INSTITUT DE FÍSICA CORPUSCULAR

VNIVERSITAT DE VALÈNCIA

CSIC
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTÍFICAS

Flavour and Origin of Matter
Sabor y Origen de la Materia

IFIC NEWCOMERS FEST 2025

Speaker: Alessandro Granelli

About Me

- I come from an etruscan city called Arezzo in Tuscany, Italy.
- **Bachelor** and **Master** in Padua, Italy.
- **Ph.D. in Astroparticle Physics** at **SISSA** in Trieste, Italy.
- **Post-doc** until Oct. 2025 at **University of Bologna**, Italy.
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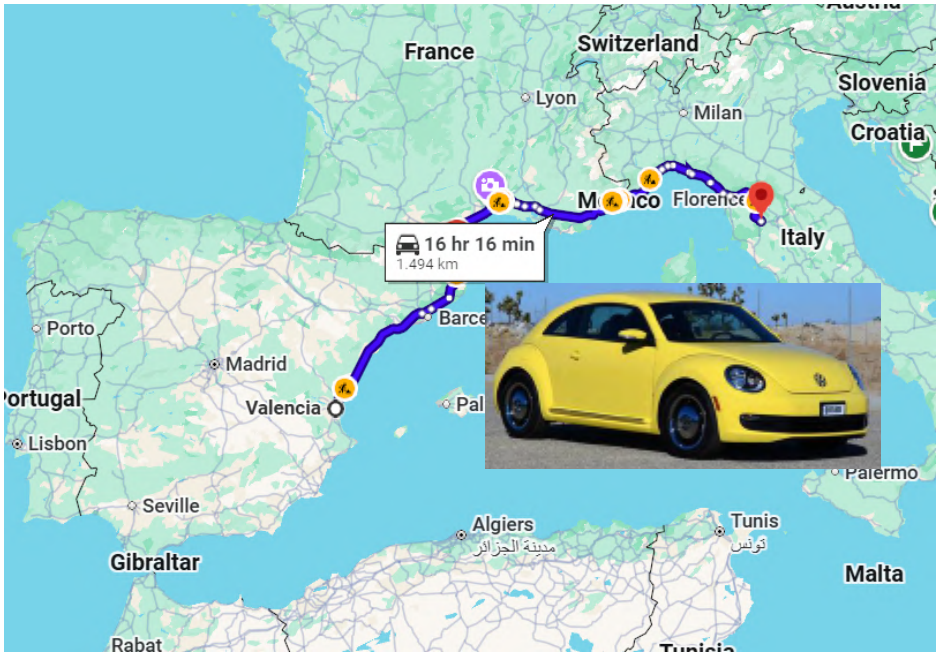


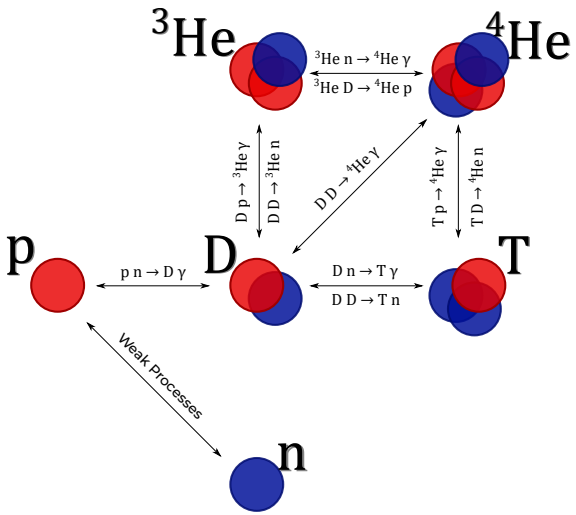
Research interests

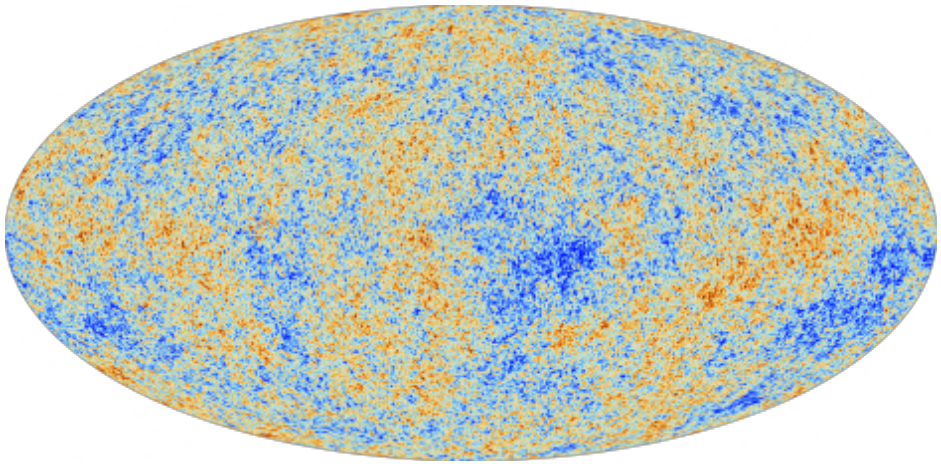
The Matter-Antimatter Asymmetry of the Universe

The observable Universe has a cosmological matter-antimatter asymmetry.

The **baryon-to-photon ratio** η_B from Big Bang Nucleosynthesis (BBN) and Cosmic Microwave Background (CMB) estimates:

$$\eta_B \equiv (n_b - n_{\bar{b}})/n_\gamma \cong 6.1 \times 10^{-10} .$$

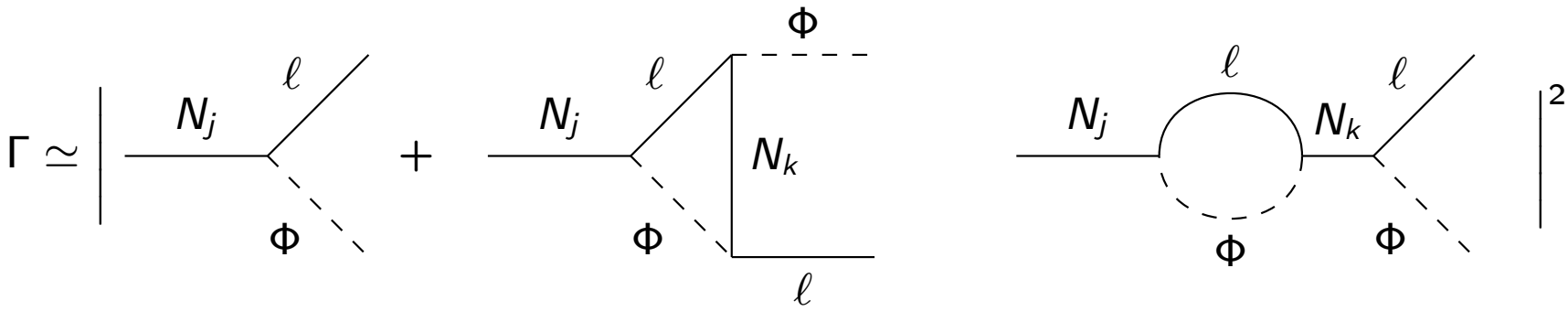




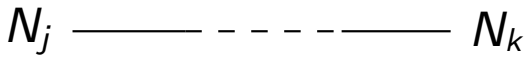
A compelling mechanism for generating this excess in the early Universe: ***Leptogenesis.***

Leptogenesis within the Seesaw Extension

1. **L-, C- and CP-violating heavy-neutrino processes**
   - **CP-violating N_j decays:**



   - **CP-violating $N_j \leftrightarrow N_k$ oscillations:**



2. **Sphalerons:** violate $B + L$ but conserve $B - L$, converting the generated lepton asymmetry into a baryon asymmetry.
3. **Out-of-equilibrium expansion of the Universe:** ensures departure from thermal equilibrium ($\Gamma < H$).

$\Rightarrow$ Successful generation of the Baryon Asymmetry of the Universe

Research directions in leptogenesis

Low-energy test

HNL searches; leptonic CP-violation tests.

BSM frameworks

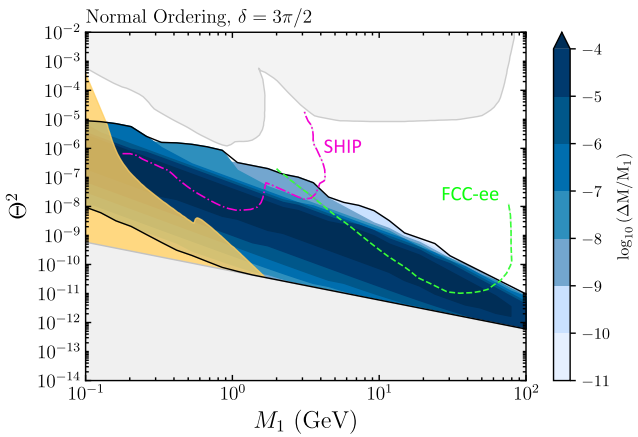
E.g., flavour and modular symmetry models, dark sectors.

3RHN scenario

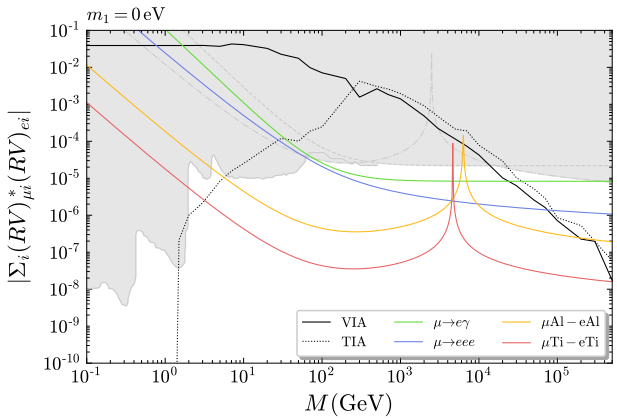
Full $N_{1,2,3}$ dynamics, models and low-energy tests.

Tools & codes

Ultimate density matrix equations; **ULYSSES** Python package.



LG with Dirac CPV

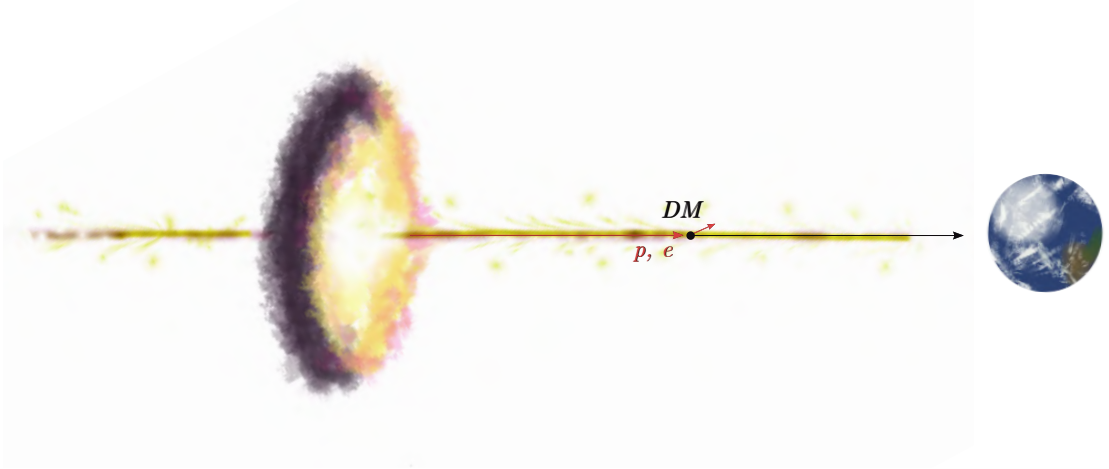


cLFV probes of LG

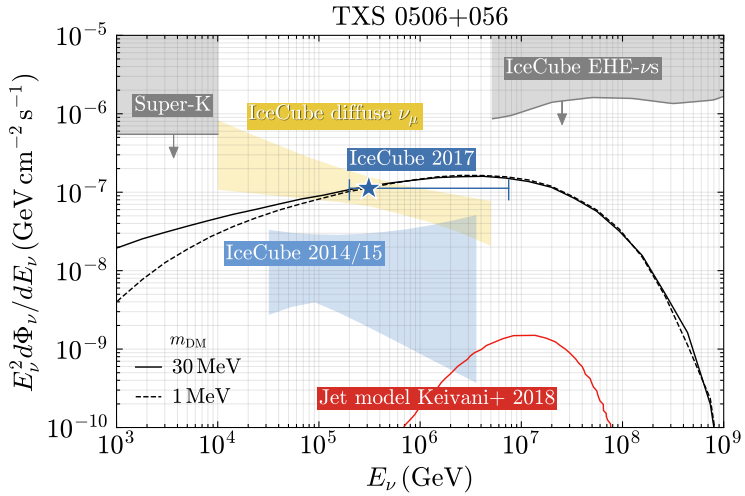
ULYSSES logo

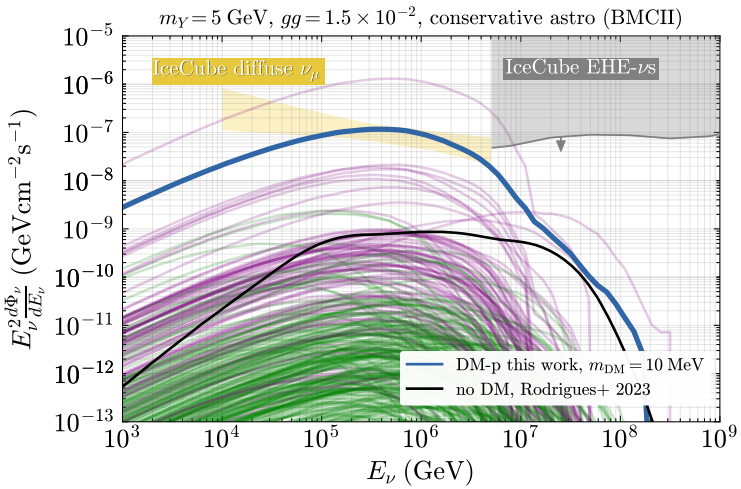
Blazars as probes of sub-GeV dark matter

- **Blazars as ideal DM boosters**, we proposed this for the first time in PRL 128, 221104 (2022), see recent developments in arXiv:2507.12278.



- **High-energy neutrinos** from **DM-proton inelastic collisions** in blazars, we proposed this in PRD 112 (2025) 043042 and PLB 871 (2025) 140015





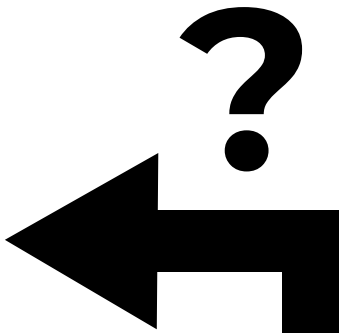
General research interests

NEUTRINOS

Neutrino masses and the flavour problem

Leptogenesis

Matter-antimatter asymmetry



Model Buiding: Flavour models, modular symmetries, dark sectors...
Phenomenology: high-energy neutrinos, cosmic rays, astrophysical anomalies...

DARK MATTER

Thank you for your attention!

Contacts

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