



Jupiter is a Leptophilic Dark Matter Refrigerator

Thong T.Q. Nguyen



Stockholm
University



Oskar Klein

Based on

- **TTQN**, Carlos Blanco, Rebecca Leane, Tim Linden, *Jupiter is a Leptophilic Dark Matter Refrigerator*, in preparation for PRL.



Tim Linden
(Stockholm U.)



Carlos Blanco
(Penn State U.)

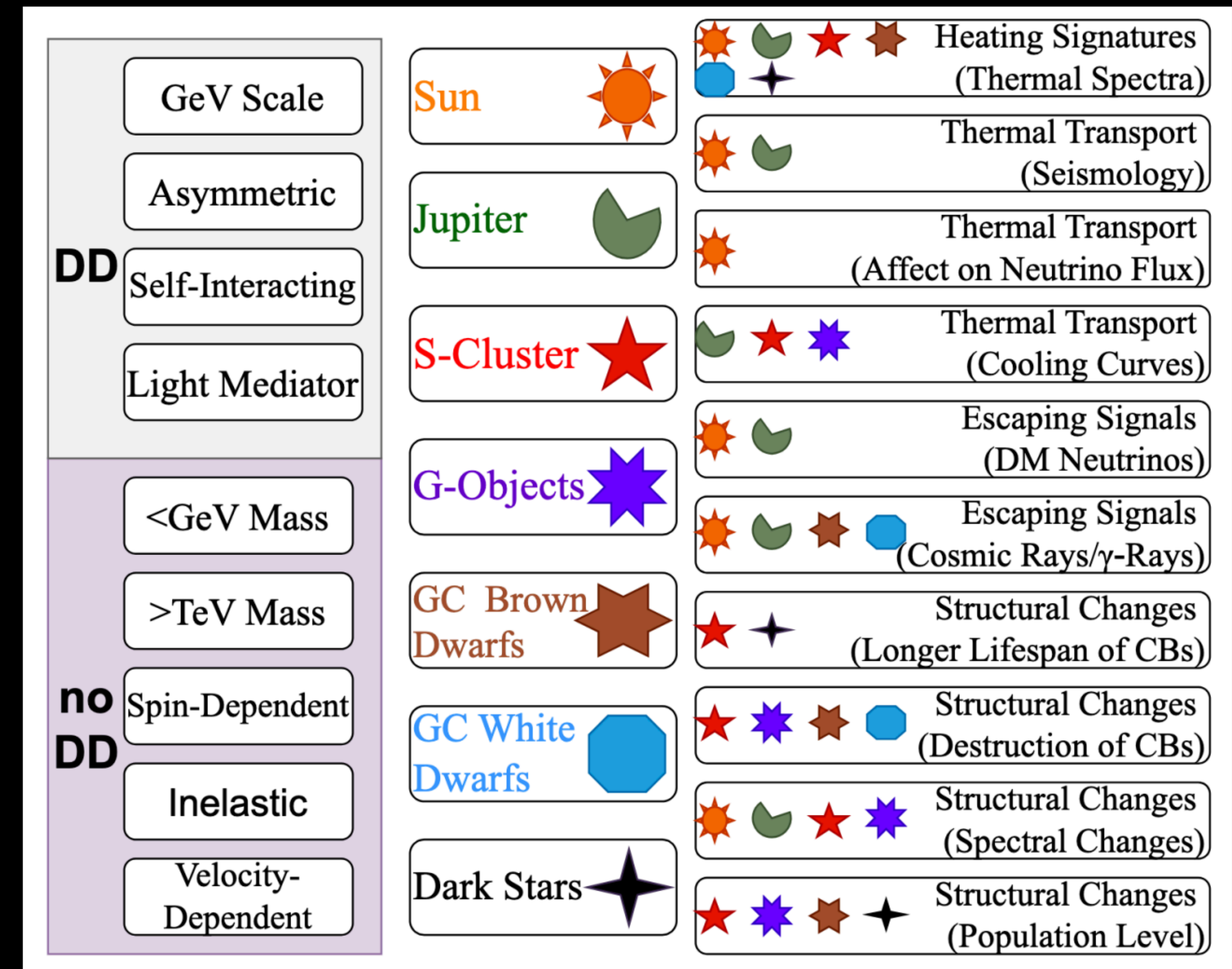


Rebecca Leane
(SLAC)

Dark matter capture in celestial objects

Large-exposure DM “detectors” outer space!

- DM scattering with nucleons/electron inside the Object.
- DM loose Kinetic Energy.
- Its velocity is below the escaped velocity \rightarrow Being Captured!
- Trapped DM can annihilate to produce observational signature!



Dark matter capture in celestial objects

Large-exposure DM “detectors” outer space!

arXiv:2501.14864

Talks at TeVPA

- Woosik Kang (IceCube), Monday
- Chiara Poirè (ANTARES), Monday
- Takuya Okawa-san talk, before mine!

Review: J. Bramante and N. Raj,
2307.14435

Thong Nguyen, Stockholm University

Super-Kamiokande Strongly Constrains Leptophilic Dark Matter Capture in the Sun

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<https://doi.org/10.1140/epjc/s10052-025-14144-7>

THE EUROPEAN
PHYSICAL JOURNAL C



Regular Article - Experimental Physics

Search for dark matter from the center of the Earth with 10 years of IceCube data

IceCube data collaboration^a

Search for High-Energy Neutrinos From the Sun Using Ten Years of IceCube Data

IceCube Collaboration • R. Abbasi (Loyola U., Chicago) [Show All\(428\)](#)

Jul 11, 2025

11 pages

e-Print: [2507.08457](#) [hep-ex]

Experiments: [ICECUBE](#)

Indirect dark matter searches towards the Sun using the full ANTARES data set



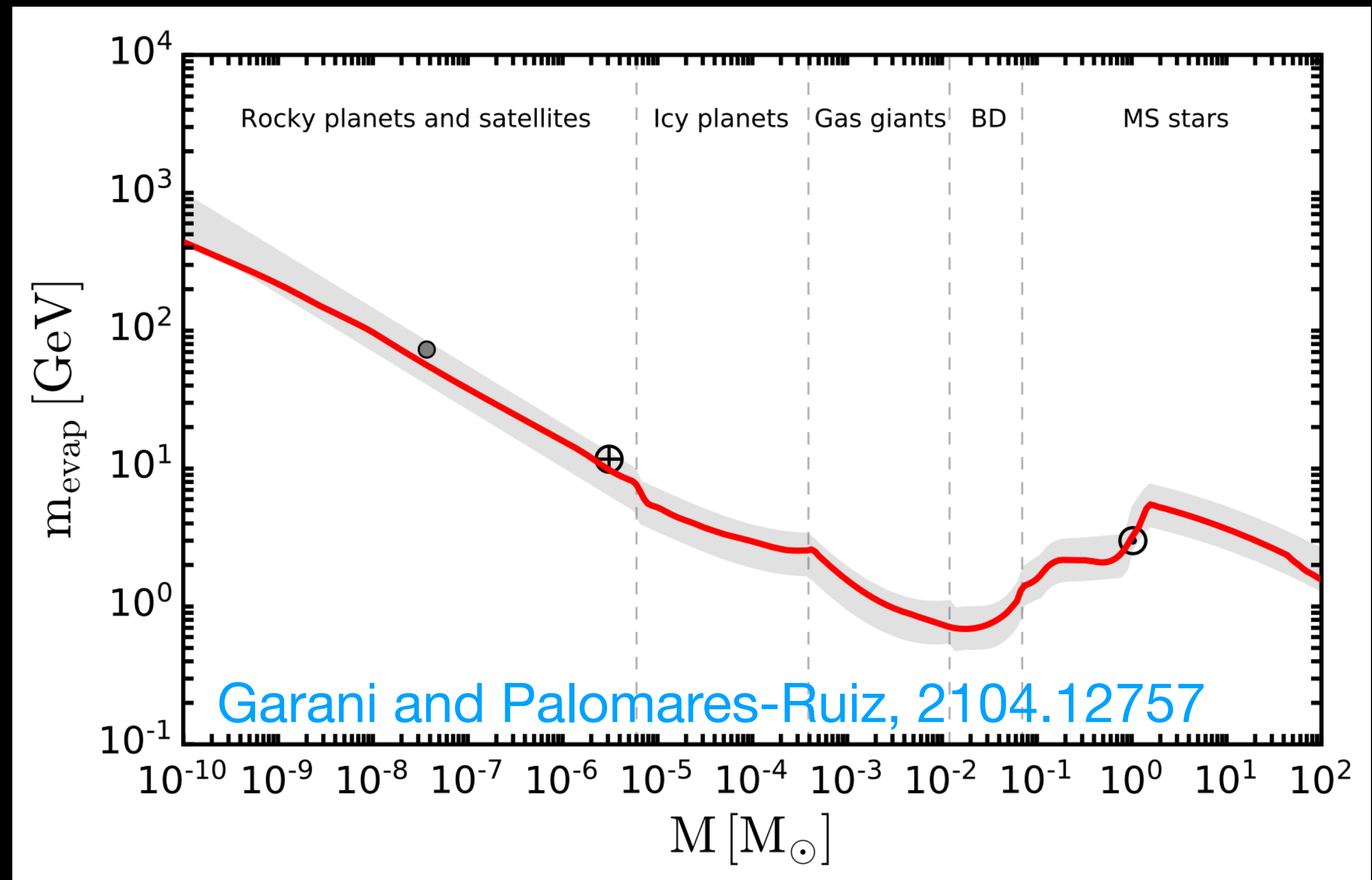
PROCEEDINGS
OF SCIENCE

Chiara Poirè^{a,*} and Juan García Mendéz^b on behalf of the ANTARES Collaboration

Dark matter evaporation!

The challenge in dark matter capture scenario

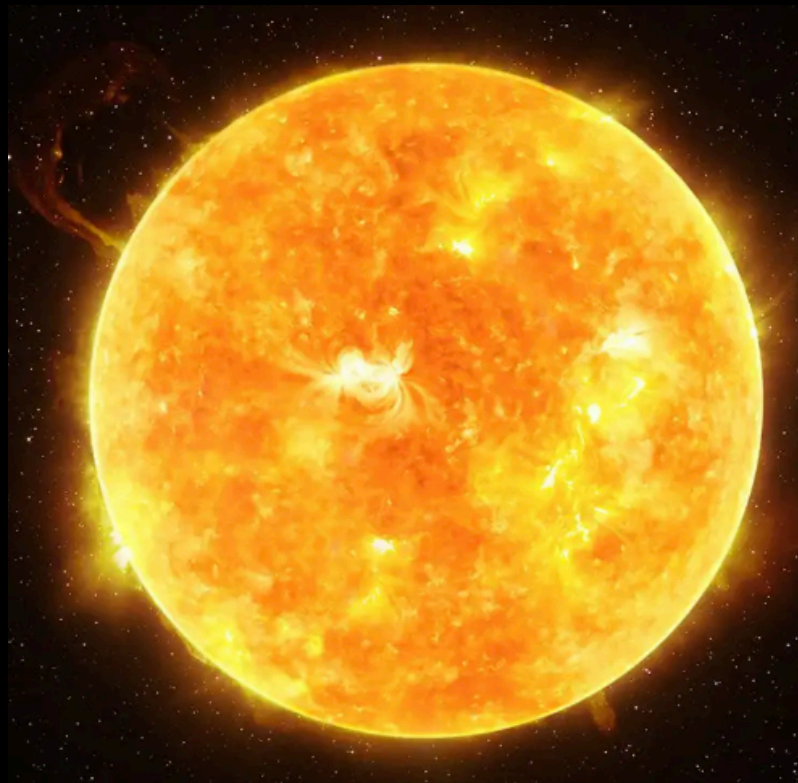
- Trapped DM can be up-scattered again by nucleon/electron.
- DM gains kinetic energy.
- Light DM can escape the object!
- There are lower limits for dark matter mass to be captured!



The challenge in dark matter capture scenario

Summary the DM mass limits in DM capture scenarios

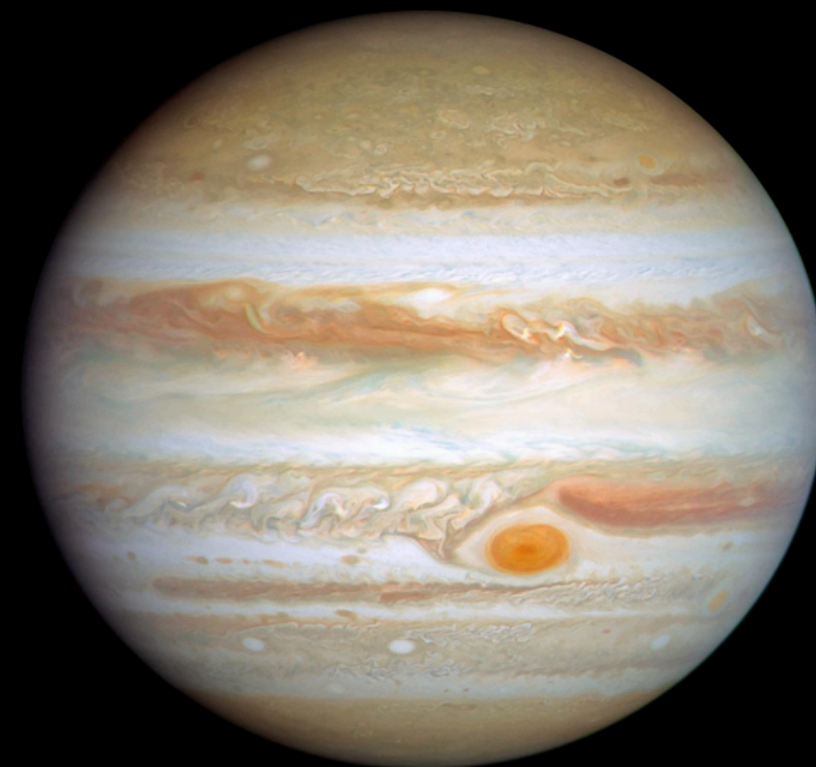
Here come the Sun!



4 GeV

Nucleon + electron
Scattering

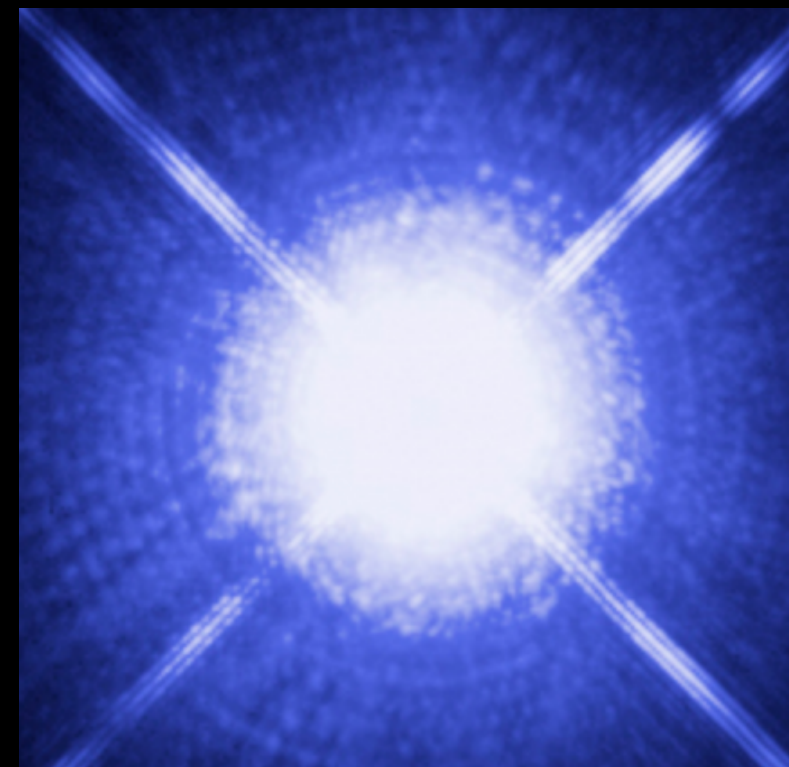
Jupiter



1 GeV

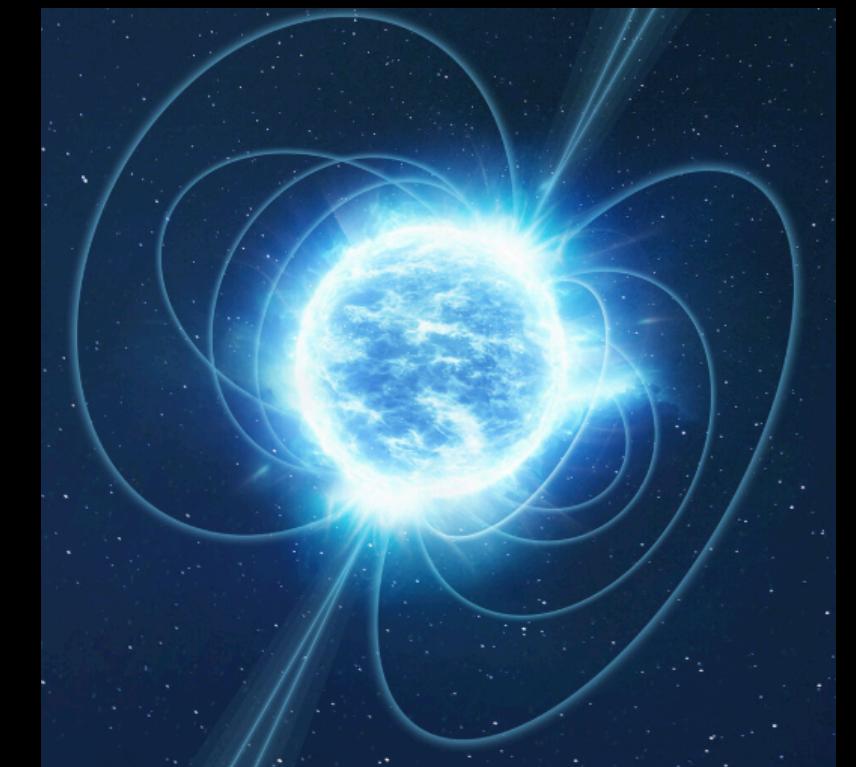
Nucleon Scattering

White Dwarfs



MeV

Neutron Stars



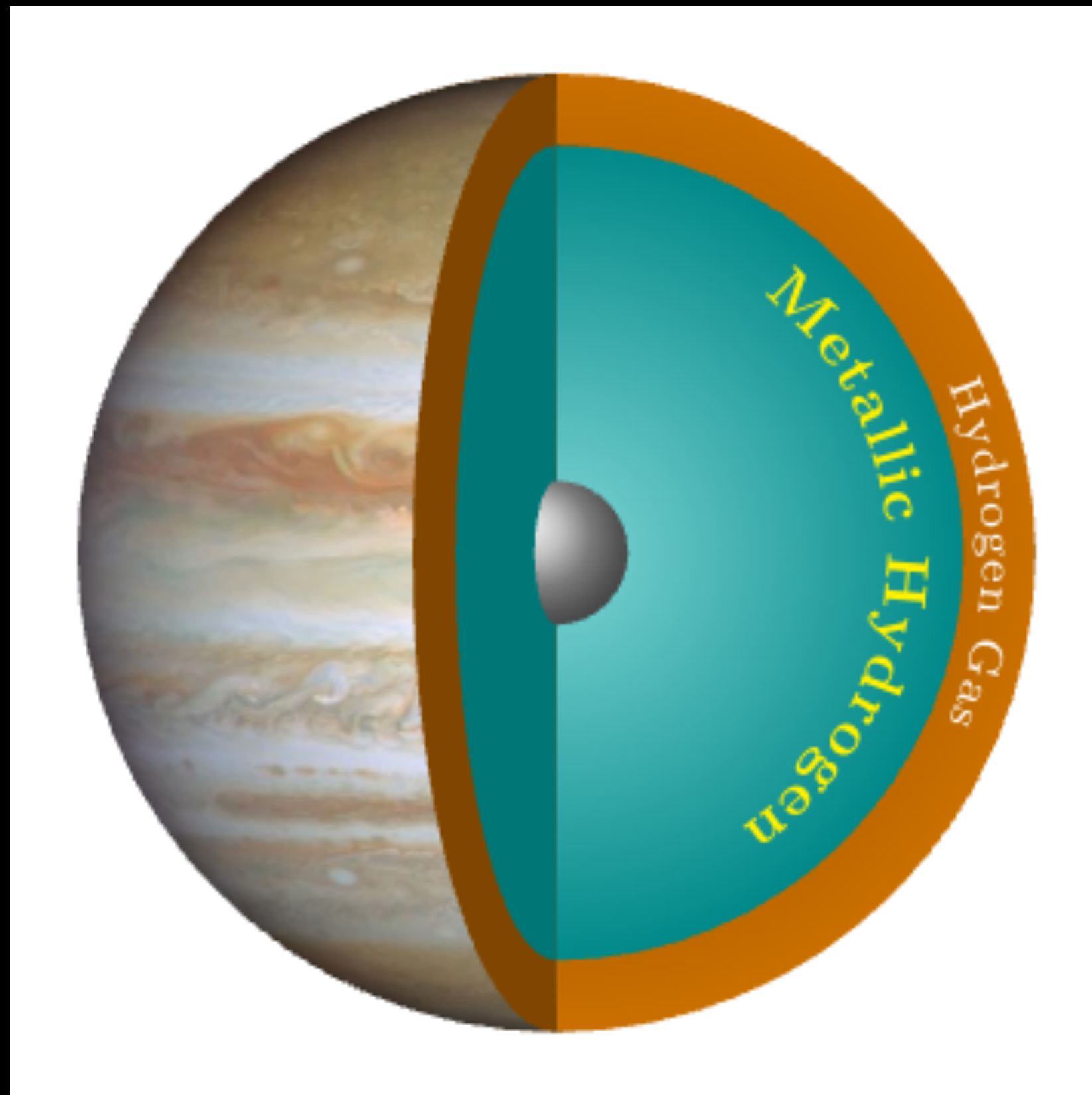
keV

Assuming targets follow the Boltzmann distribution!

How about DM-electron scattering in Jupiter?

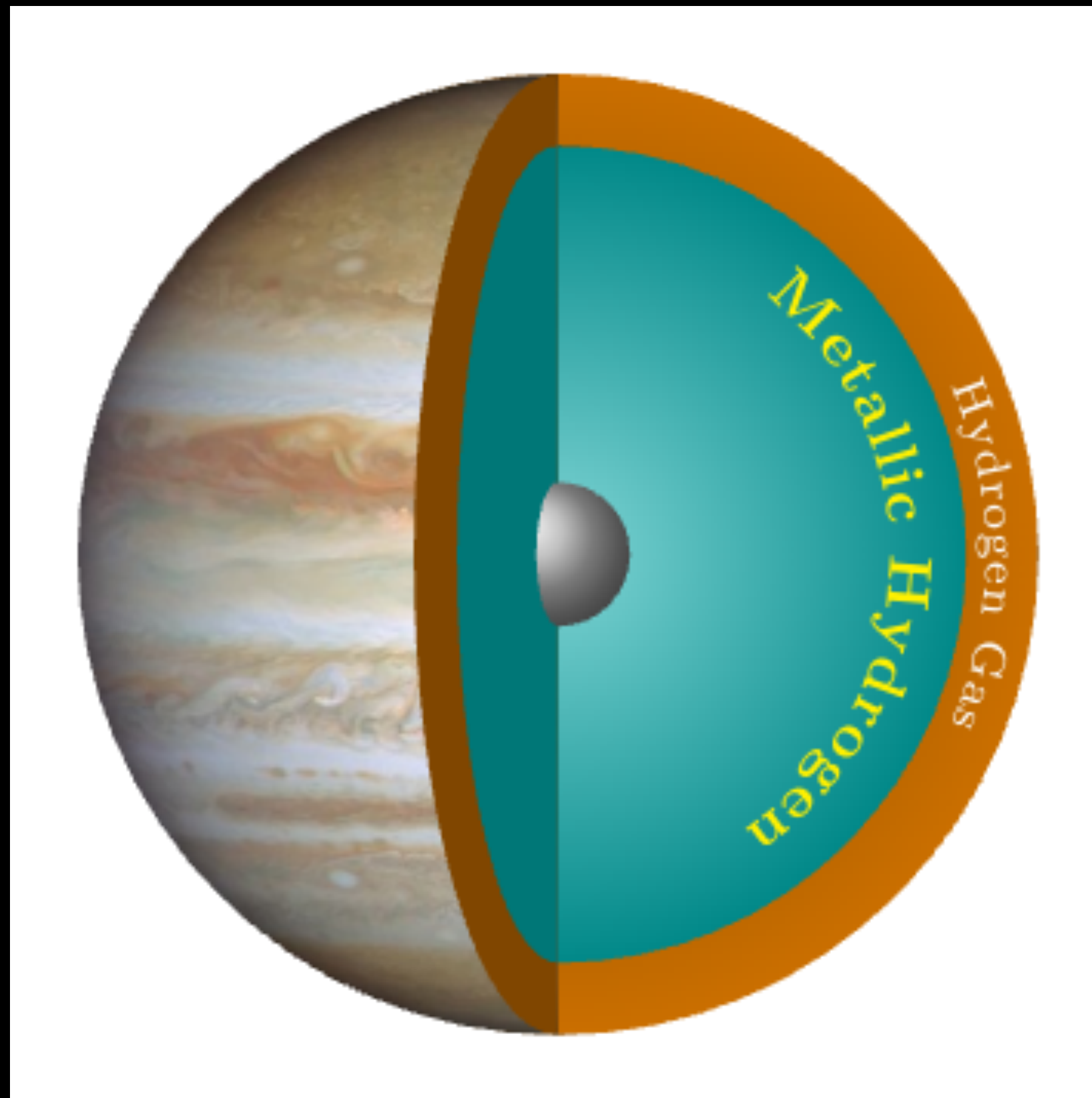
(The curious case of Leptophilic DM)

Jupiter has a lot of Metallic Hydrogen



Jupiter has a lot of Metallic Hydrogen

Wikipedia also said so!



Wikipedia

[https://en.wikipedia.org › wiki › Metallic_hydrogen](https://en.wikipedia.org/wiki/Metallic_hydrogen)

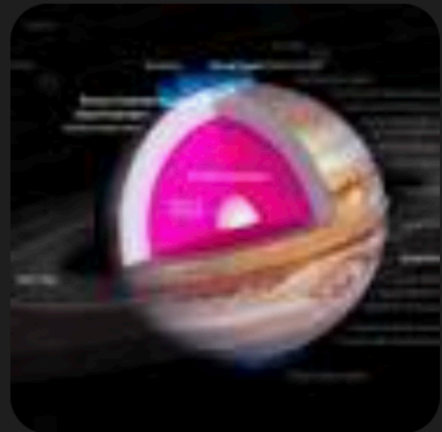
Metallic hydrogen

Metallic hydrogen is a phase of hydrogen in which it **behaves like an electrical conductor**. This phase was predicted in 1935 on theoretical grounds.

Solid hydrogen

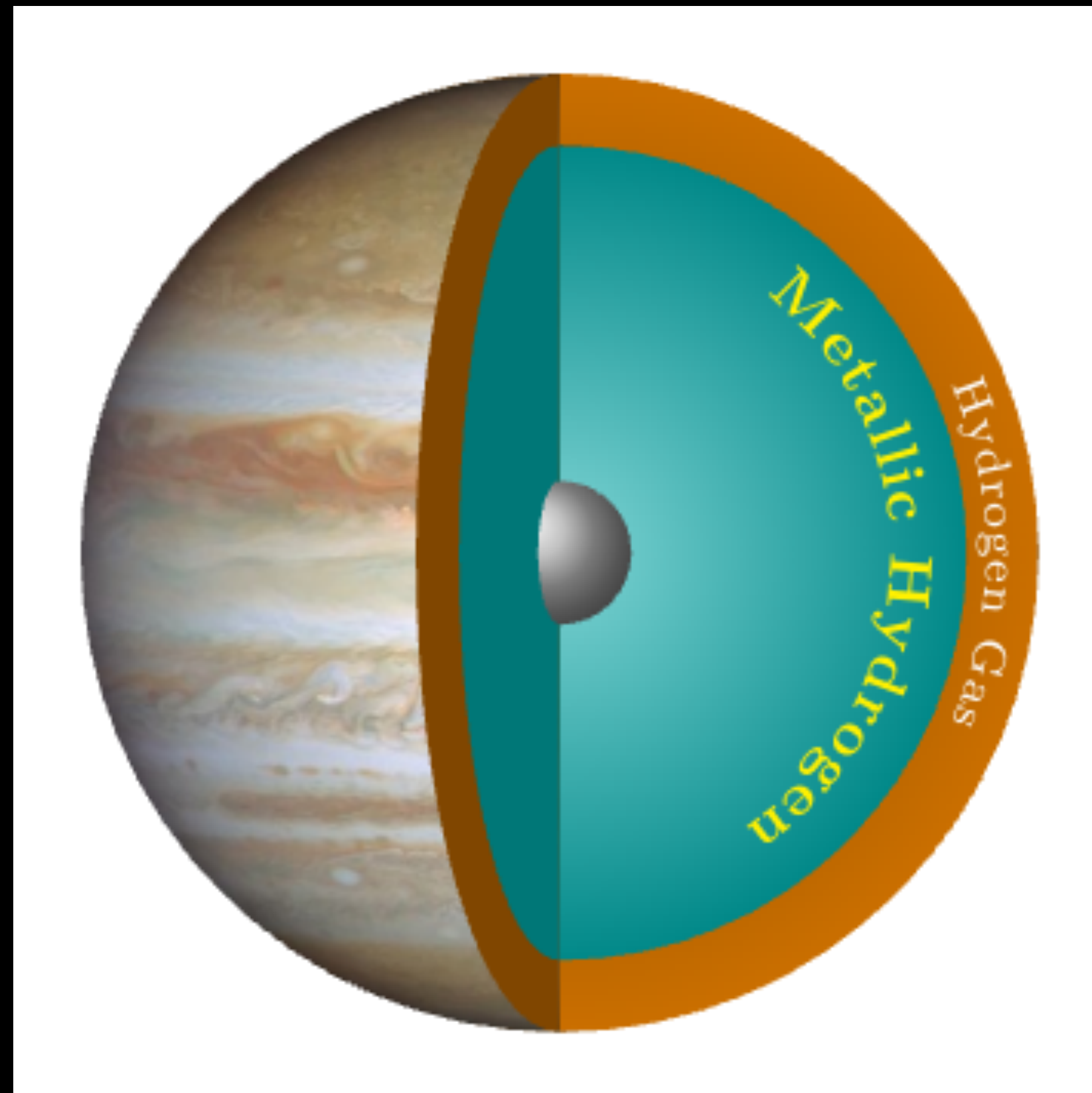
Supersolid

Diamond anvil cell



Jupiter has a lot of Metallic Hydrogen

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Wikipedia

https://en.wikipedia.org/wiki/Metallic_hydrogen

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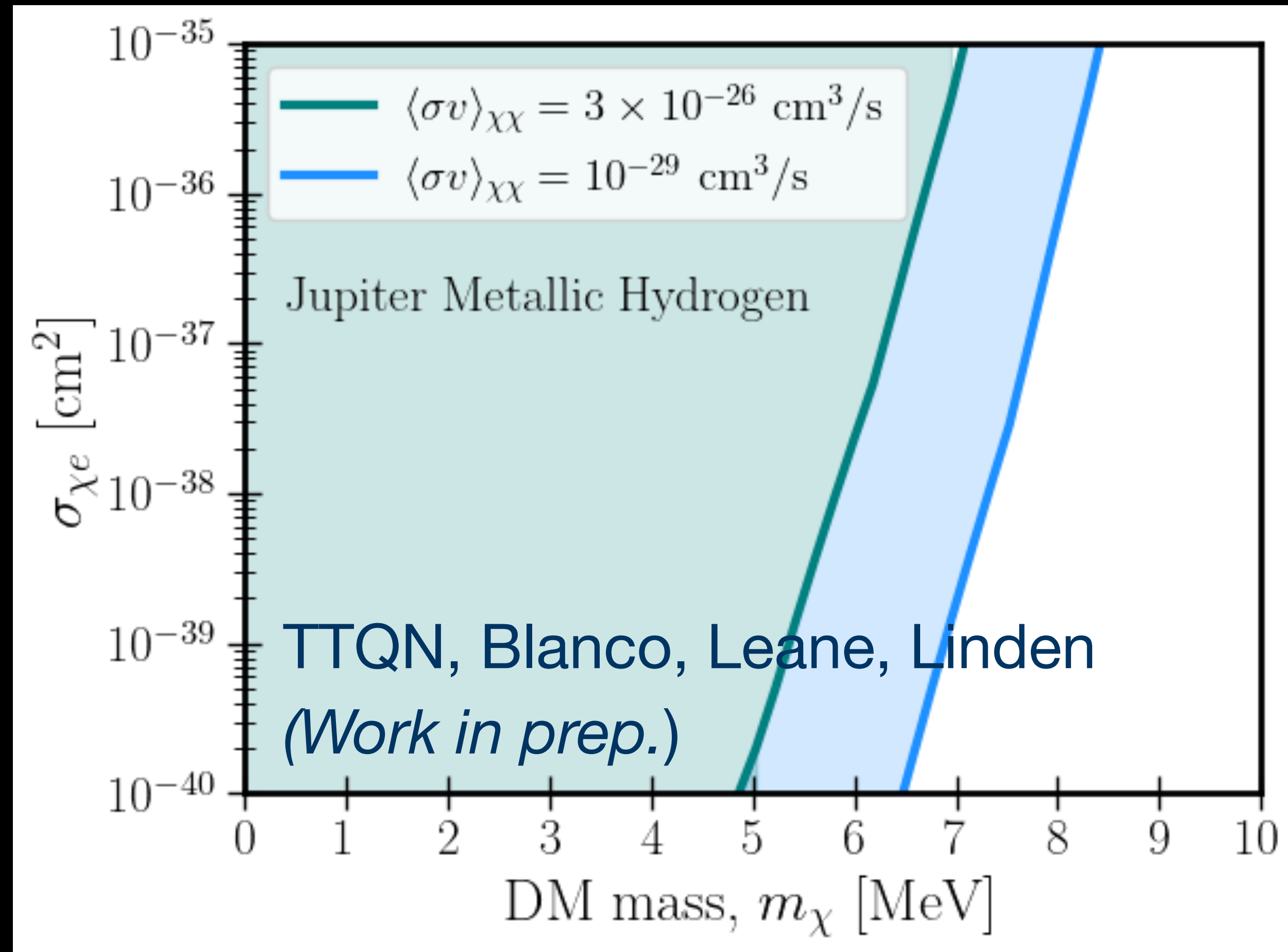
Diamond anvil cell



- Jupiter's high pressure stripped electrons out from their Hydrogen Molecules.
- Electrons move freely in the metallic layer!
- Electrons fill out all possible energy states that are bounded by the Fermi Sphere of Metallic Hydrogen!
- **Electrons follow the Fermi-Dirac Distribution!**

Jupiter Evaporation mass of Leptophilic DM

The lowest DM mass that can stay inside Jupiter



We calculate:

- The DM Capture Rate
- The DM Evaporation Rate
- DM Annihilation Rate
- DM Equilibrium time scale

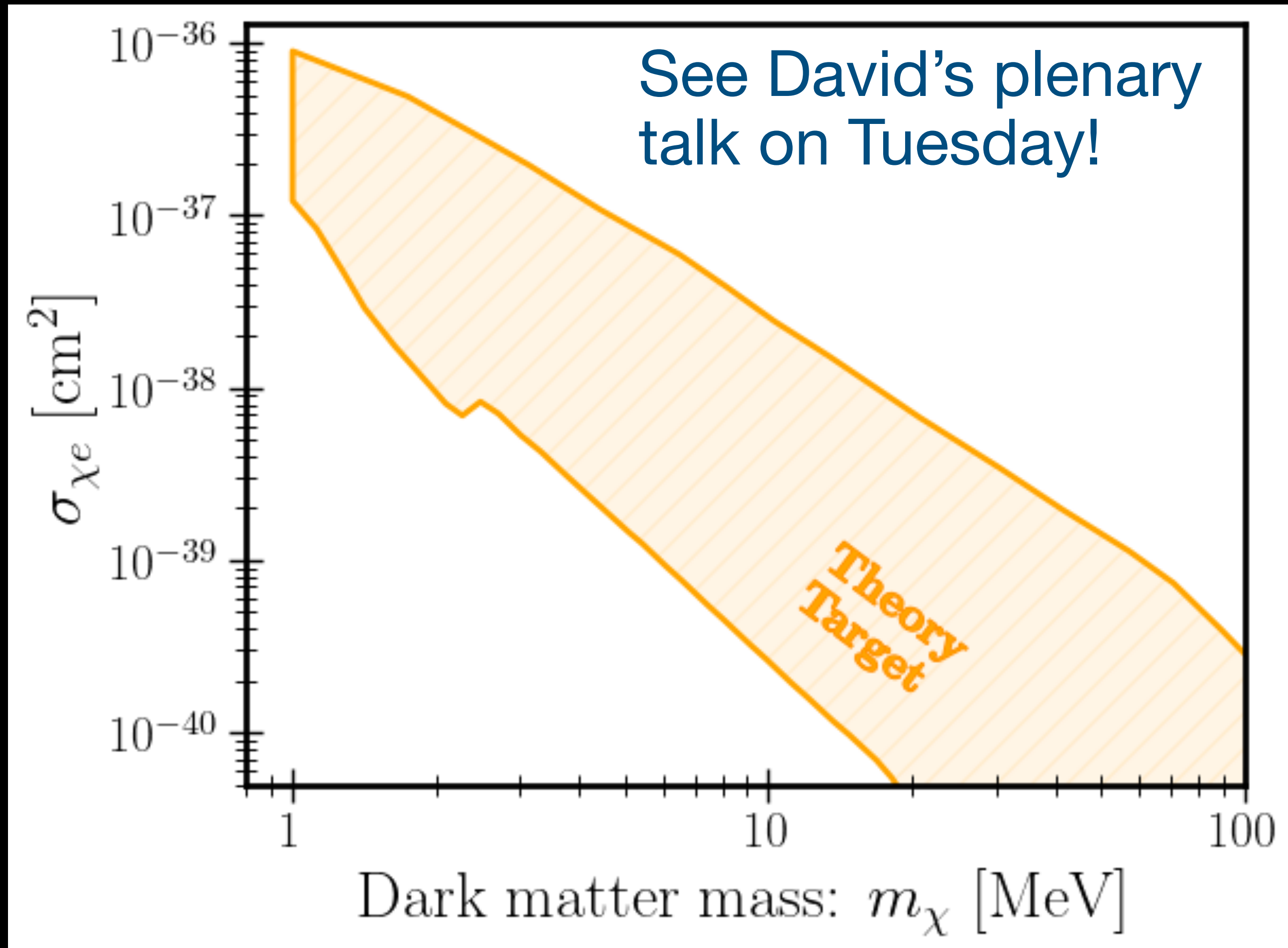
We find the minimum DM mass that can survive in Jupiter: around 5 - 8 MeV

How could we
detect these MeV
DM inside
Jupiter?
And why do we
care about them?



DM-electron cross section

The Theory Target (Heavy Mediator)



[arXiv:2203.08297](https://arxiv.org/abs/2203.08297)

Snowmass2021 Cosmic Frontier:
The landscape of low-threshold dark matter direct
detection in the next decade

Coordinators:

Rouven Essig¹, Graham K. Giovanetti², Noah Kurinsky³, Dan McKinsey^{4,5},

Contributors:

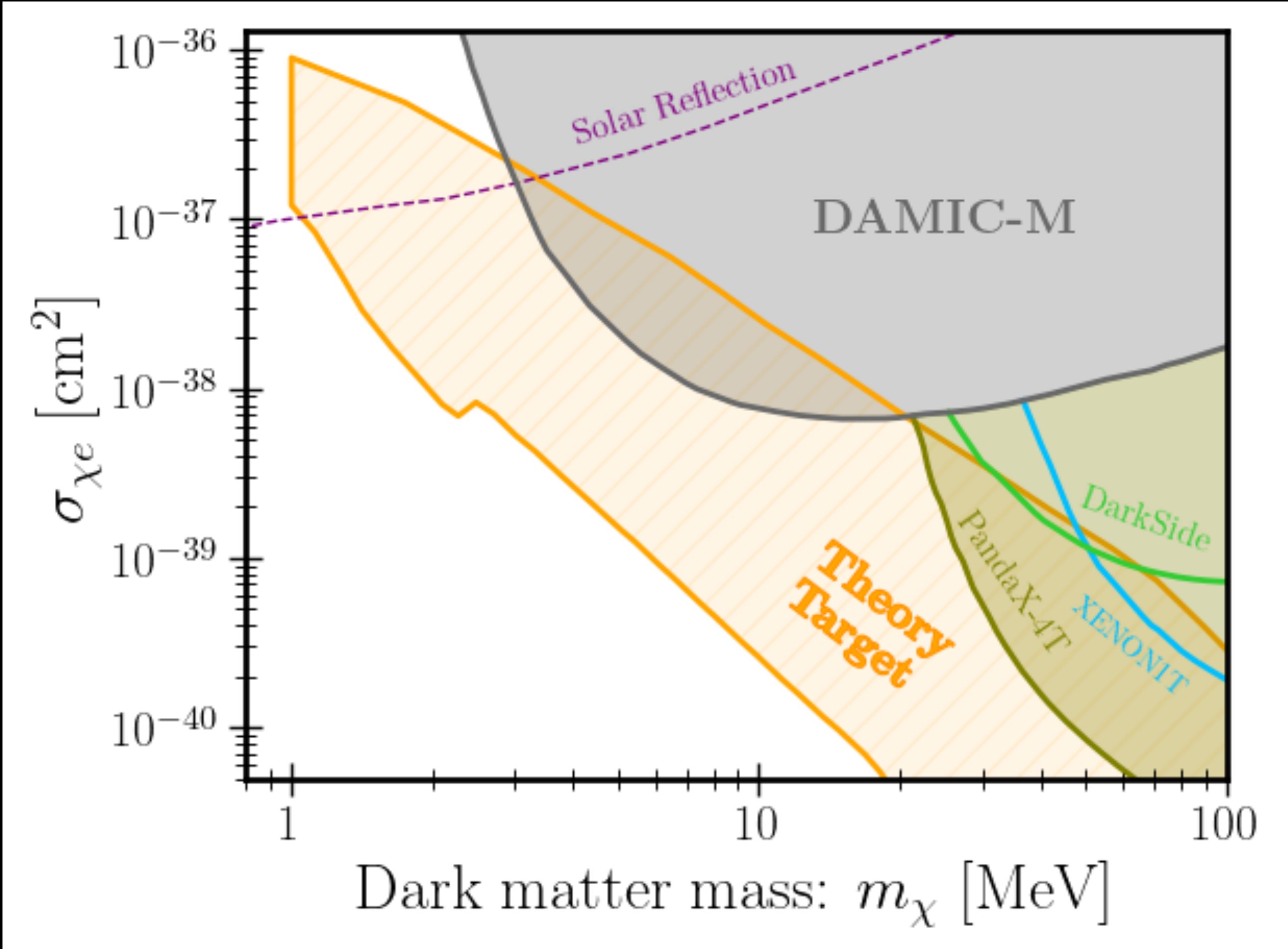
Karthik Ramanathan⁶, Kelly Stifter⁷, Tien-Tien Yu⁸,

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G. Testera⁸⁴, K. Thieme⁸⁵, N. Toro⁸⁶, T. Trickle⁸⁷, S. Uemura⁸⁸, V. Velan⁸⁹, E. Vitagliano⁹⁰,
F. Wagner⁹¹, G. Wang⁹², S. Westerdale⁹³, and K. M. Zurek⁹⁴

DM-electron cross section

Very competitive target in the DM community!



Probing Benchmark Models of Hidden-Sector Dark Matter with DAMIC-M

[K. Aggarwal](#)¹, [I. Arnquist](#)², [N. Avalos](#)³, [X. Bertou](#)^{4,5}, [N. Castelló-Mor](#)⁶, [A. E. Chavarria](#)¹, [J. Cuevas-Zepeda](#)⁷, [A. Dastgheibi-Fard](#)⁸, [C. De Dominicis](#)⁵ et al. (DAMIC-M Collaboration)

[Show more](#)

Phys. Rev. Lett. **135**, 071002 – Published 13 August, 2025

See Sravan Munagavalasa’s talk!

Search for Light Dark Matter with 259-day data in PandaX-4T

[Minzhen Zhang](#), [Zihao Bo](#), [Wei Chen](#), [Xun Chen](#), [Yunhua Chen](#) [Show All\(111\)](#)

Jul 16, 2025

e-Print: [2507.11930](#) [hep-ex]
View in: [ADS Abstract Service](#)

See Qing Lin’s talk!

(arXiv:2507.15956) See Pablo Figueroa’s talk!

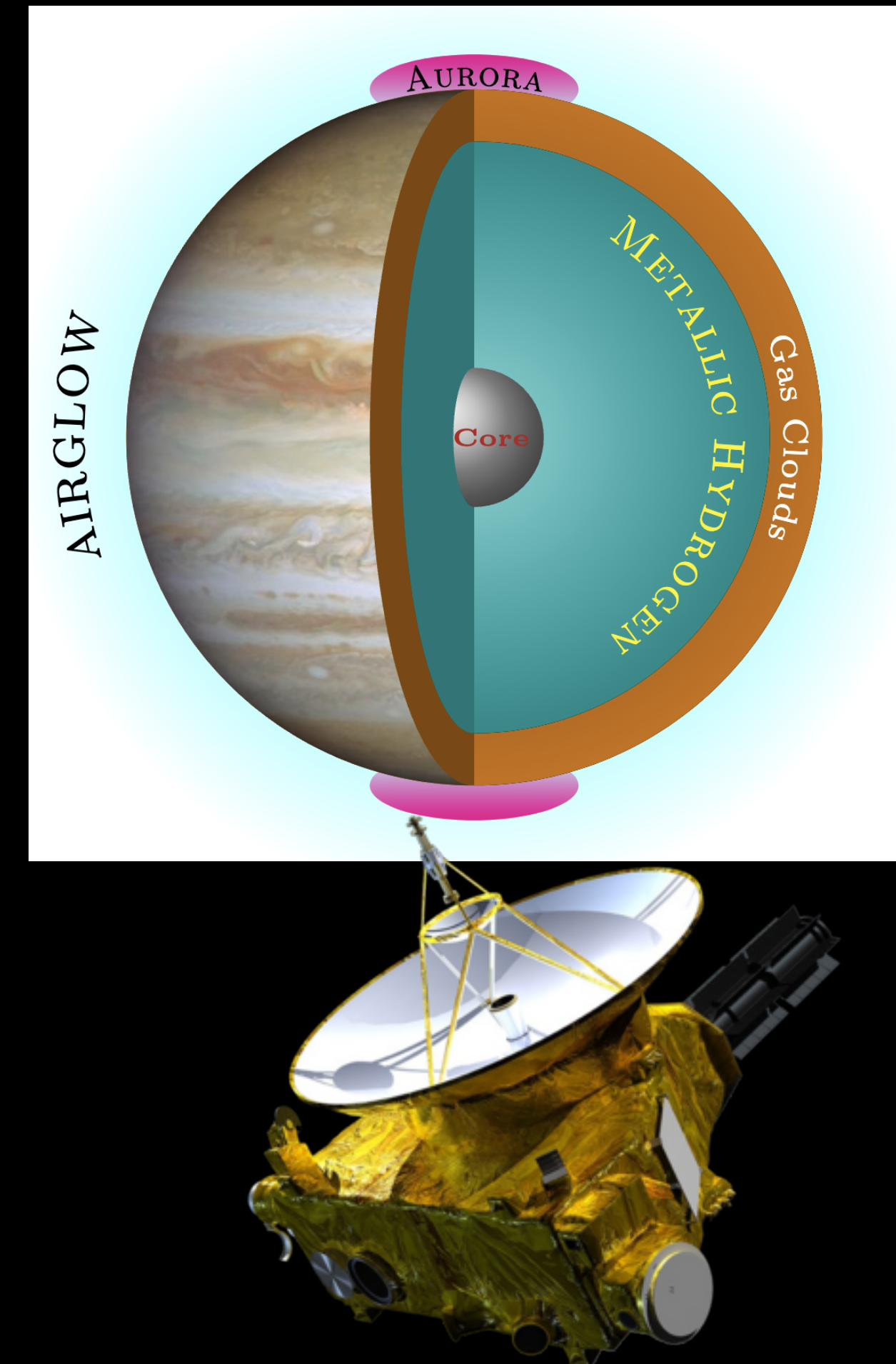
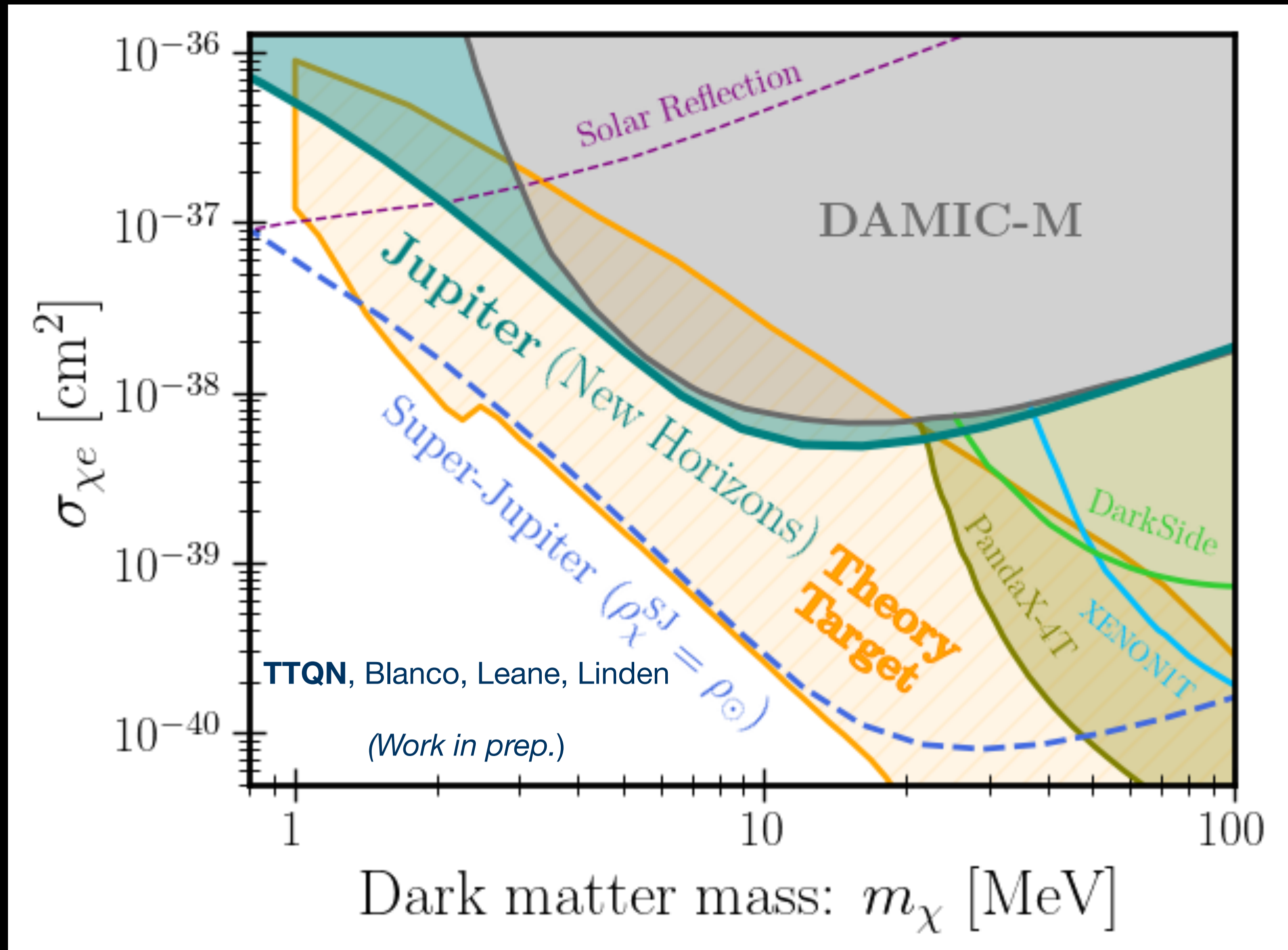
Sub-GeV Dark Matter Under Pressure from Direct Detection

[Andrew Cheek](#)^{1,*} [Pablo Figueroa](#)^{2,†} [Gonzalo Herrera](#)^{3,‡} and [Ian M. Shoemaker](#)^{3,§}

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²*Instituto de Física Corpuscular (IFIC), Consejo Superior de Investigaciones Científicas (CSIC) and Universitat de València, C/ Catedrático José Beltrán 2, E-46980 Paterna, Spain*
³*Center for Neutrino Physics, Department of Physics, Virginia Tech, Blacksburg, Virginia 24061, USA*

DM-electron cross section

Ionization of Jupiter atmosphere measurement from New Horizons



Take home message

- Jupiter is cool!
- There could be a large density of leptophilic MeV dark matter particles trapped inside Jupiter!
- We need new strategies to detect these DM!

Thank you for listening!

Chiao is searching
for Dog-matter
too!

