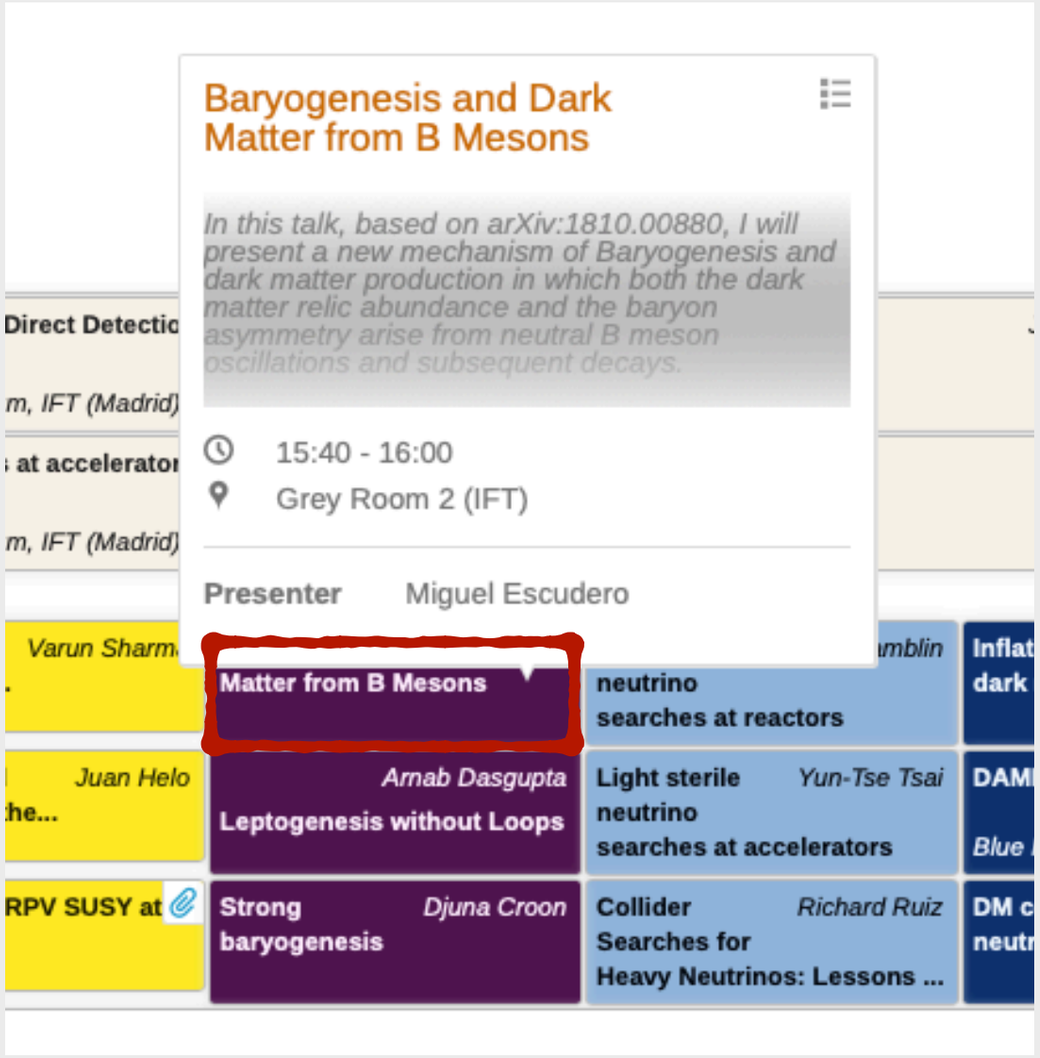
2. The baryon asymmetry is related to B-meson observables.

3. SUSY theory contains all the ingredients.

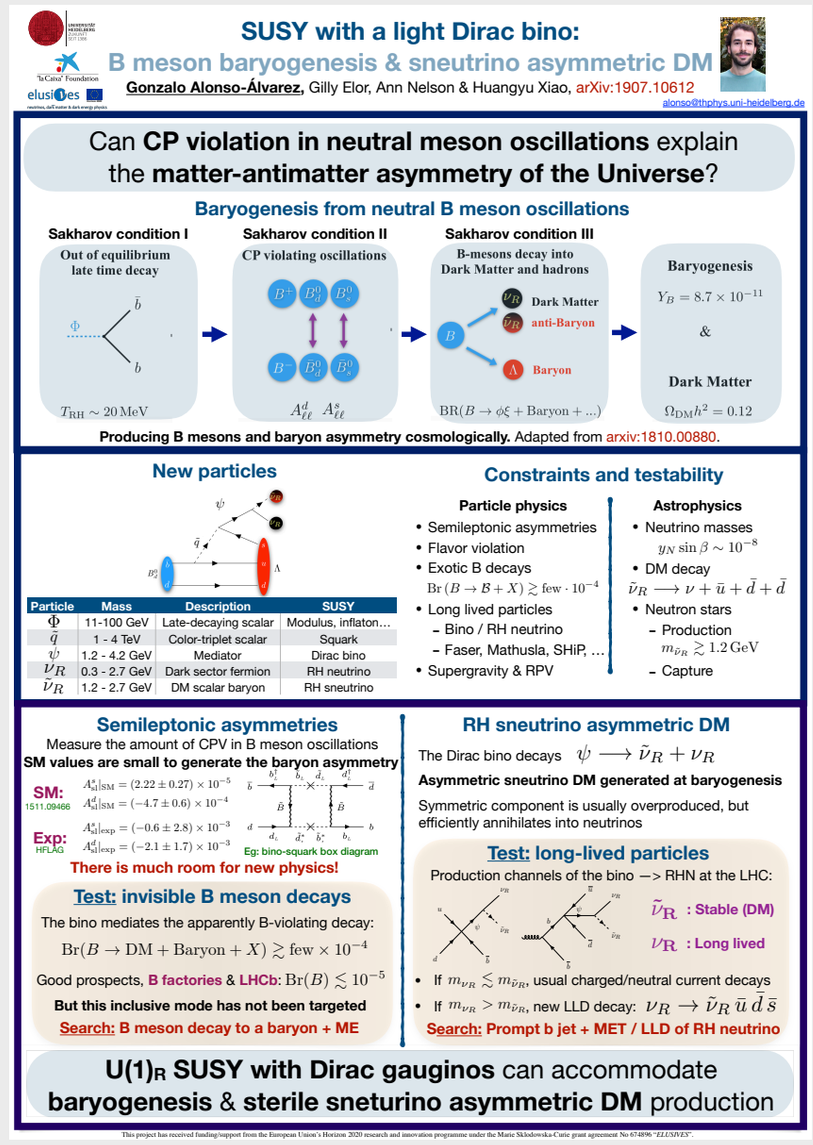
4. Fully testable model: flavor, collider & astrophysical observables.

If you want to know more...

1. Go to Miguel Escudero's talk this afternoon



2. Talk to me!



Baryogenesis mechanism

Sakharov I

Out of equilibrium late time decay

$T_{\rm RH} \sim 20\,{\rm MeV}$

Sakharov II

CP violating oscillations

$A_{\ell\ell}^d \quad A_{\ell\ell}^s$

Sakharov III

B-mesons decay into Dark Matter and hadrons

${\rm BR}(B \to \phi\xi + {\rm Baryon} + \ldots)$

Baryogenesis

$Y_B = 8.7 \times 10^{-11}$

&

Dark Matter

$\Omega_{\rm DM} h^2 = 0.12$

New particles & SUSY model

Particle	Mass	Description	SUSY

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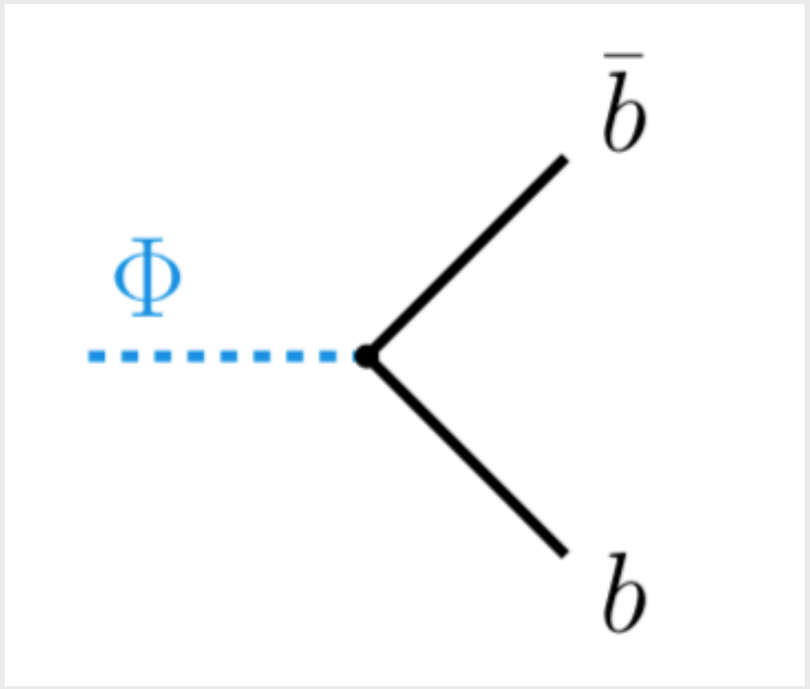

A scalar with mass

$$m_\Phi \in 11 - 100\,\mathrm{GeV}$$

generically decays into *b* quarks.

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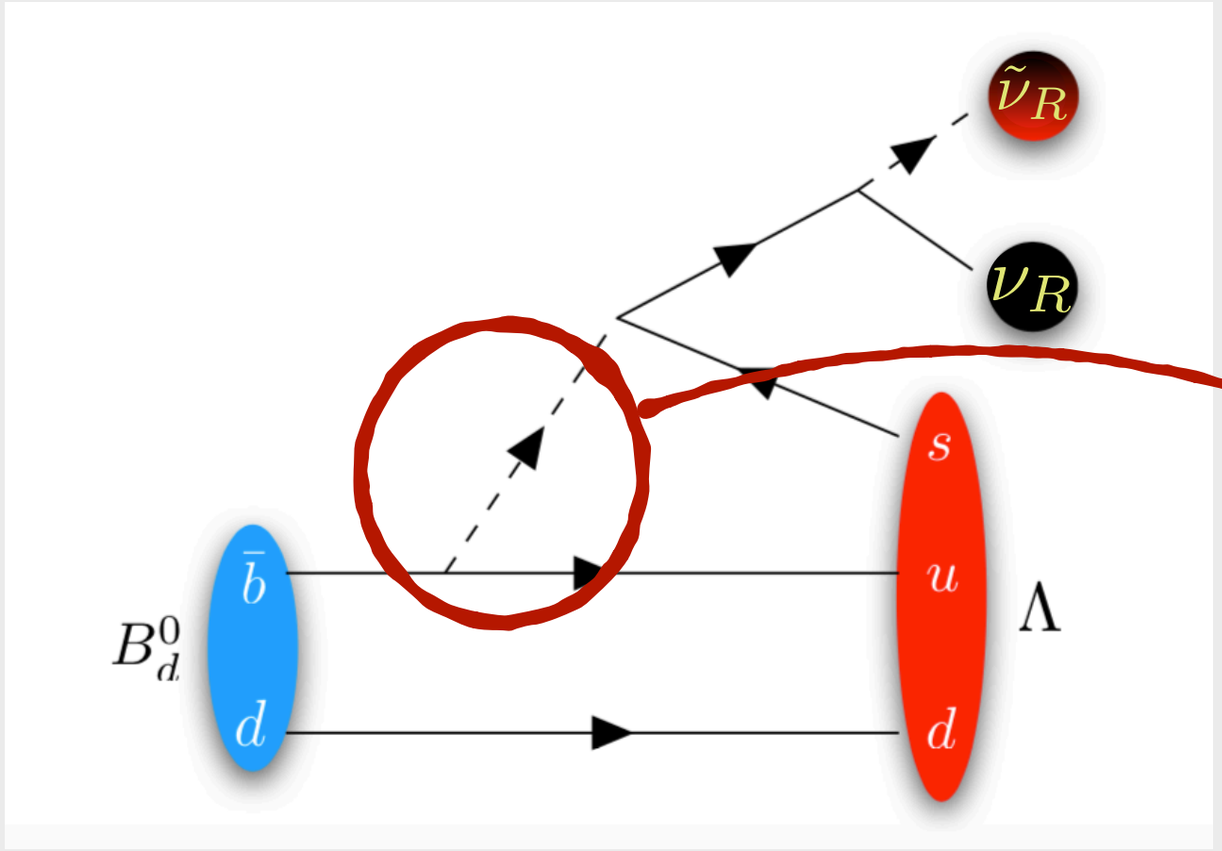
$\tilde{q}$	1 - 4 TeV	Color-triplet scalar	Squark



Color-triplet scalar coupling to quarks

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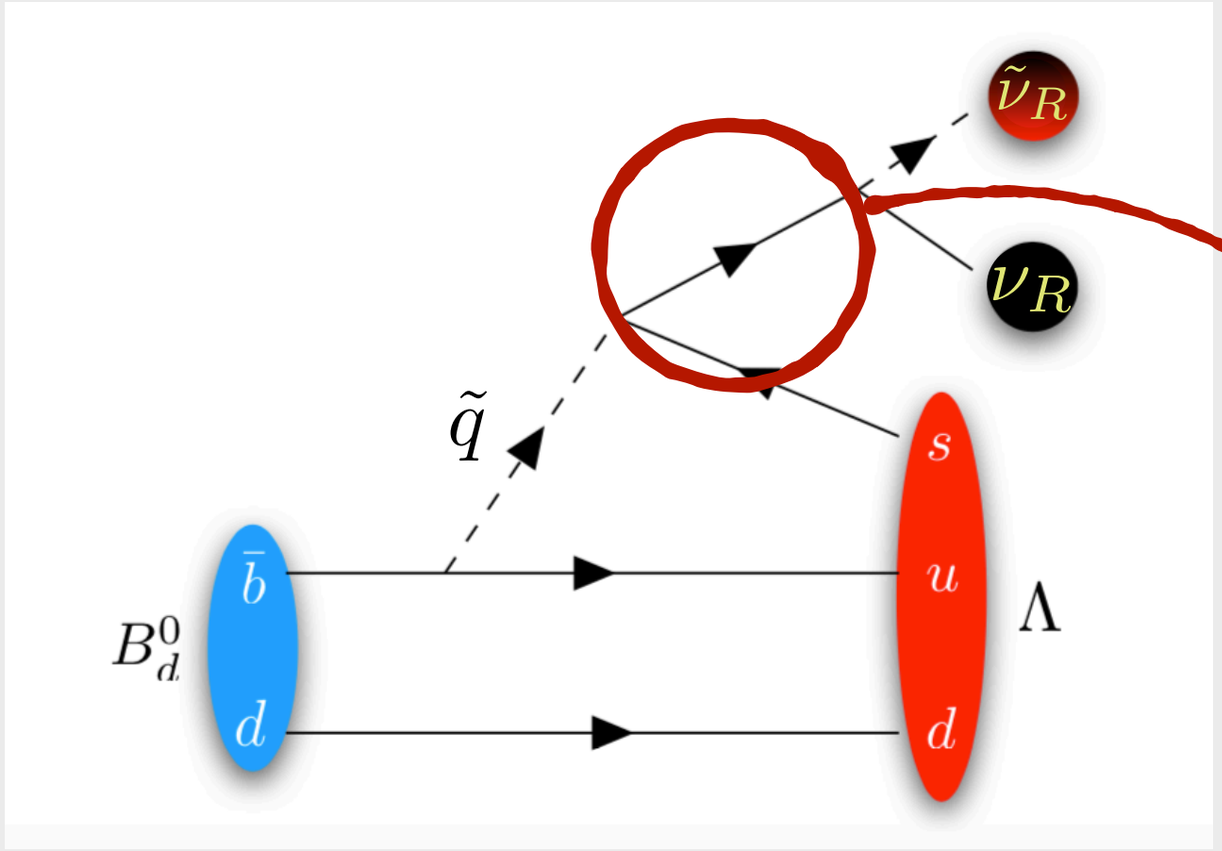

Dirac fermion connecting the visible and dark sectors

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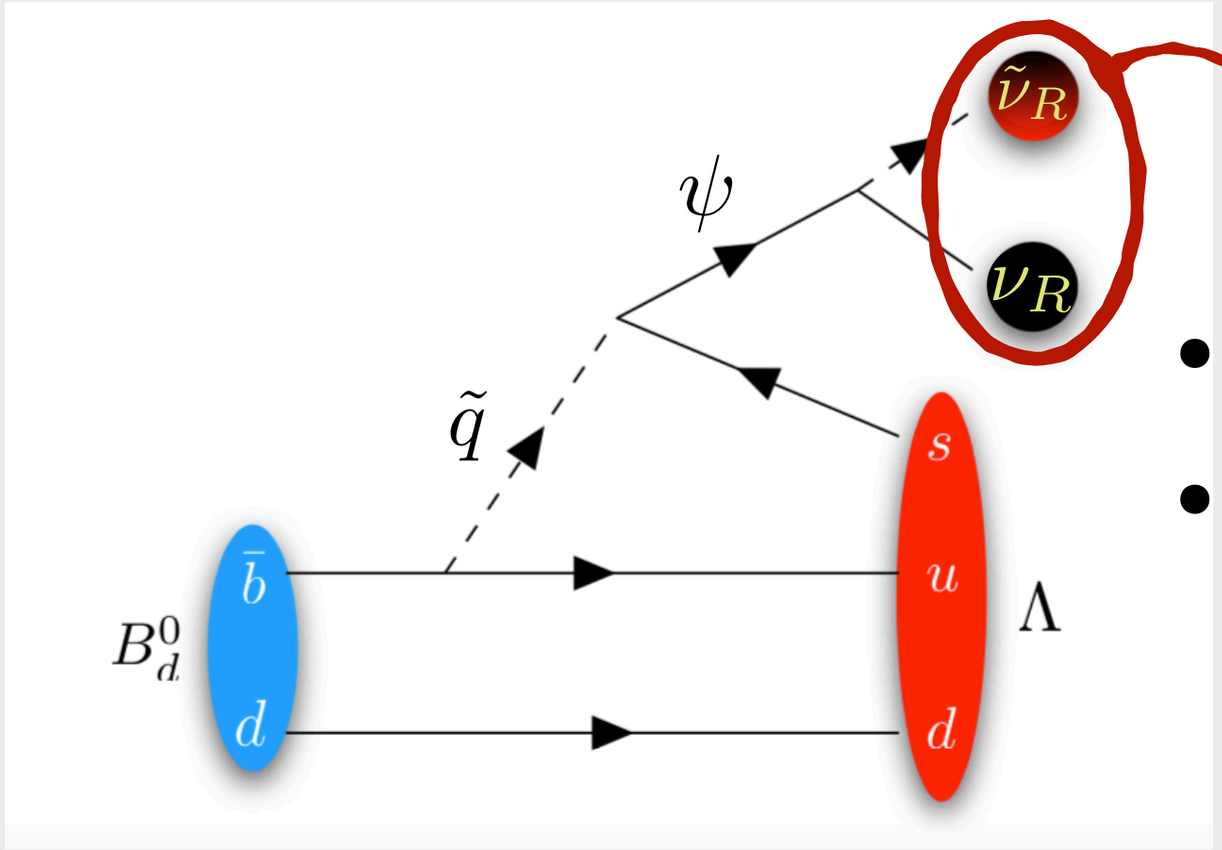
ν_R	0.3 - 2.7 GeV	Dark sector fermion	RH neutrino
$\tilde{\nu}_R$	1.2 - 2.7 GeV	Dark sector scalar baryon	RH sneutrino



Dark sector singlet states:

- Fermion: RH neutrino
- Scalar baryon: RH sneutrino

<u>Good DM candidate!</u>

A very testable scenario

Particle physics

- Semileptonic asymmetries
- Flavor violation
- Exotic B decays

$$\mathrm{Br}\,(B \to \mathcal{B} + X) \gtrsim \mathrm{few} \cdot 10^{-4}$$

- Long lived particles
  - Bino / RH neutrino
  - Faser, Mathusla, SHiP, …
- Supergravity & RPV

Astrophysics

- DM decay

$$\tilde{\nu}_R \longrightarrow \nu_R + \bar{u} + \bar{d} + \bar{d}$$

- Neutron stars
  - Production

$$m_{\tilde{\nu}_R} \gtrsim 1.2\,\mathrm{GeV}$$

  - Capture
- Neutrino masses

$$y_N \sin\beta \sim 10^{-8}$$

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Thanks!

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$\mathbf{U(1)_R}$ SUSY

The U(1)R symmetry is identified with **baryon number**

Superfield	$U(1)_R$ (B #)
$\mathbf{U}^c, \mathbf{D}^c$	$2/3$
$\mathbf{Q}$	$4/3$
$\mathbf{H}_u, \mathbf{H}_d$	0
$\mathbf{R}_u, \mathbf{R}_d$	2
$\mathbf{S}, \mathbf{T}, \mathbf{O}$	0
$\mathbf{L}$	1
$\mathbf{E}^c, \mathbf{N}_R^c$	1

Majorana gaugino masses are forbidden.

$\Rightarrow$ Dirac gauginos, can be light.

$$m_{\tilde{B}} \sim \mathrm{GeV}$$