

Dark Matter Models & Candidates

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&
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Dark Matter

Invitation

NATAL – BRAZIL!

DARKWIN

Dark Matter and Weak Interactions Conference – Sept 2-13, 2019

Neutrino Physics

Steven Weinberg – Texas U.

Manfred Lindner - MPIK

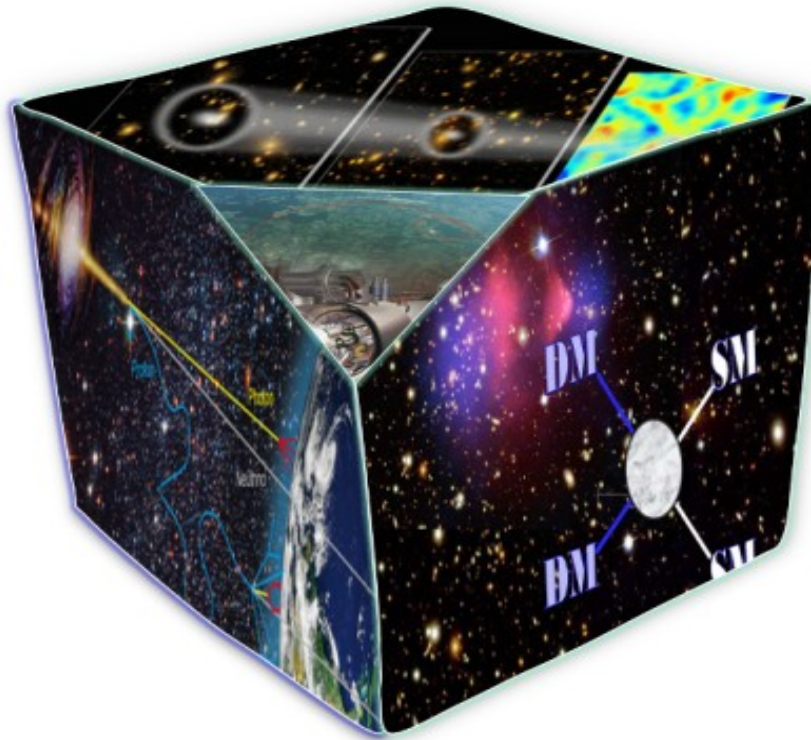
Stefano Profumo - UCSC

Pasquale Serpico - Annecy

Volker Springel – MPI Garching

Andreas Ringwald – DESY

Chris Kouvari – Denmark U.



Fabio Iocco- ICTP-SAIFR

Orlando Peres- UNICAMP

Emanuele Vecchi – USP

Enrico Bertuzzo -USP

Carlos Pires -UFPB

Paulo Sérgio – UFPB

Alex Dias – UFABC

A. Alves – UFSP

Martin Makler – CBPF

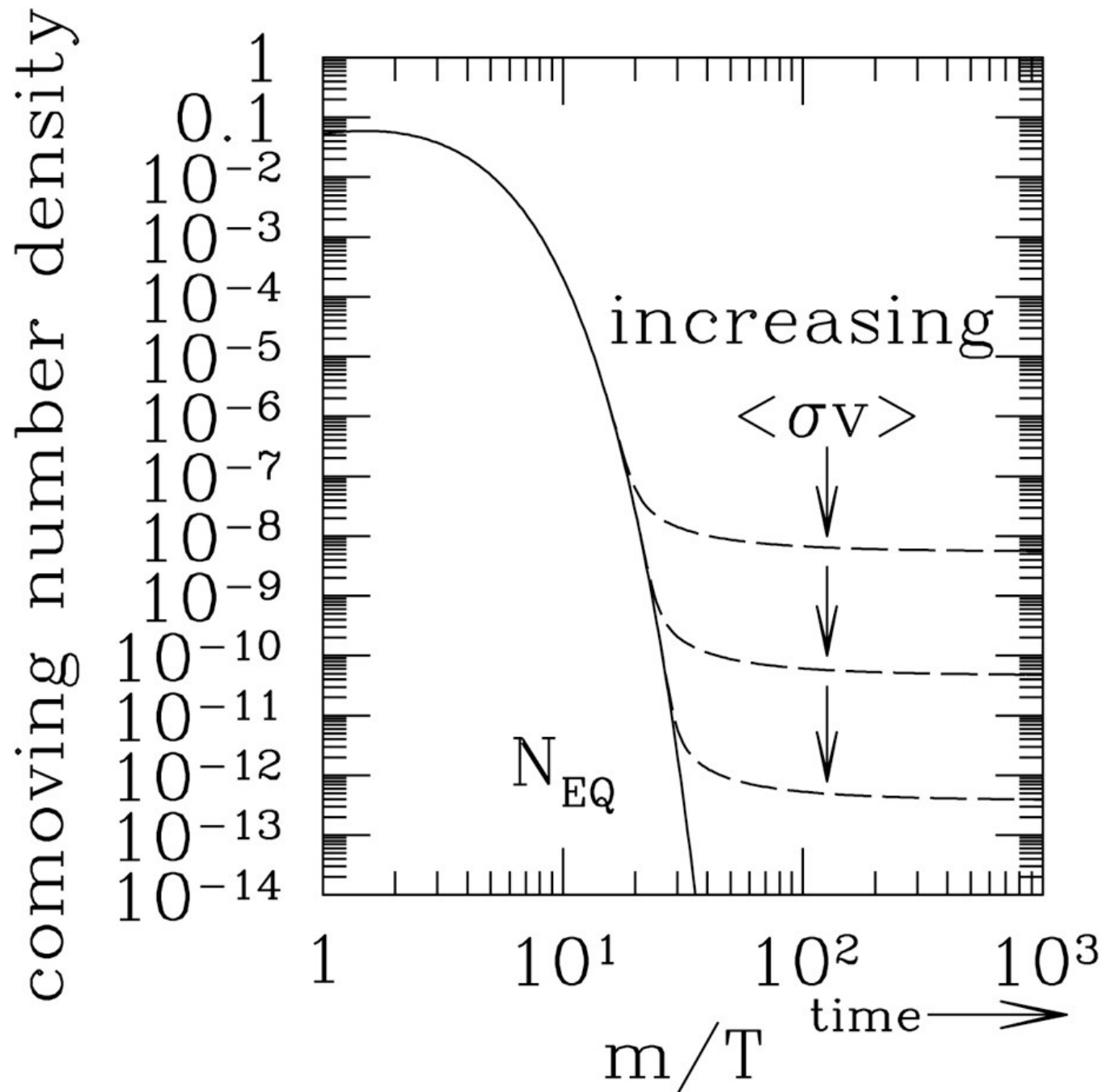
Ettore Segreto - UNICAMP

Organizers: Farinaldo Queiroz, Antonio Masiero, Werner Rodejohann, Carlos Yaguna

Astrophysics

**Awards for the best
posters and talks
(students&postdocs)**

Collider Physics



Outline

Dark Matter Models

Higgs Portal

Dark Photon

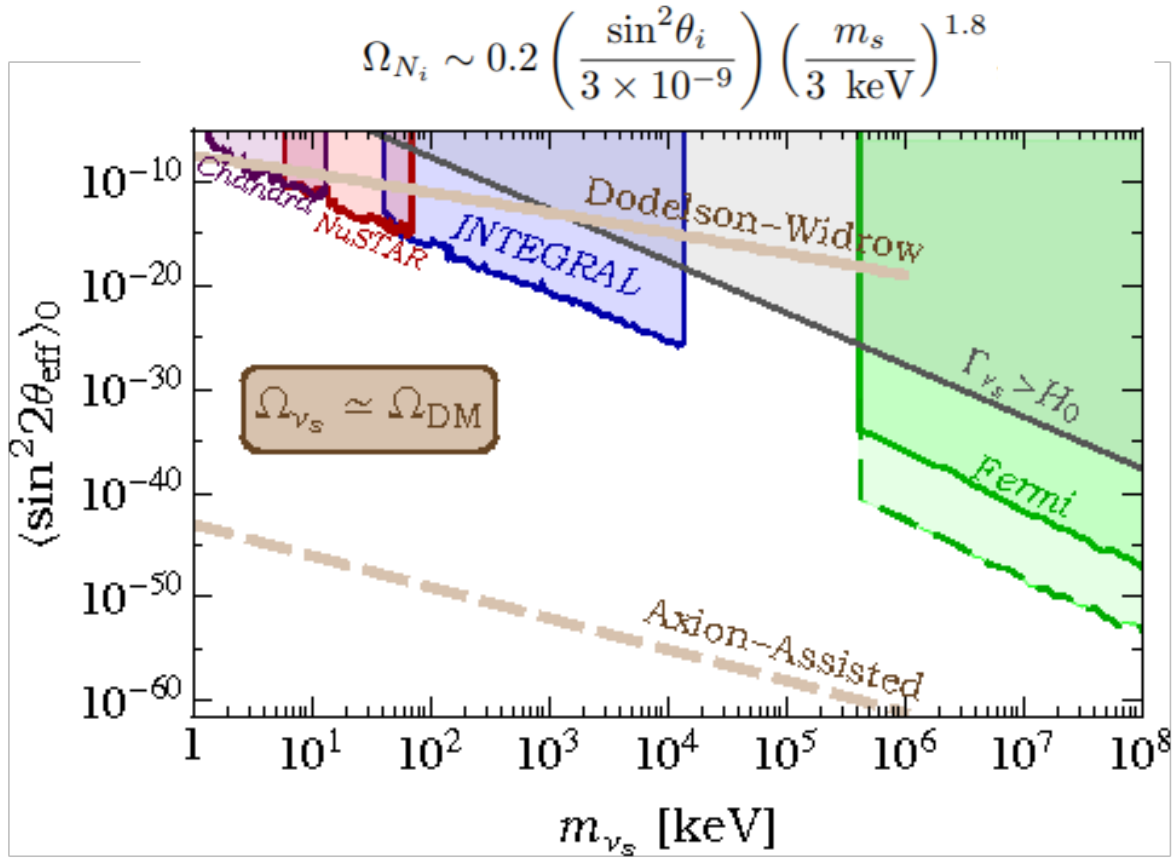
Gravitino

Asymmetric Dark Matter

Sterile Neutrino

Axions

Sterile Neutrino Dark Matter: oscillations, freeze-in, axion assisted, scalar decay etc...



Higgs Portals Freeze-out : scalar, vector and fermion dark matter

Review of dark matter models:1703.07364

Scalar

Fermion

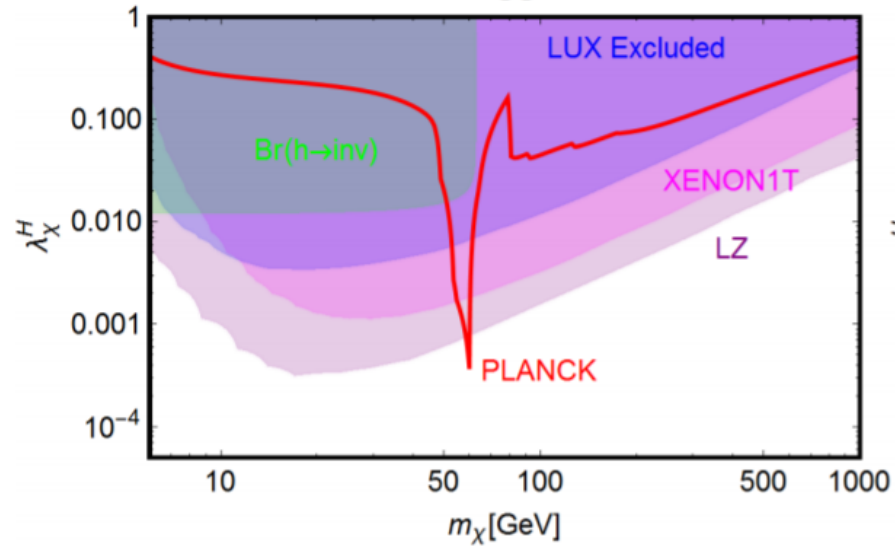
Vector

$$\xi \lambda_\chi^H \chi^* \chi H^\dagger H,$$

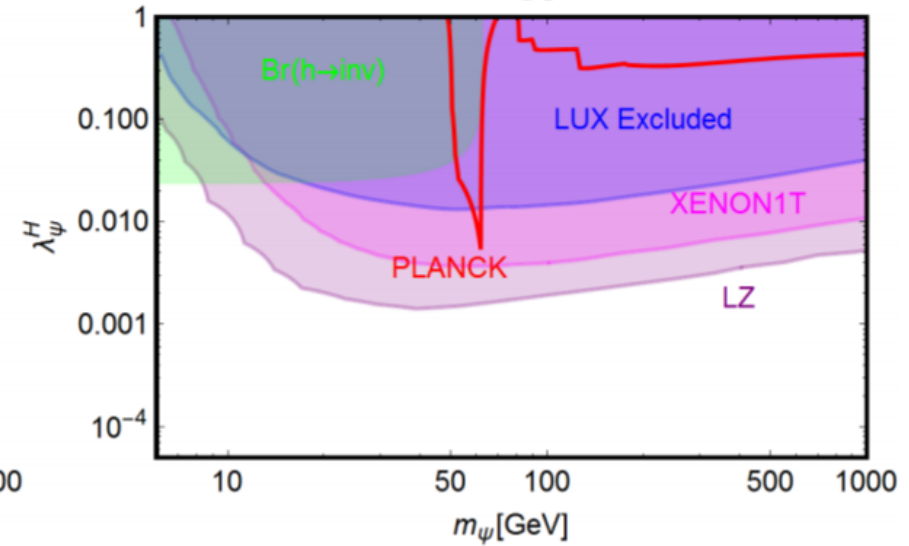
$$\xi \frac{\lambda_\psi^H}{\Lambda} \bar{\psi} \psi H^\dagger H$$

$$\xi \lambda_V^H V^\mu V_\mu H^\dagger H$$

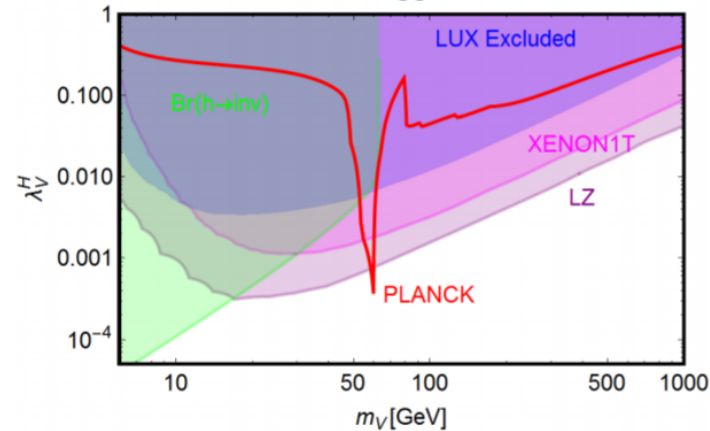
Scalar Higgs Portal



Fermion Higgs Portal



Vector Higgs Portal



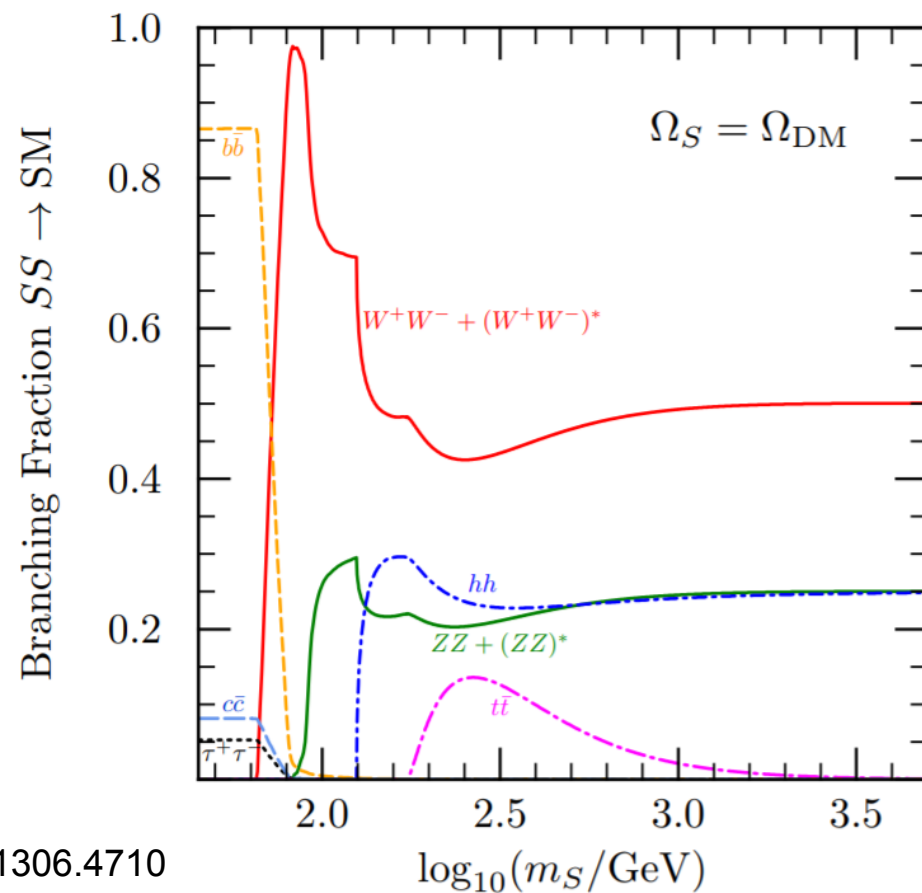
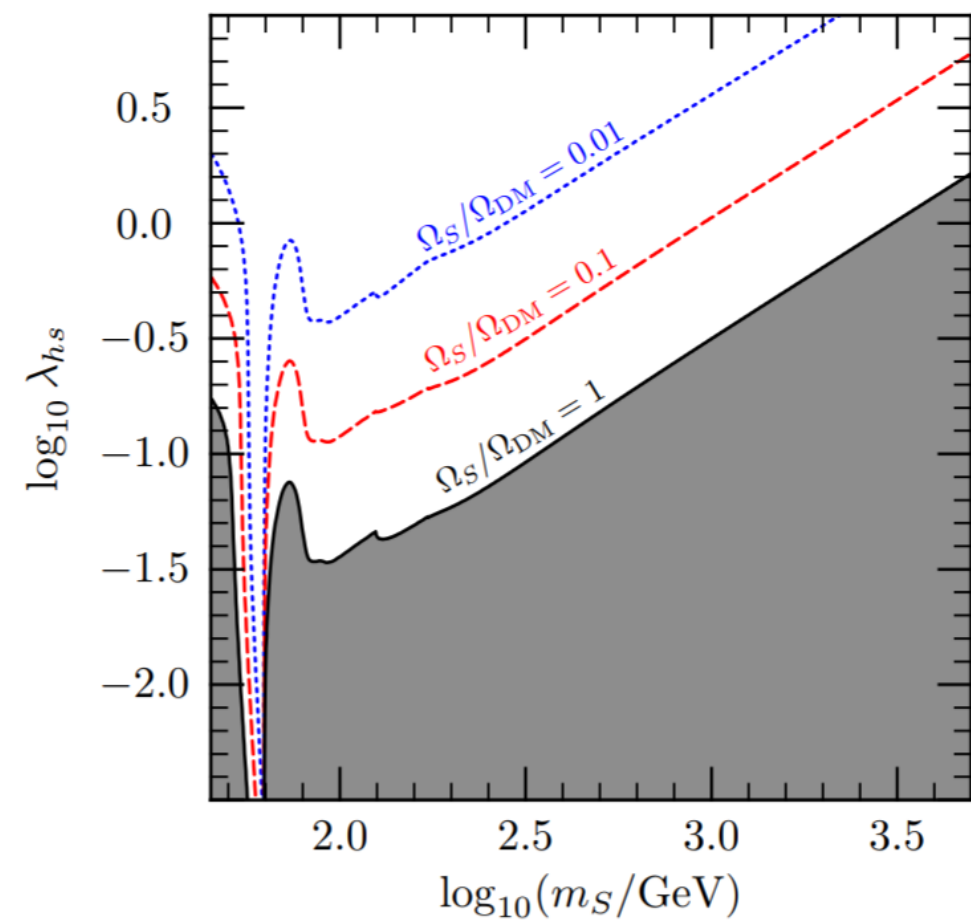
Higgs Portal (freeze-out)

$$V = \frac{1}{2}\mu_S^2 S^2 + \frac{1}{2}\lambda_{hS} S^2 |H|^2$$

$$m_S = \sqrt{\mu_S^2 + \frac{1}{2}\lambda_{hS} v_0^2}$$

Right abundance $\sim \frac{1}{\text{---}}$

Weak scale cross section

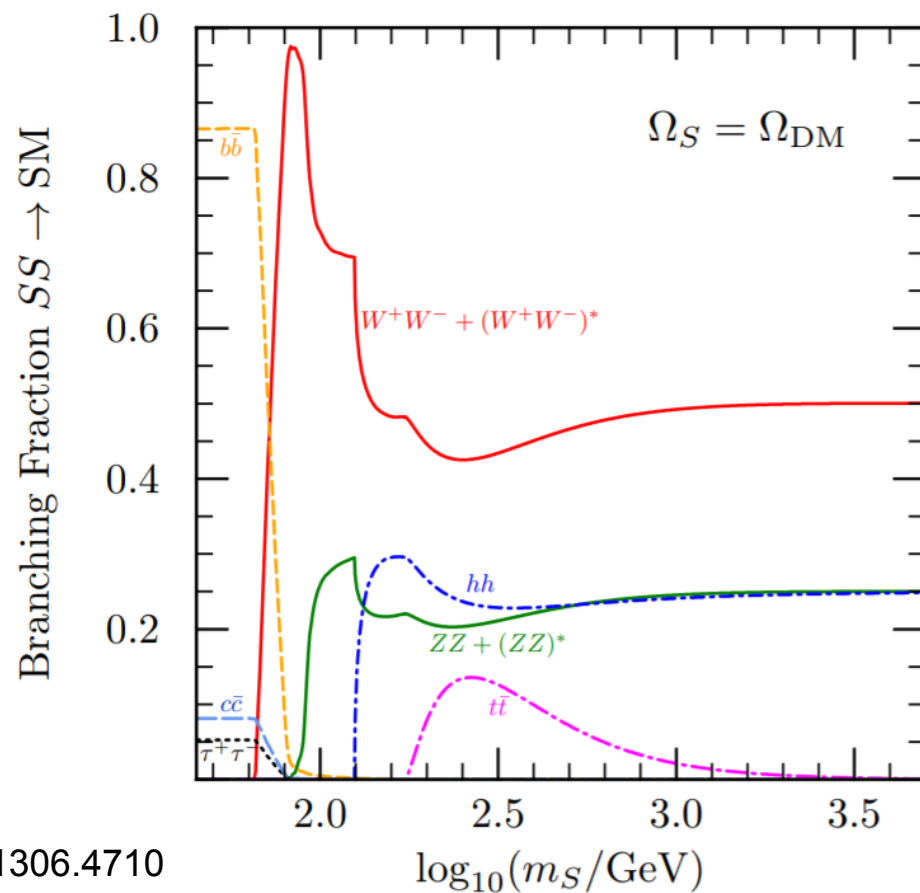
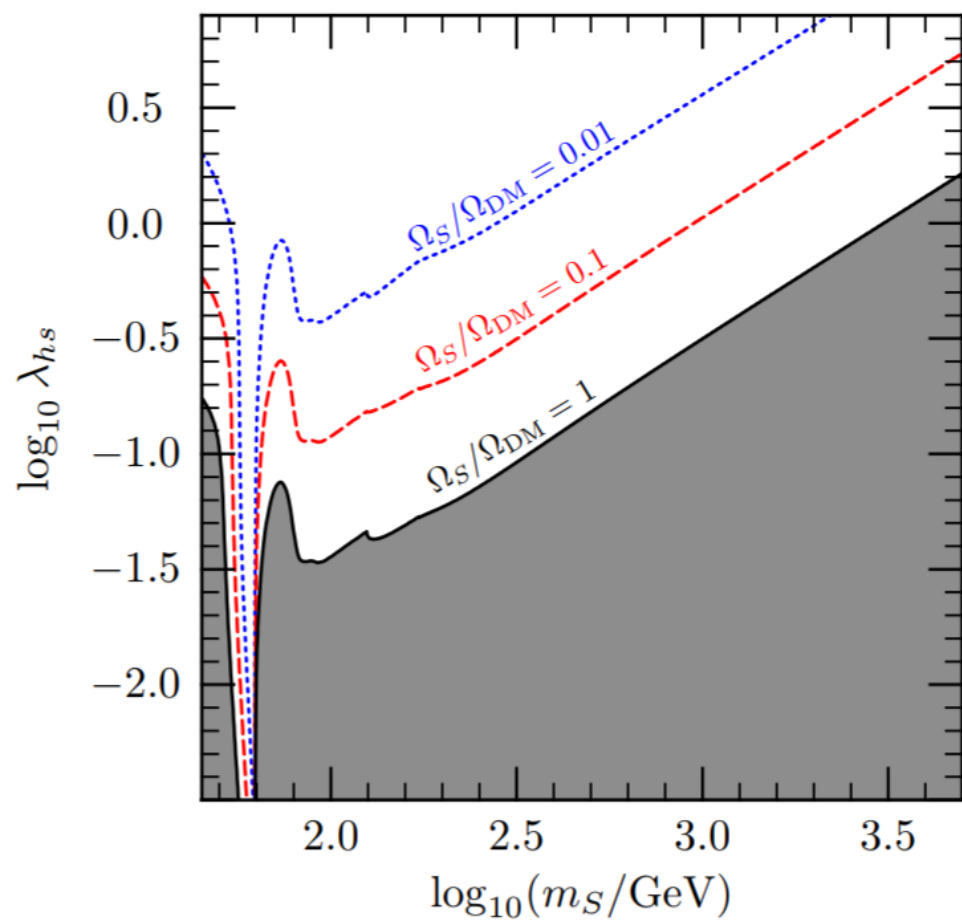


Higgs Portal (freeze-in)

$$V = \frac{1}{2}\mu_S^2 S^2 + \frac{1}{2}\lambda_{hs} S^2 |H|^2$$

$$m_S = \sqrt{\mu_S^2 + \frac{1}{2}\lambda_{hs} v_0^2}$$

$$\frac{\Omega_S h^2}{0.12} \simeq 5.3 \times 10^{21} \lambda_{hs}^2 \left(\frac{m_S}{\text{GeV}} \right)$$



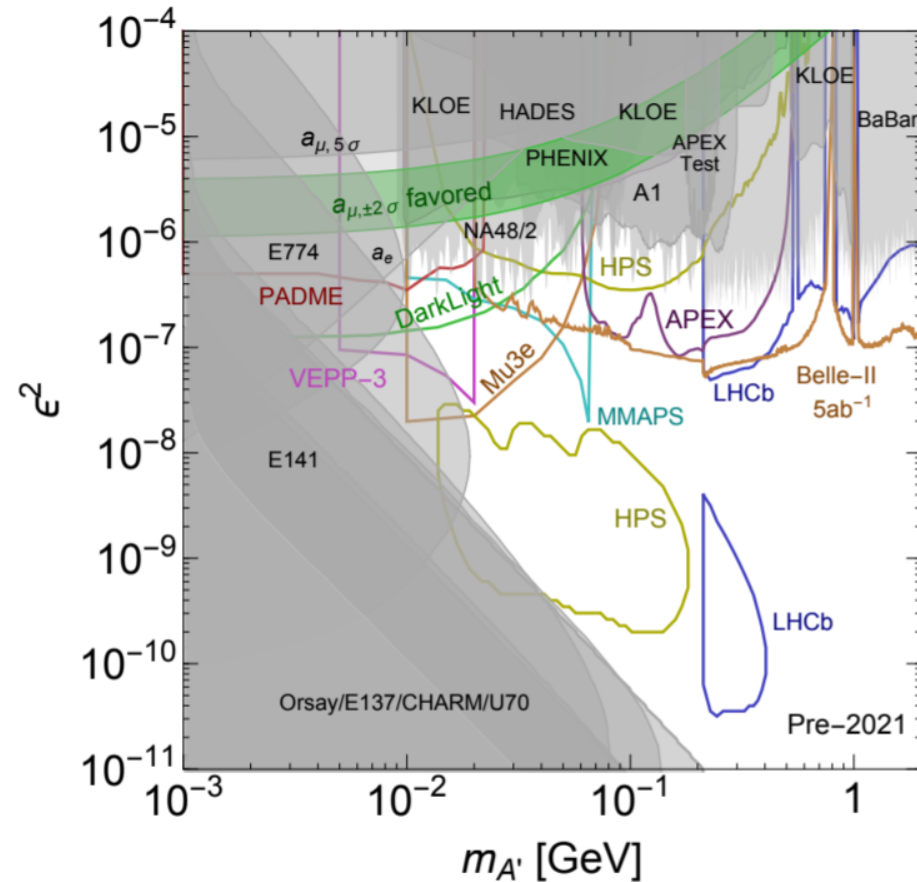
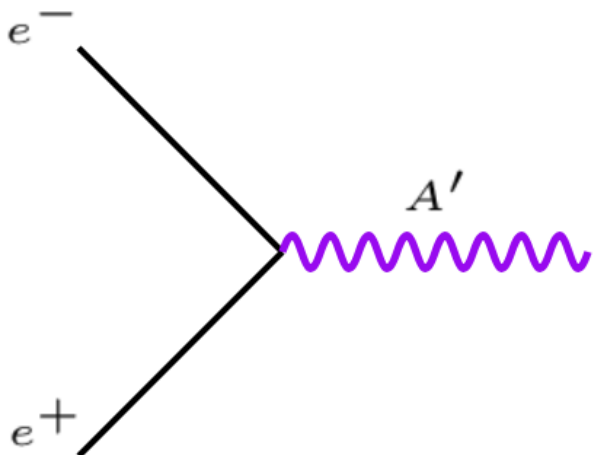
Dark Photon

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}^2 - \frac{1}{4}V_{\mu\nu}^2 - \frac{\kappa}{2}F_{\mu\nu}V^{\mu\nu} + \frac{m_V^2}{2}V_\mu V^\mu + eJ_{em}^\mu A_\mu$$

The dark photon (V) inherits the interactions of the QED photon

Modified Cosmological History: $\Omega_V \sim 0.3 \sqrt{\frac{m_V}{1 \text{ keV}}} \left(\frac{H_{\text{inf}}}{10^{12} \text{ GeV}} \right)$ H is the expansion rate during Inflation, see arxiv:1412.8378

Direct bounds on dark photons

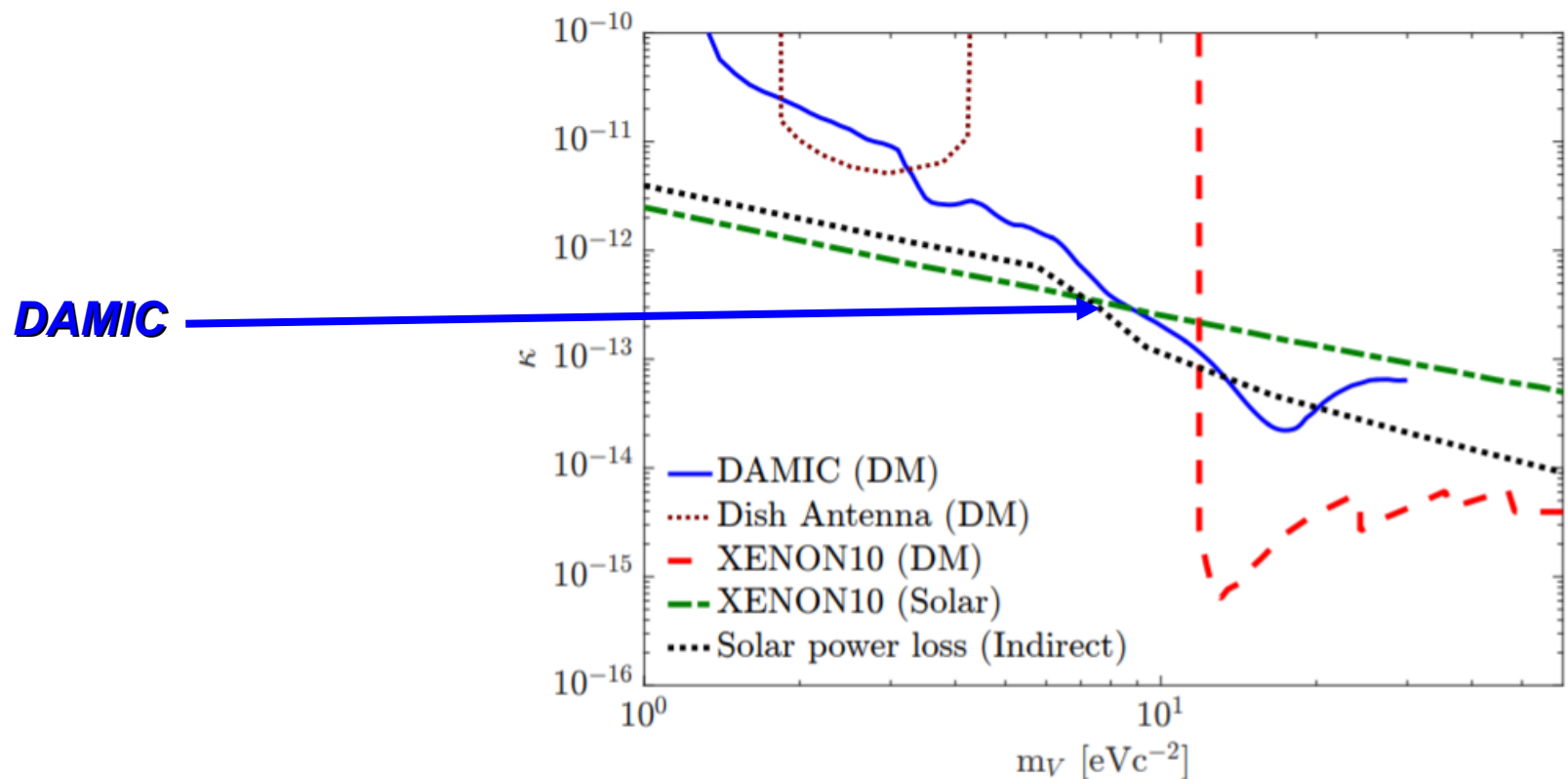


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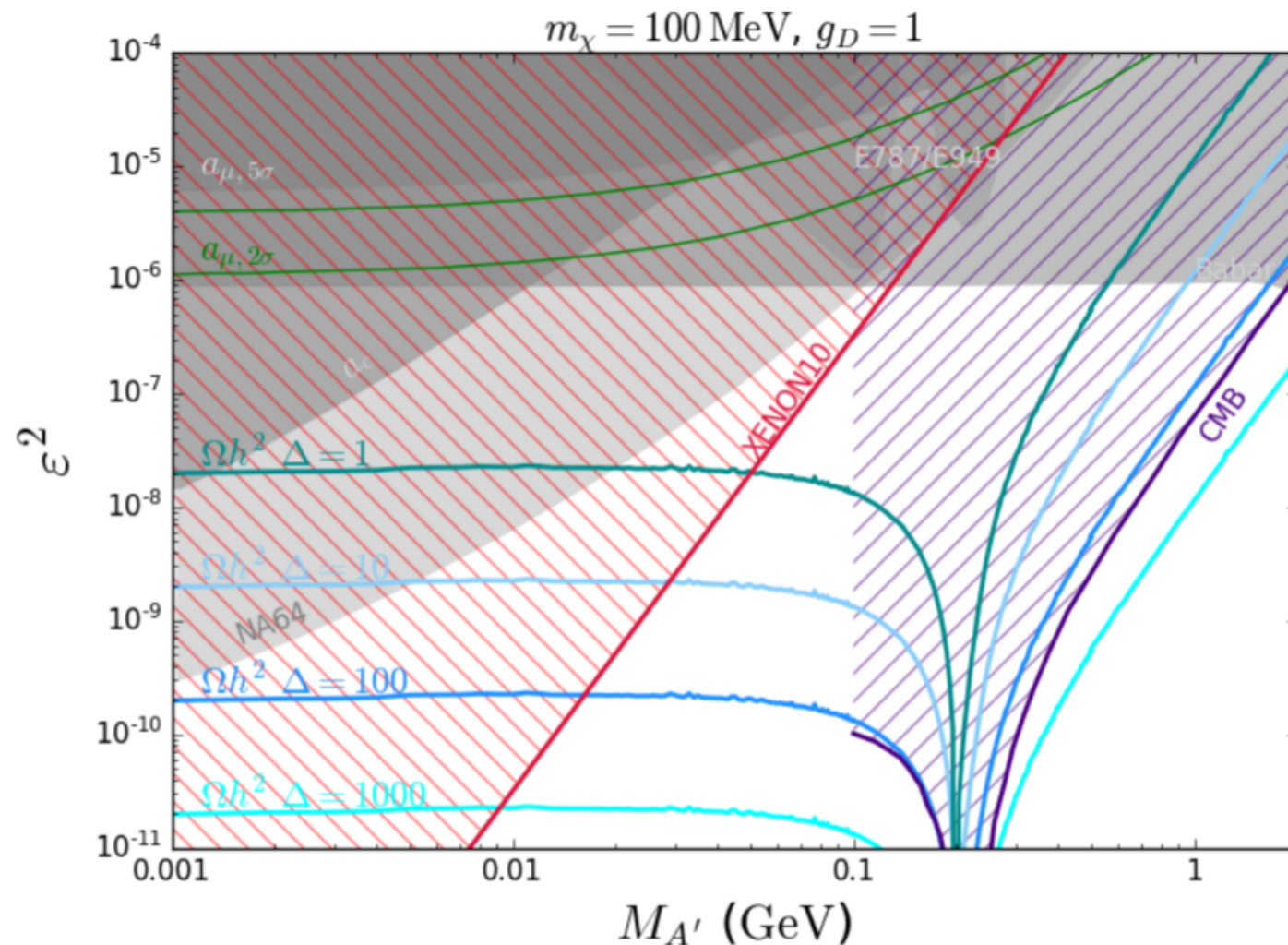
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Dark Photon Portal

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}^2 - \frac{1}{4}V_{\mu\nu}^2 - \frac{\kappa}{2}F_{\mu\nu}V^{\mu\nu} + \frac{m_V^2}{2}V_\mu V^\mu + eJ_{\text{em}}^\mu A_\mu$$

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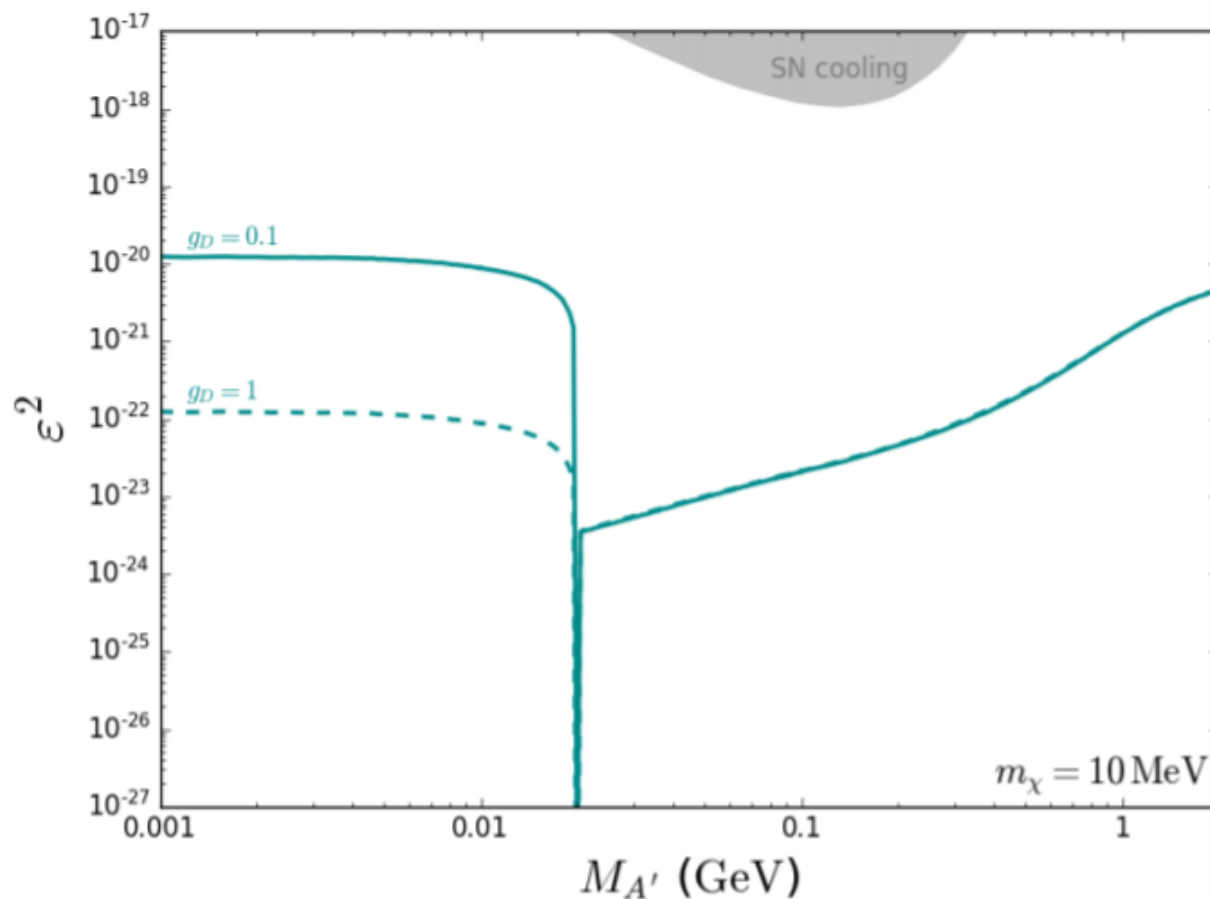
Thermal Production

Dark Photon Portal

$$\mathcal{L} = -\frac{1}{4}F_{\mu\nu}^2 - \frac{1}{4}V_{\mu\nu}^2 - \frac{\kappa}{2}F_{\mu\nu}V^{\mu\nu} + \frac{m_V^2}{2}V_\mu V^\mu + eJ_{\text{em}}^\mu A_\mu$$

The dark photon (V) inherits the interactions of the QED photon

Freeze-in Production



Asymmetric Dark Matter

The connection between the DM and baryon densities arises naturally when the DM has an asymmetry in the number density

$$n_X - n_{\bar{X}} \sim n_b - n_{\bar{b}}$$

$$\eta \equiv \frac{n_B}{n_\gamma} = \frac{n_b - n_{\bar{b}}}{n_\gamma} \approx 6 \times 10^{-10}$$

$$\rho_{DM}/\rho_B \sim 5$$

