Phenomenology 2026 Symposium
University of Pittsburgh

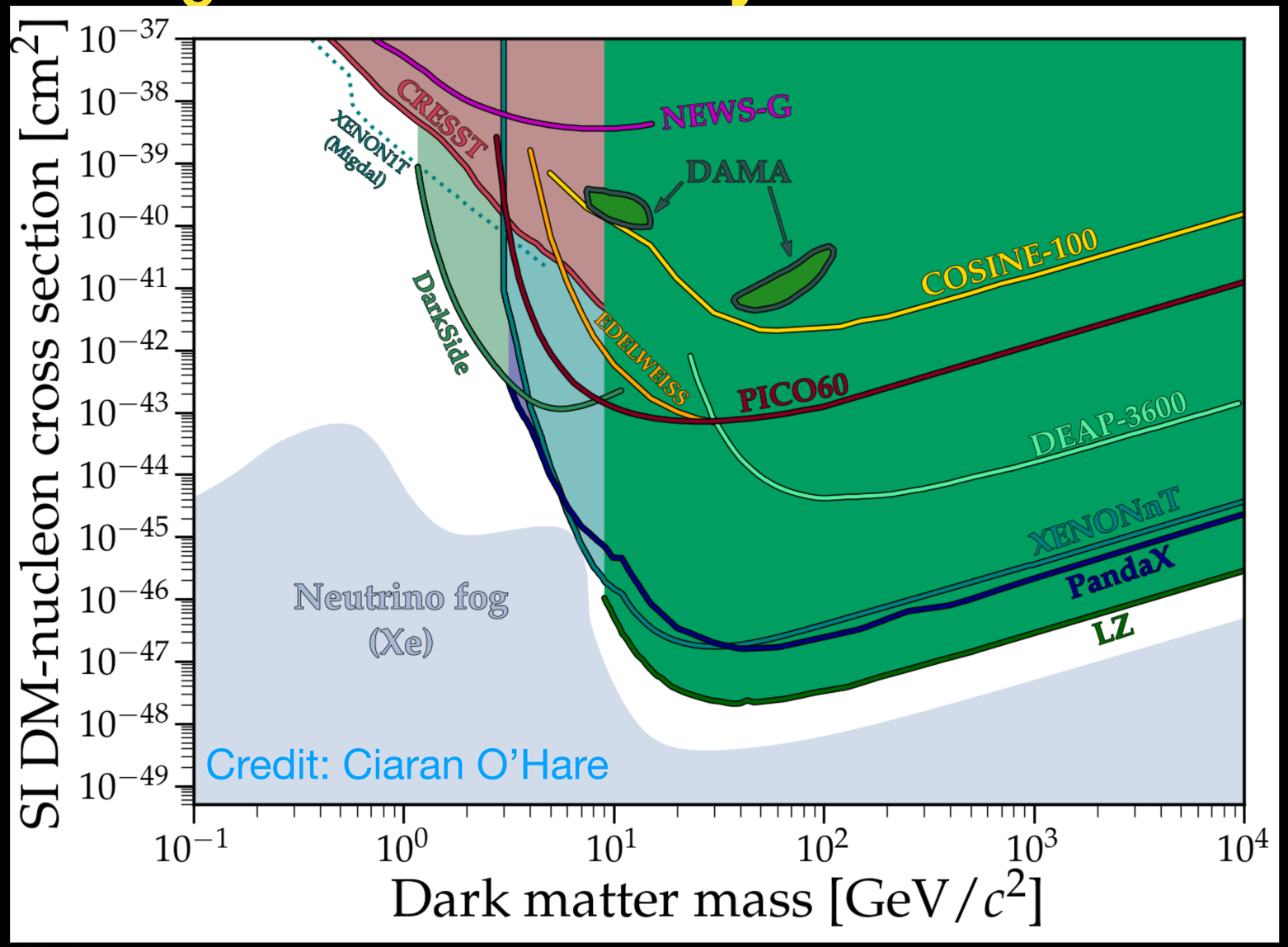
Jupiter is a Dark Matter Refrigerator: Electron Degeneracy Inhibits Evaporation

Thong T.Q. Nguyen

Stockholm University
Oskar Klein

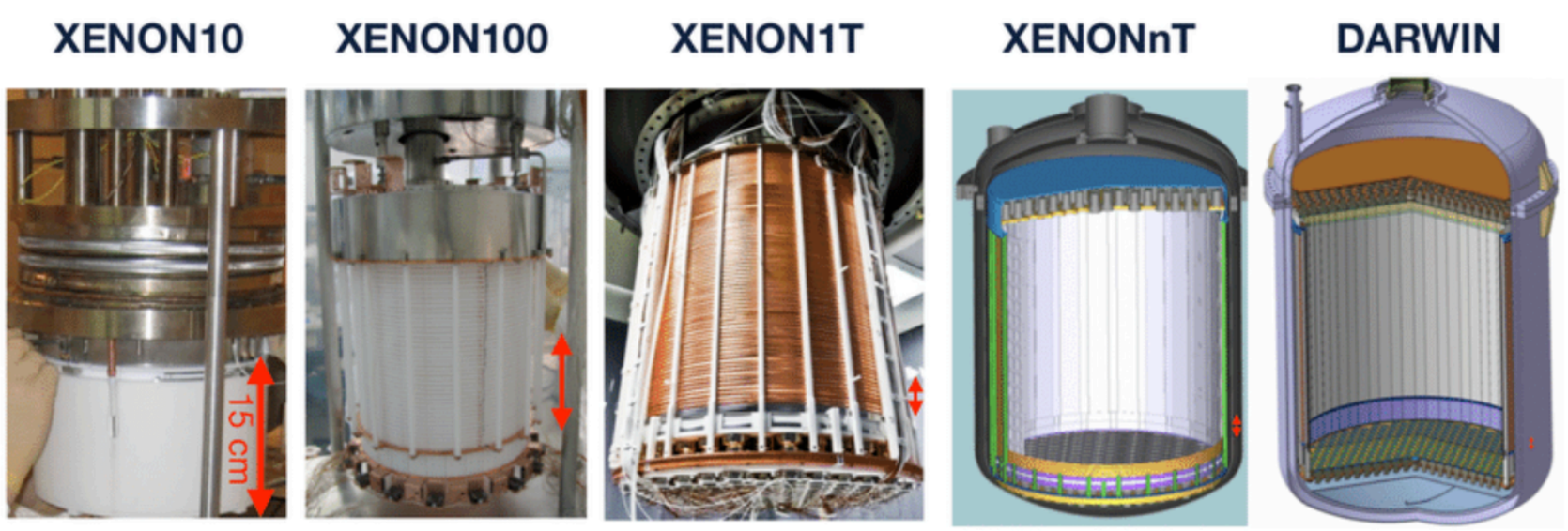
Direct Detection

Current results: Hugh's talk on Monday



Direct Detection

The common strategy for heavy WIMP



2005 – 2007	2008 – 2016	2012 – 2018	2019 – 2023	2025 –
~15 kg	~62 kg	~2 t	~5.9 t	40 t
15 cm	30 cm	1 m	1.5 m	2.6 m
~10^{-43} cm^2	~10^{-45} cm^2	~10^{-47} cm^2	~10^{-48} cm^2	~10^{-49} cm^2

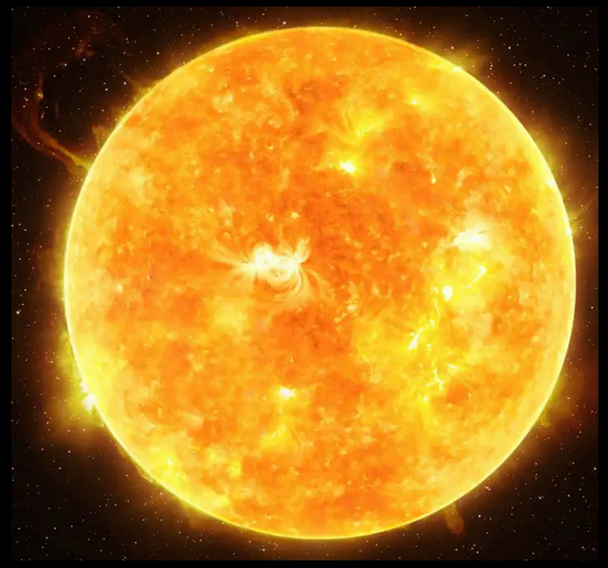
The Sun as Natural Dark Matter Detector

Large Exposure from the Heaven!

XENONnT:

- 7000 kg
- 700 days

5×10^{6} kg day



The Sun:

- 3×10^{30} kg
- 2×10^{10} days

6×10^{40} kg day

The Sun as Natural Dark Matter Detector

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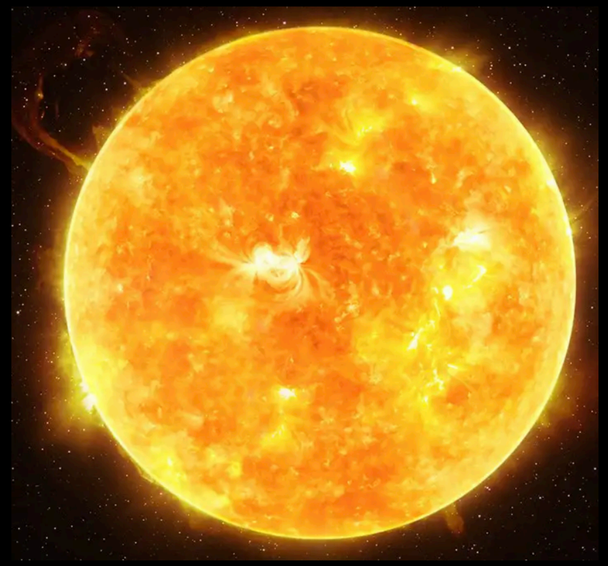

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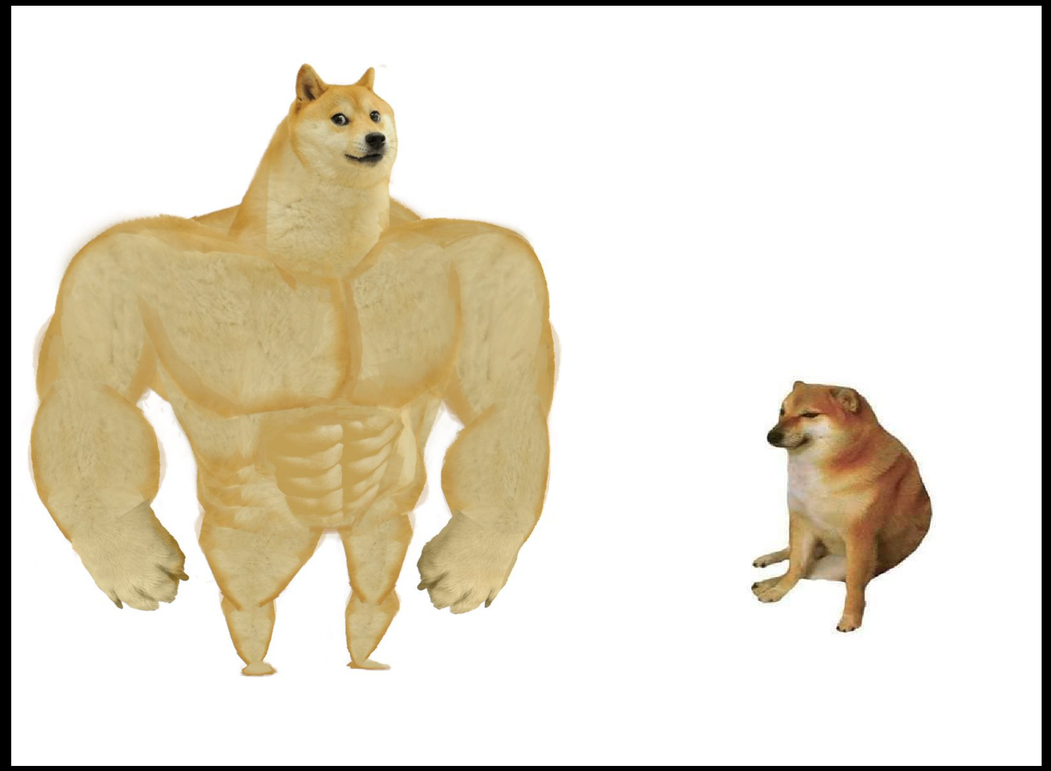
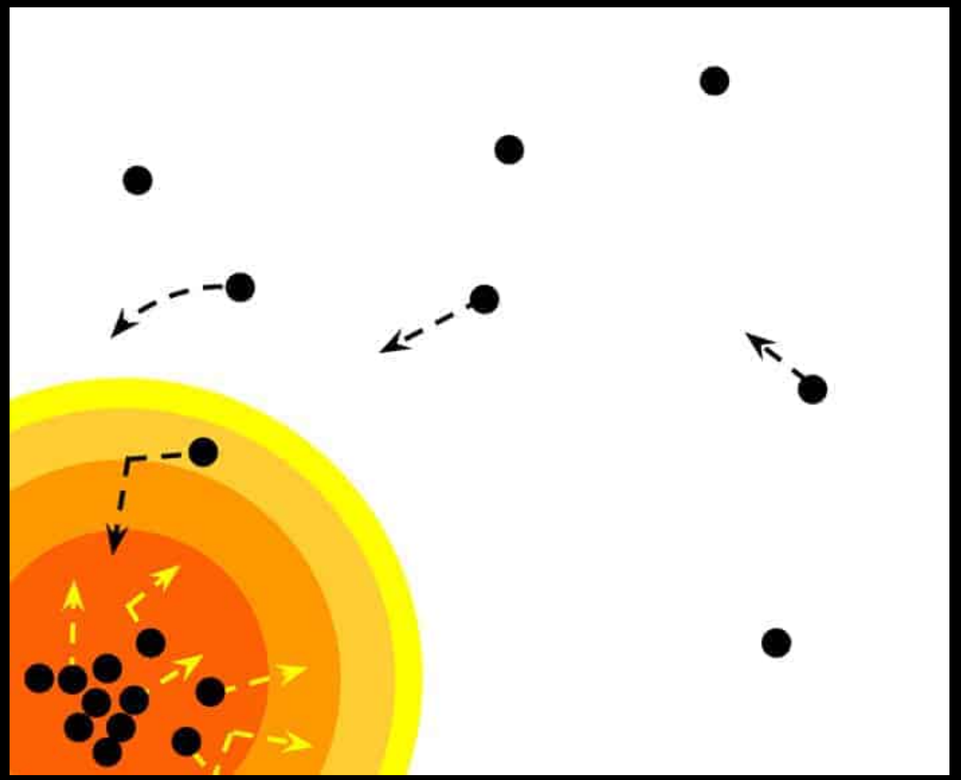


Dark Matter Capture in The Sun

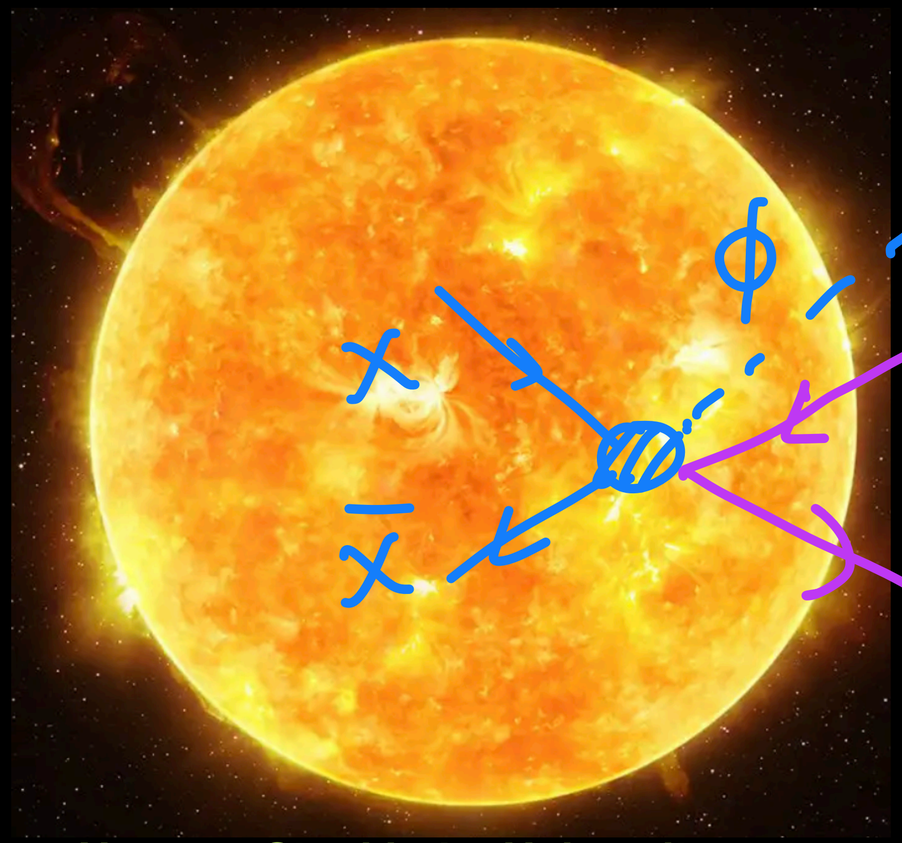
A novel idea first proposed by Press and Spergel, 1985



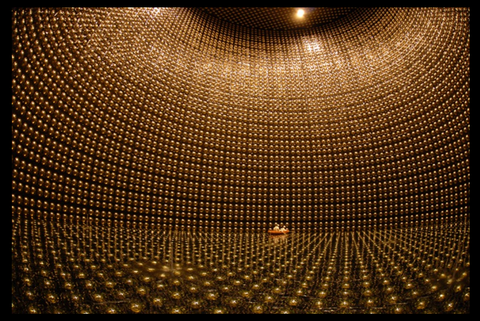
- DM scattering with nucleons and electrons inside the Sun
- Lose Kinetic Energy.
- DM Velocity below the Sun's Escape Velocity!
- Being captured! Enhance the DM density inside the Sun
- DM annihilation in the Sun: indirect detection signals

Indirect Detection signals

Gamma-ray and neutrinos



HAWC

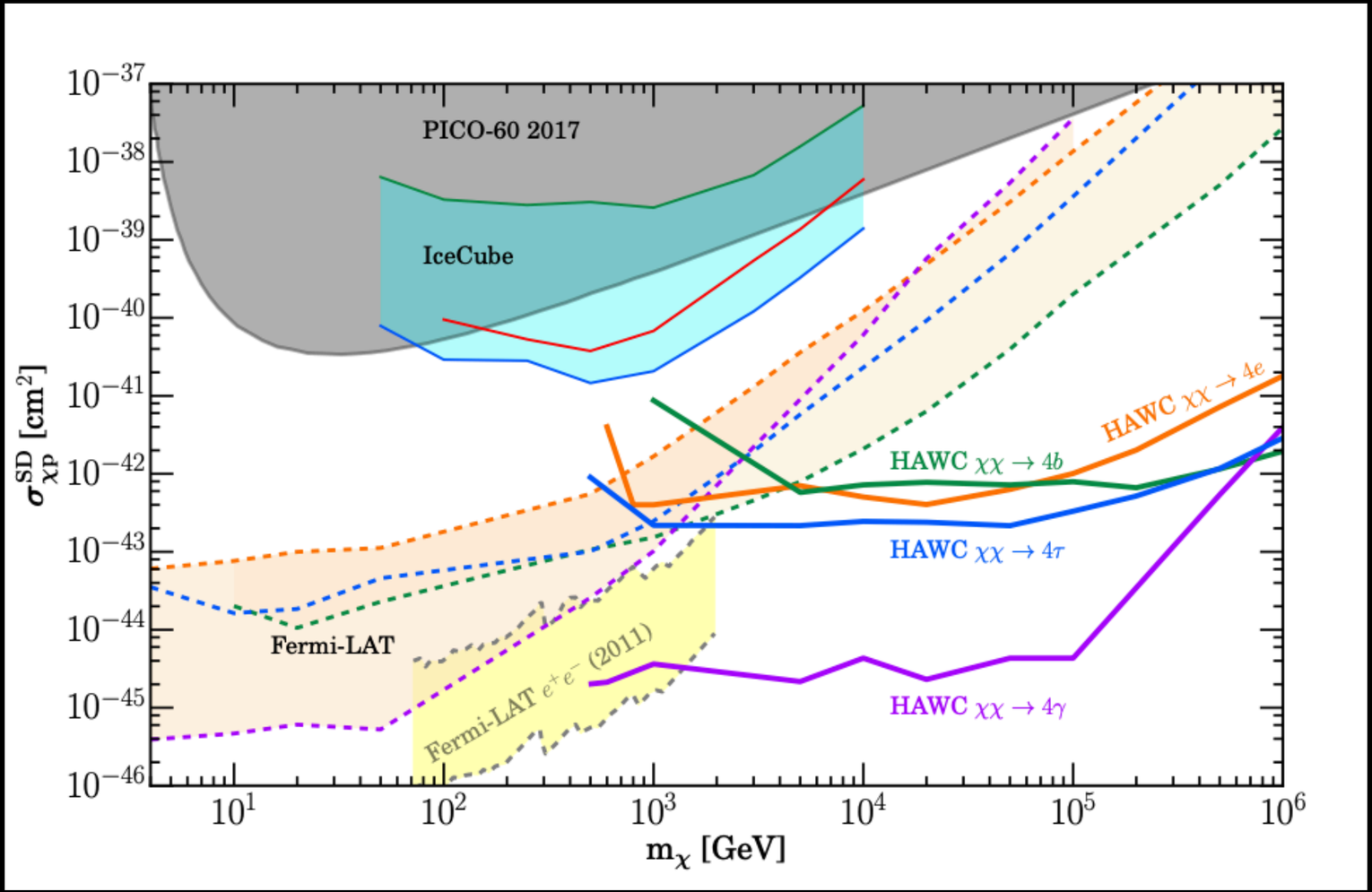


Super-Kamiokande

IceCube

An Active Research Direction

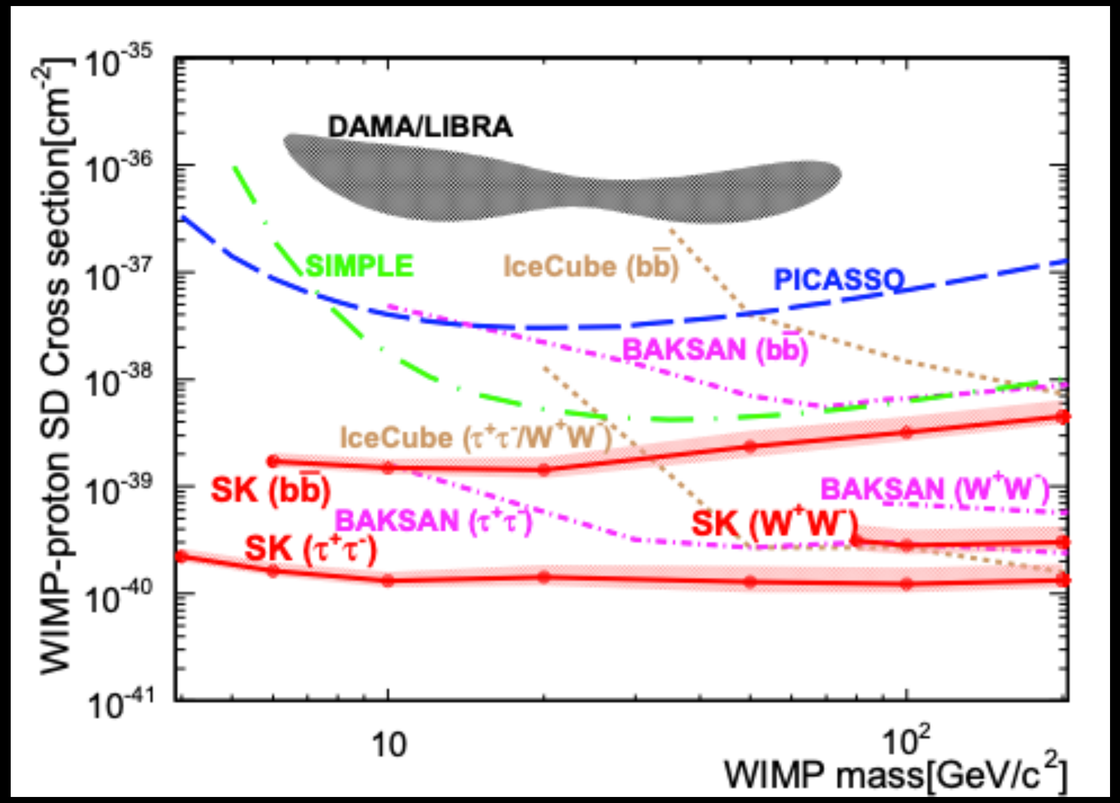
Experimental Results: gamma-ray



HAWC Collaboration, PRD 2018 (arXiv:1808.05624)

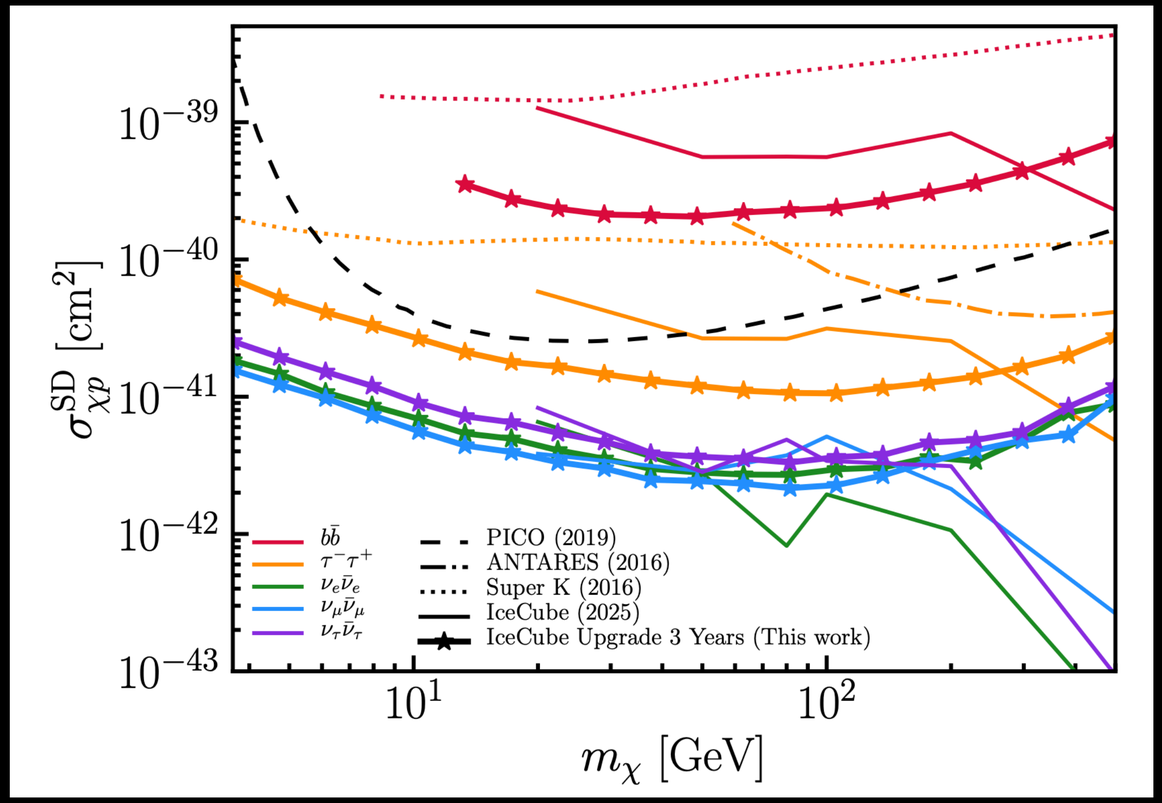
An Active Research Direction

Experimental Results: neutrinos



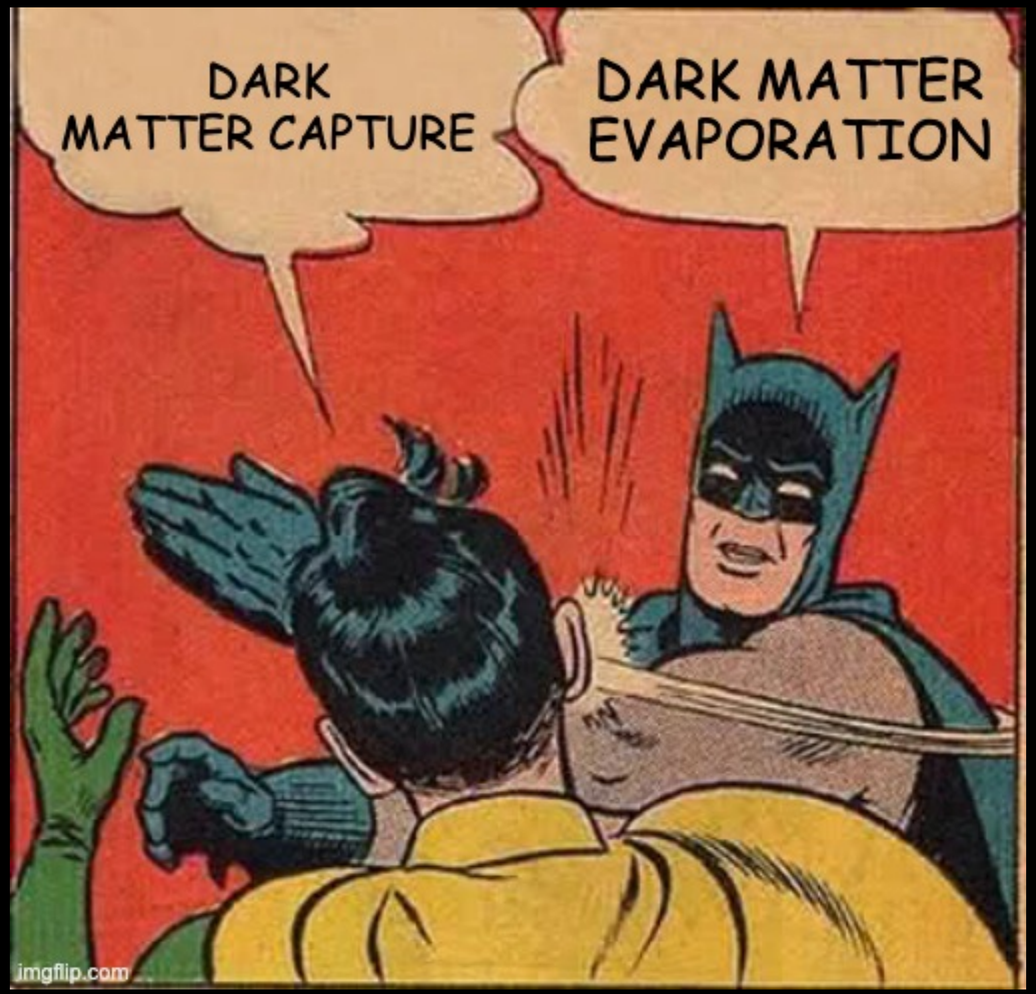
Super-K Collaboration,

PRL 2015 (arXiv:1503.04858)



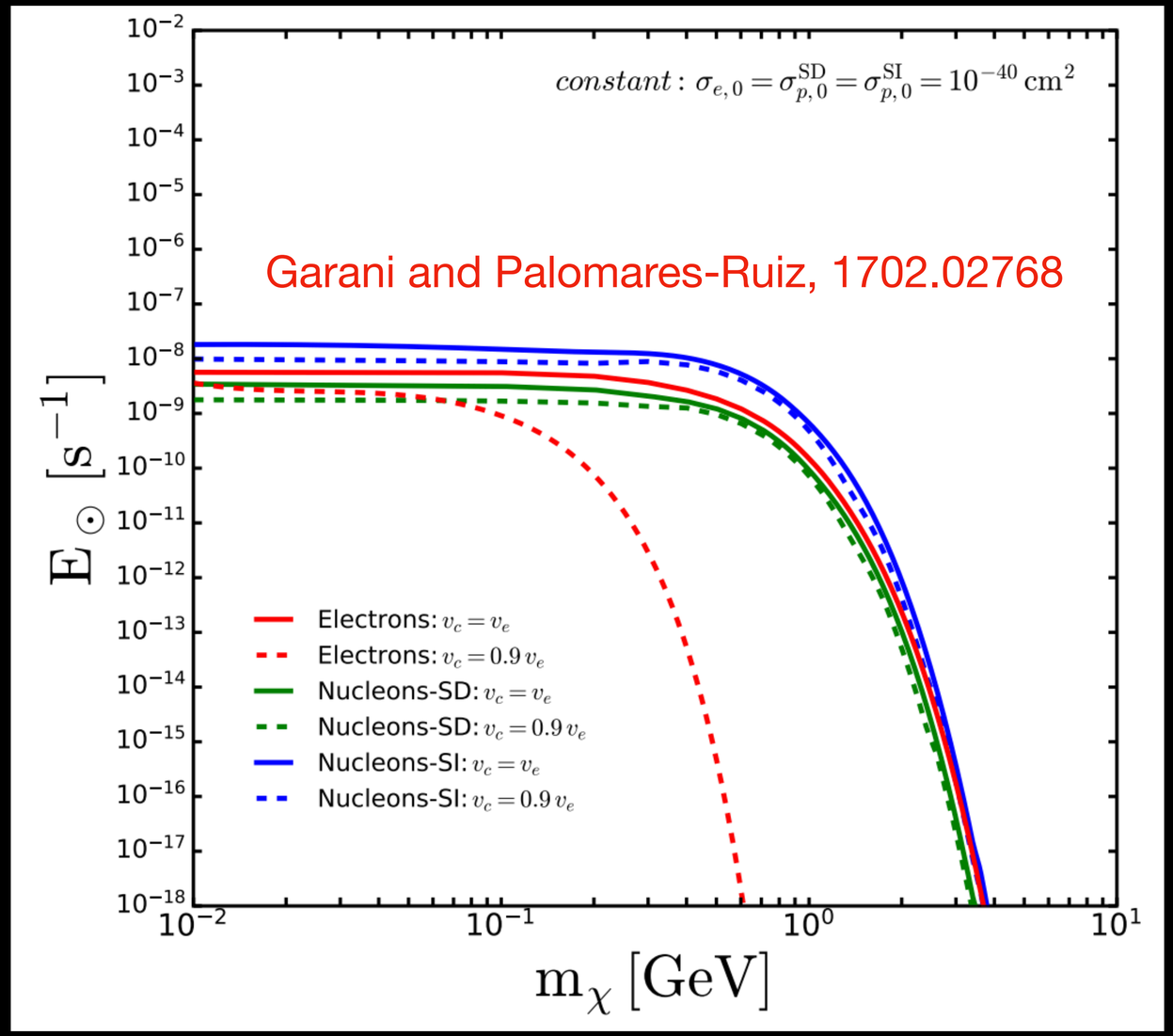
IceCube, 2026 (arXiv: 2605.06600)

Dark Matter Evaporation



Dark Matter evaporation in the Sun

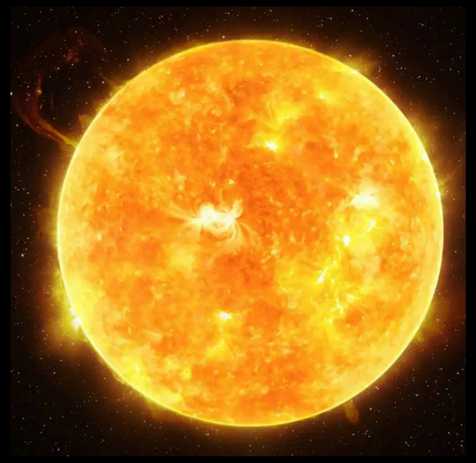
- Fast electrons/nucleons in the Sun can up-scatter captured DM.
- The up-scattered DM can exceed the Sun's escape velocity.
- Light DM can "evaporate" from the Sun.
- Previous results: DM below 4 GeV is fully evaporated from the Sun



Dark Matter Evaporation Mass

For Objects in the Solar system (Garani and Palomares-Ruiz, 2104.12757)

Here come the Sun!



4 GeV

Nucleon + electron Scattering

Jupiter

1 GeV

Nucleon Scattering

Assuming targets (electron/nucleons) follow the Boltzmann distribution!

In Prep. (2605.xxxx)

SLAC-PUB-260224

Jupiter is a Dark Matter Refrigerator: Electron Degeneracy Inhibits Evaporation

Thong T.Q. Nguyen,[1,*] Carlos Blanco,[2,3,1,†] Rebecca K. Leane,[4,5,‡] and Tim Linden[1,6,§]

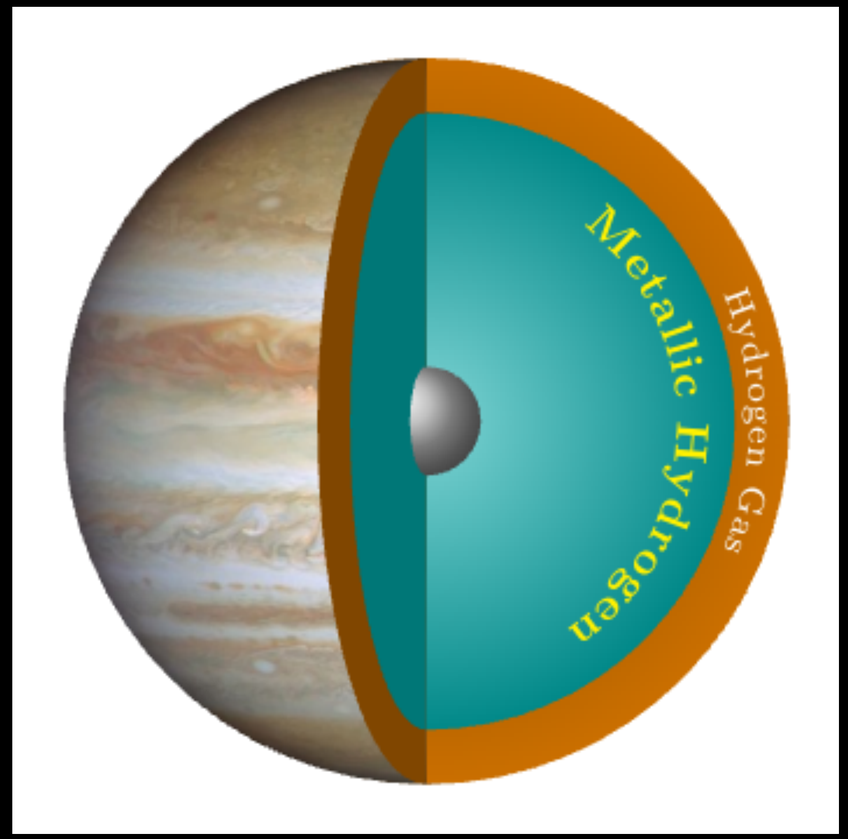
[1] *Stockholm University and The Oskar Klein Centre for Cosmoparticle Physics, Alba Nova, 10691 Stockholm, Sweden*
[2] *Institute for Gravitation and the Cosmos, The Pennsylvania State University, University Park, PA 16802, USA*
[3] *Department of Physics, Princeton University, Princeton, NJ 08544, USA*
[4] *Particle Theory Group, SLAC National Accelerator Laboratory, Stanford, CA 94305, USA*
[5] *Kavli Institute for Particle Astrophysics and Cosmology, Stanford University, Stanford, CA 94305, USA*
[6] *Erlangen Centre for Astroparticle Physics (ECAP), Friedrich-Alexander-Universität Erlangen-Nürnberg, Nikolaus-Fiebiger-Str. 2, 91058 Erlangen, Germany*

Tim Linden
(Stockholm U.)

Carlos Blanco
(Penn State U.)

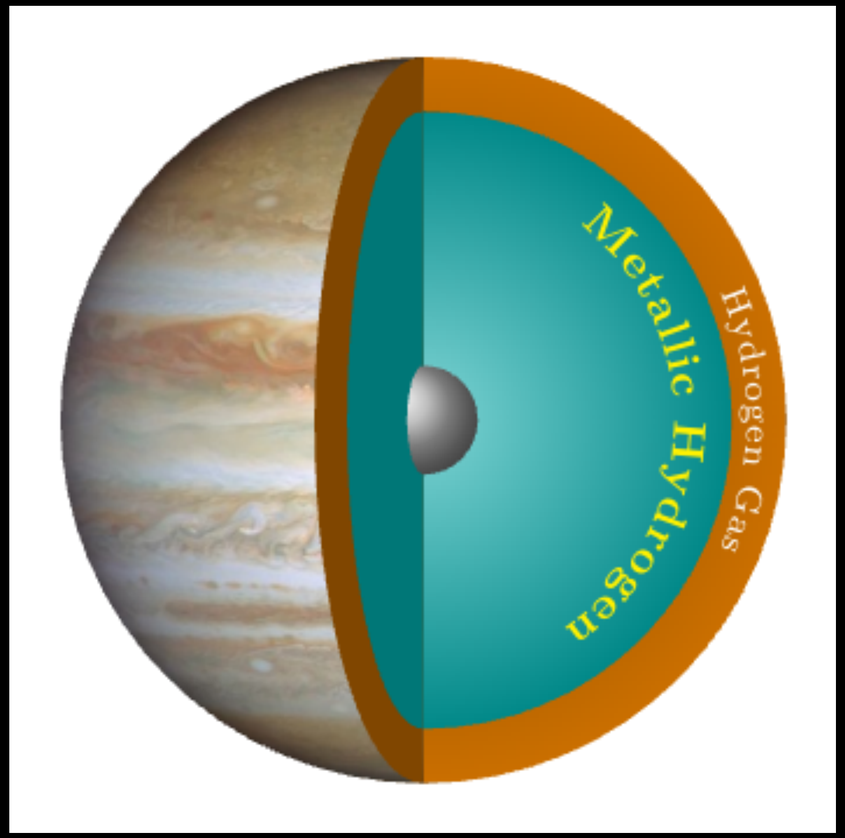
Rebecca Leane
(SLAC)

Realistic Jupiter Model



Realistic Jupiter Model

Metallic Hydrogen Layer



Wikipedia
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

Realistic Jupiter Model

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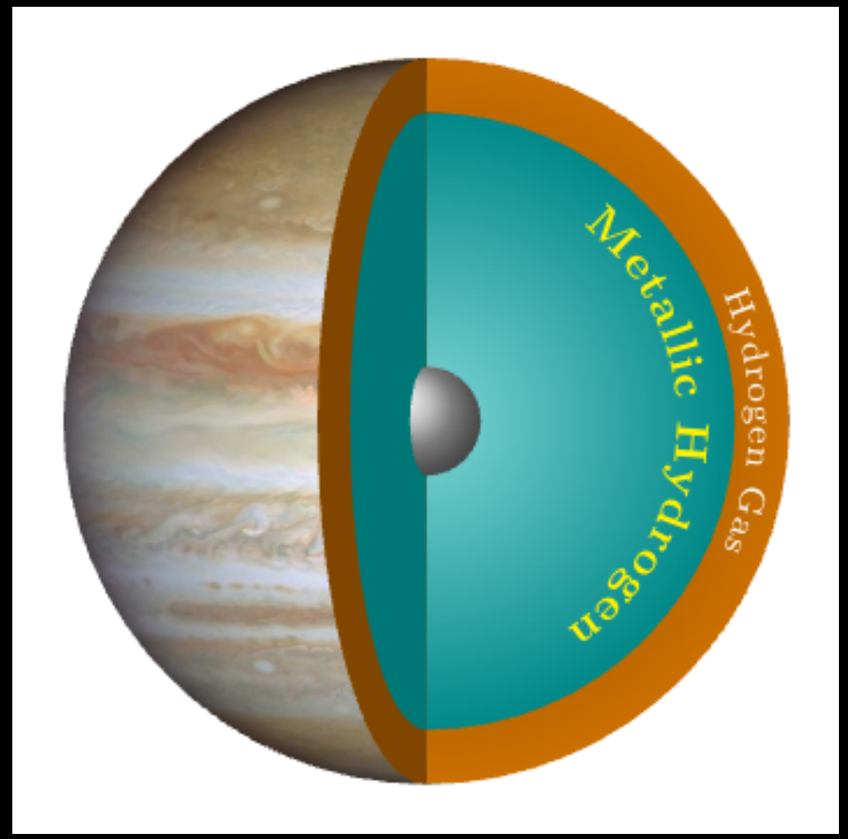
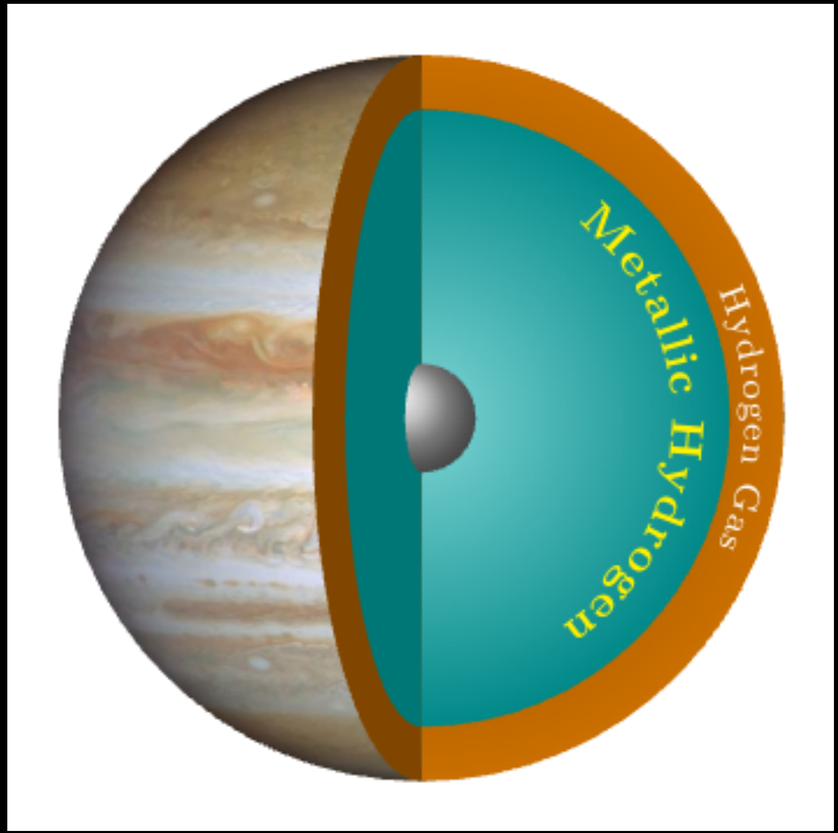


- Jupiter's high pressure stripped electrons out from their Hydrogen Molecules.
- Electrons move freely in the metallic layer!
- Electrons fill out all possible energy states that are bounded by the Fermi Sphere of Metallic Hydrogen!
- **Electrons follow the Fermi-Dirac Distribution!**

Realistic Jupiter Model

Rocky/Icy Core



High pressure ices PNAS, 2012

Andreas Hermann[a], N. W. Ashcroft[b,1], and Roald Hoffmann[a,1]

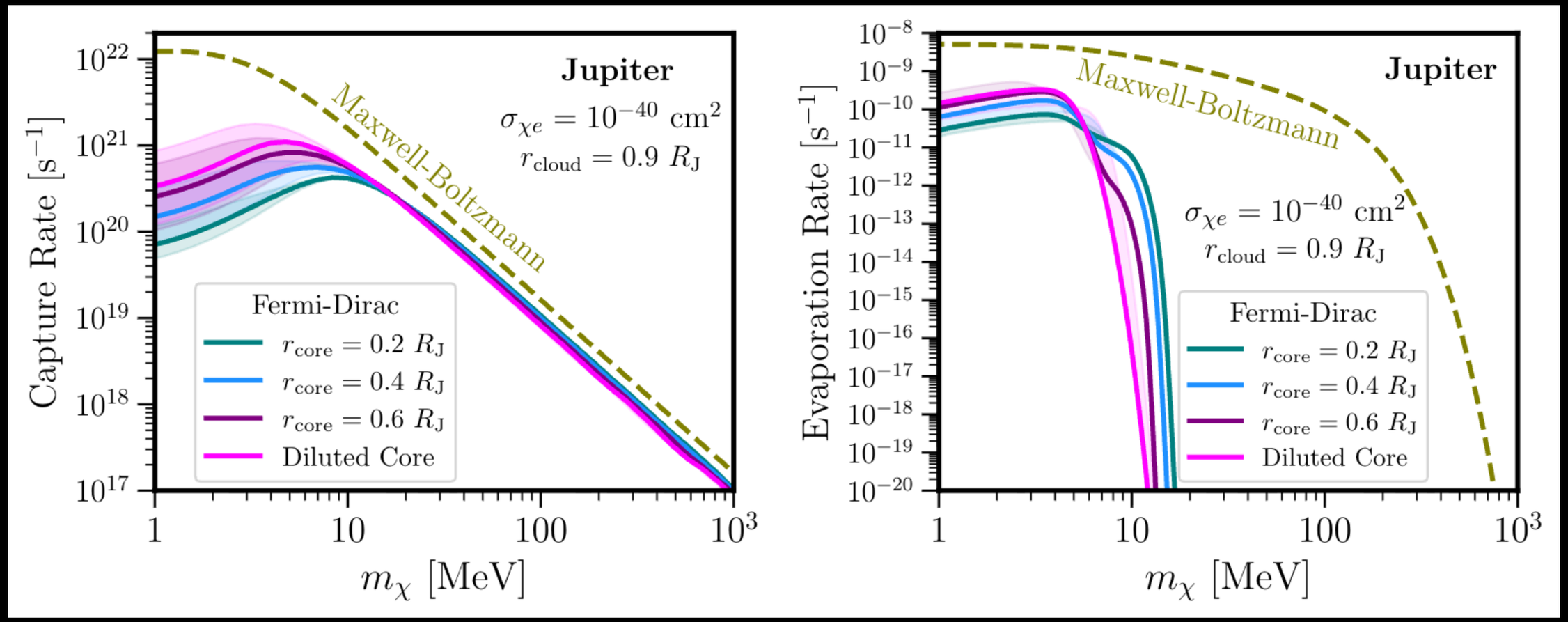
[a]Department of Chemistry and Chemical Biology, Cornell University, Ithaca, NY 14853; and [b]Laboratory of Atomic and Solid State Physics, Cornell University, Ithaca, NY 14853

Contributed by Roald Hoffmann, November 16, 2011 (sent for review September 9, 2011)

- Low Core Temperature (20,000 K) and high pressure (1-5 TPa) create an icy/rocky core.
- The core acts as an insulator with a Fermi energy bandgap.
- **Electrons also follow Fermi-Dirac distribution!**

Dark Matter Capture and Evaporation in Jupiter

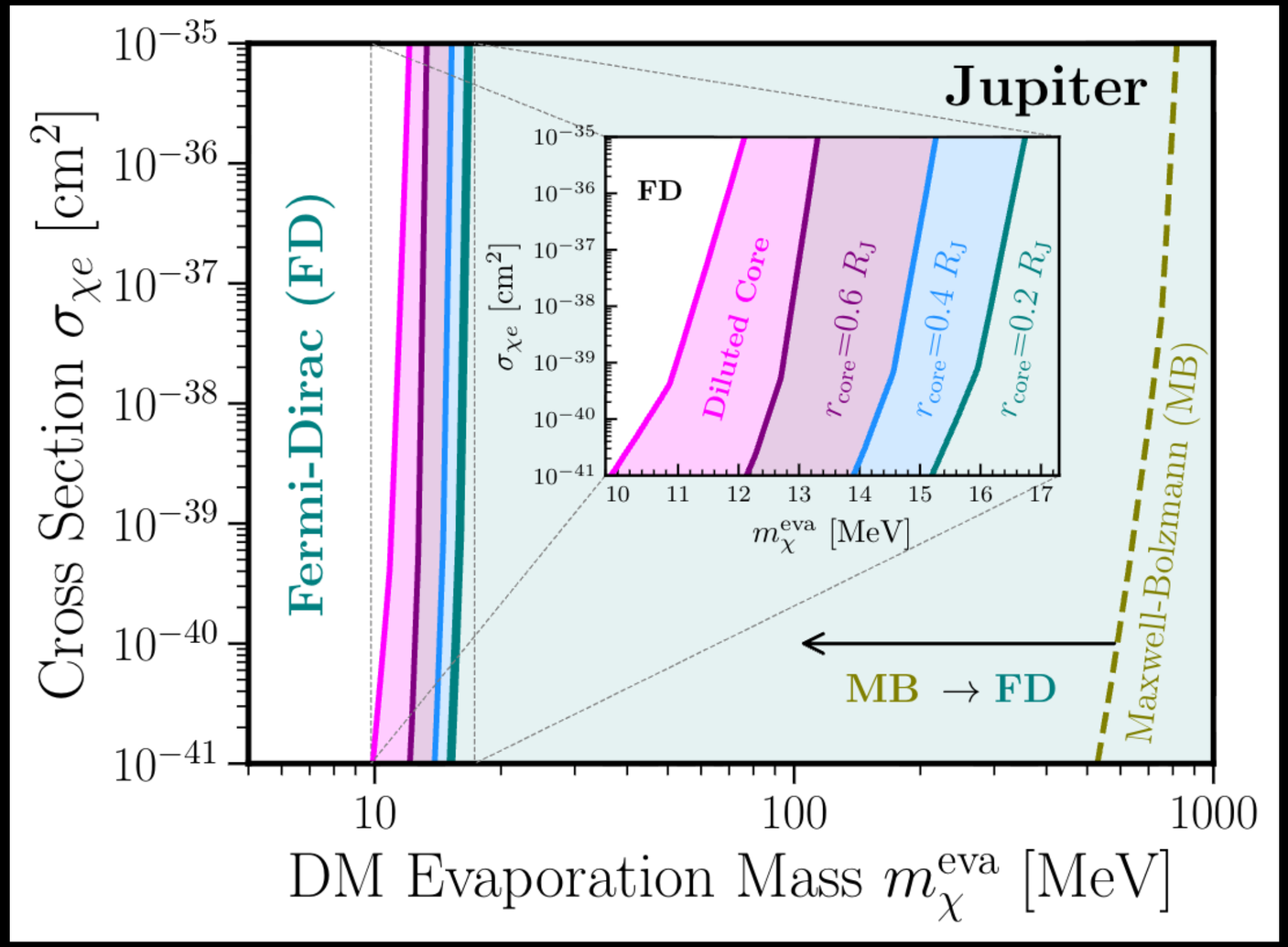
Electron Scattering with Fermi-Dirac Distribution and Pauli Blocking



TTQN, Blanco, Leane, Linden, *In Prep.*

Dark Matter Evaporation Mass in Jupiter

The minimum mass for DM to be safe from Evaporation: O(10) MeV



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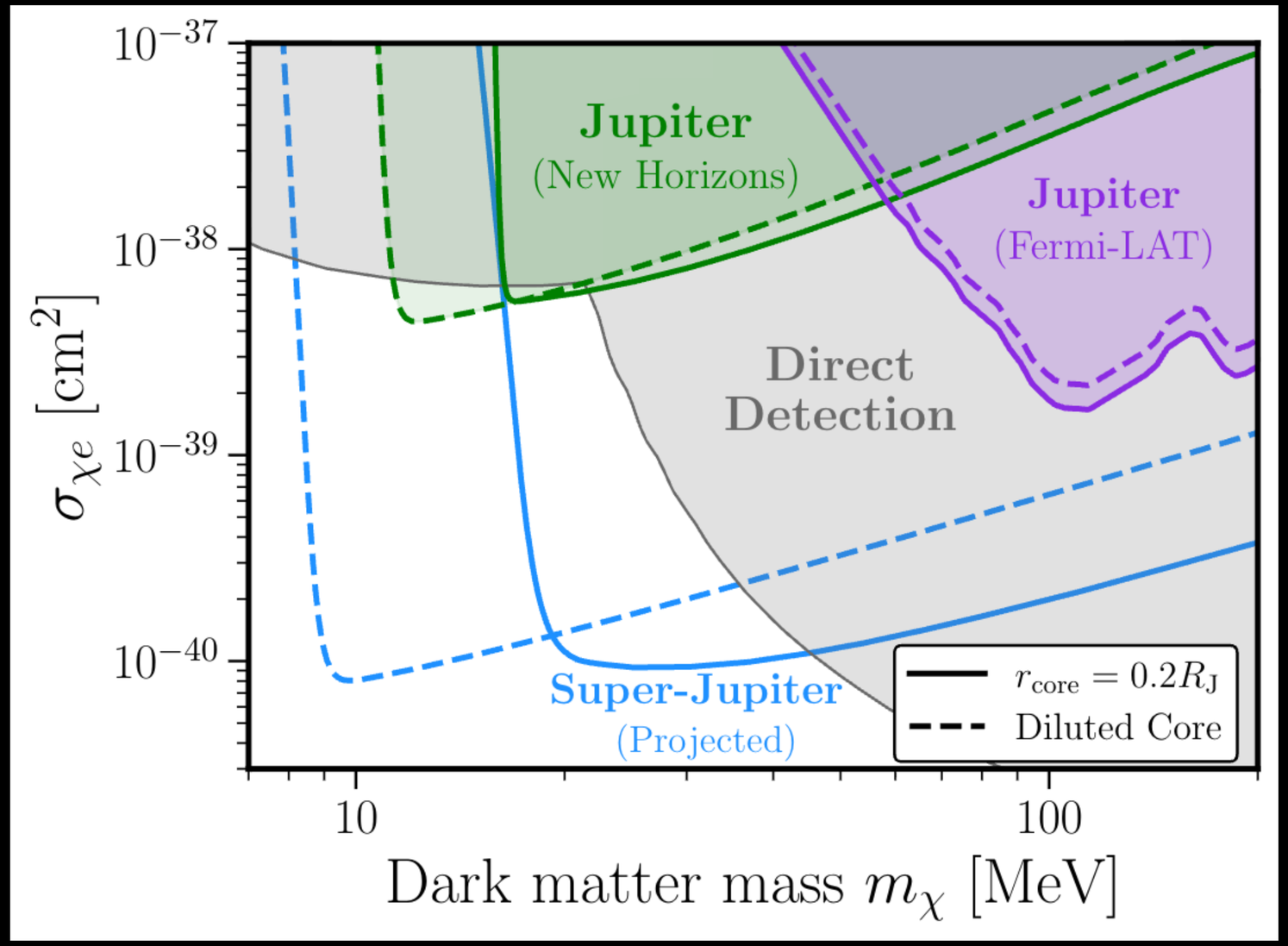
Jupiter Constraints on the MeV leptophilic DM

Dark Matter-Electron Cross Section (Preliminary Results)



Jupiter Constraints on the MeV leptophilic DM

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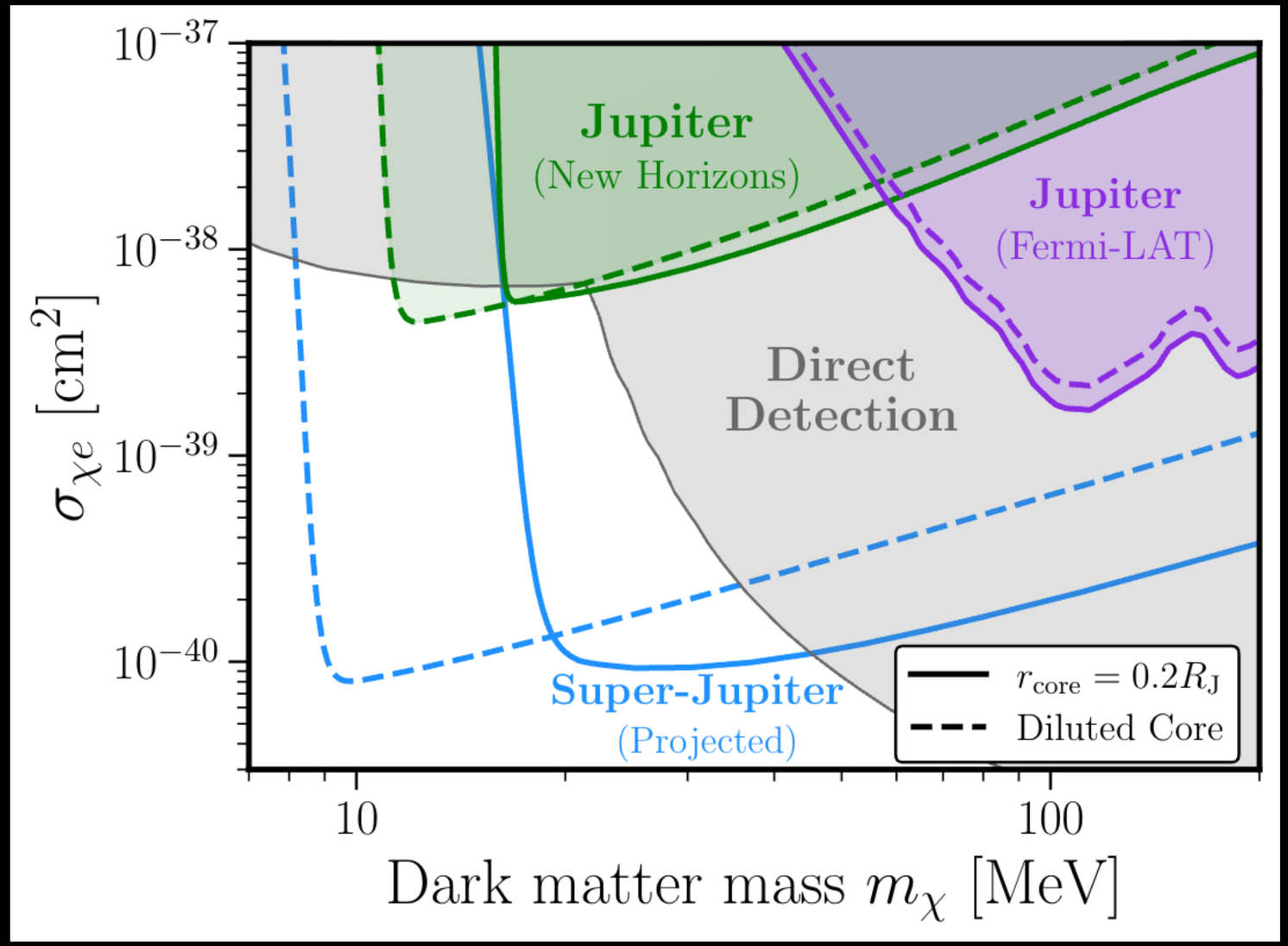
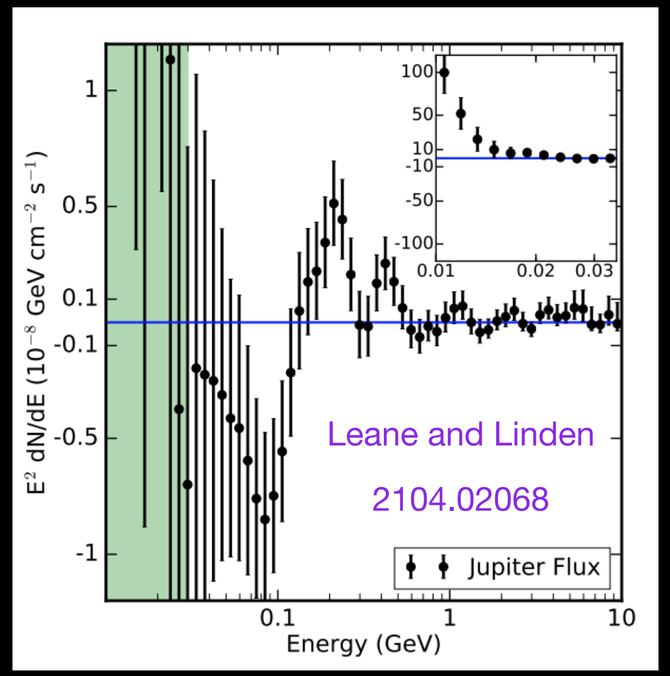


Fermi-LAT

(Gamma-ray)



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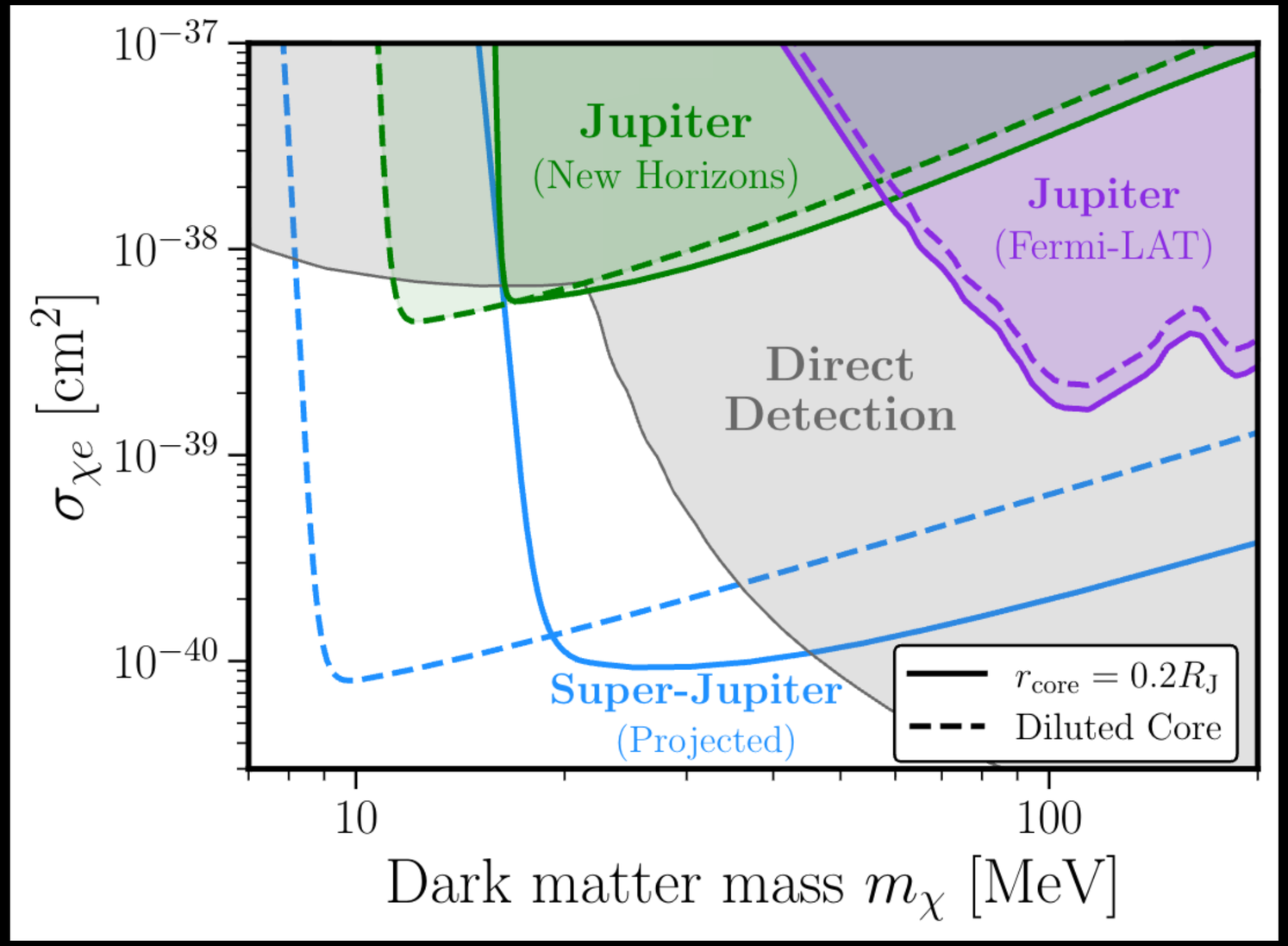
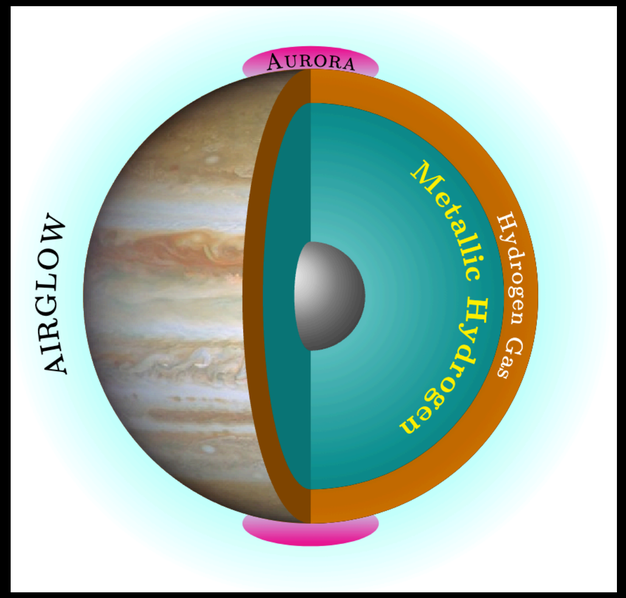
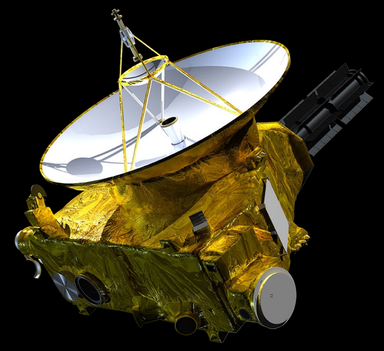






New Horizons
(UV Airglow)

Conclusion

- Jupiter is cool! (Pun intended)
- **There could be a lot of MeV Leptophilic Dark Matter particles trapped inside Jupiter.**
- We need new strategies for investigating these Dark Matter.

Thong Nguyen, Stockholm University

Thank you!

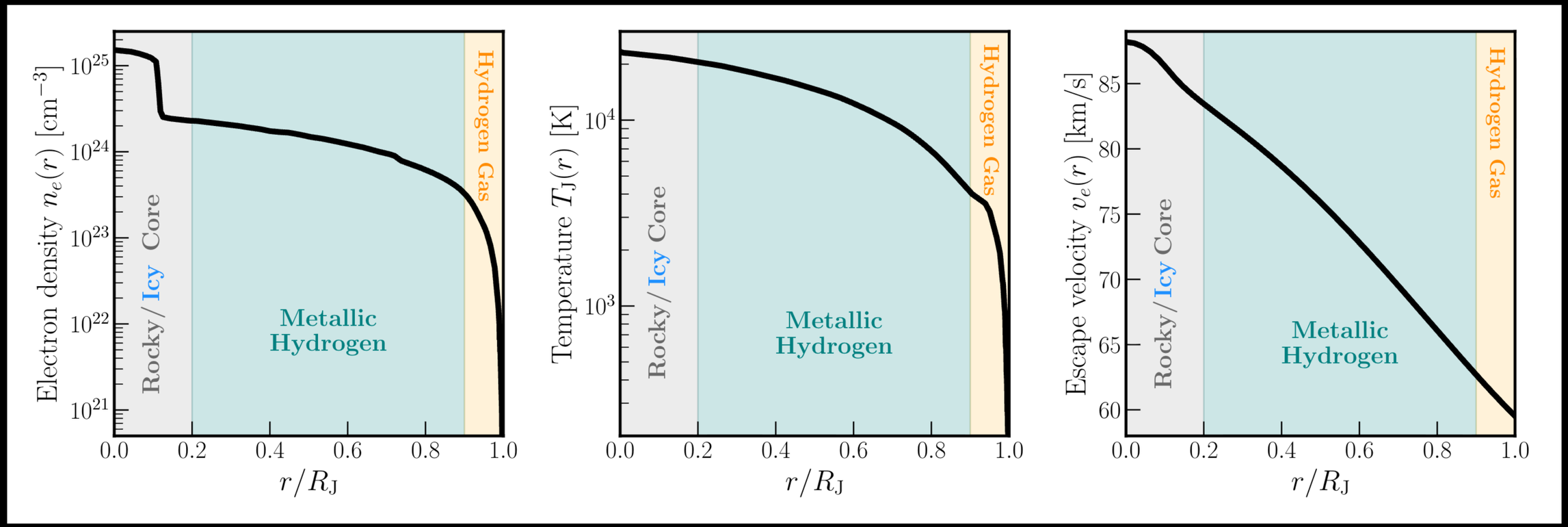
Here is a Dog-Matter!

Thong.nguyen@fysik.su.se

Backup Slides

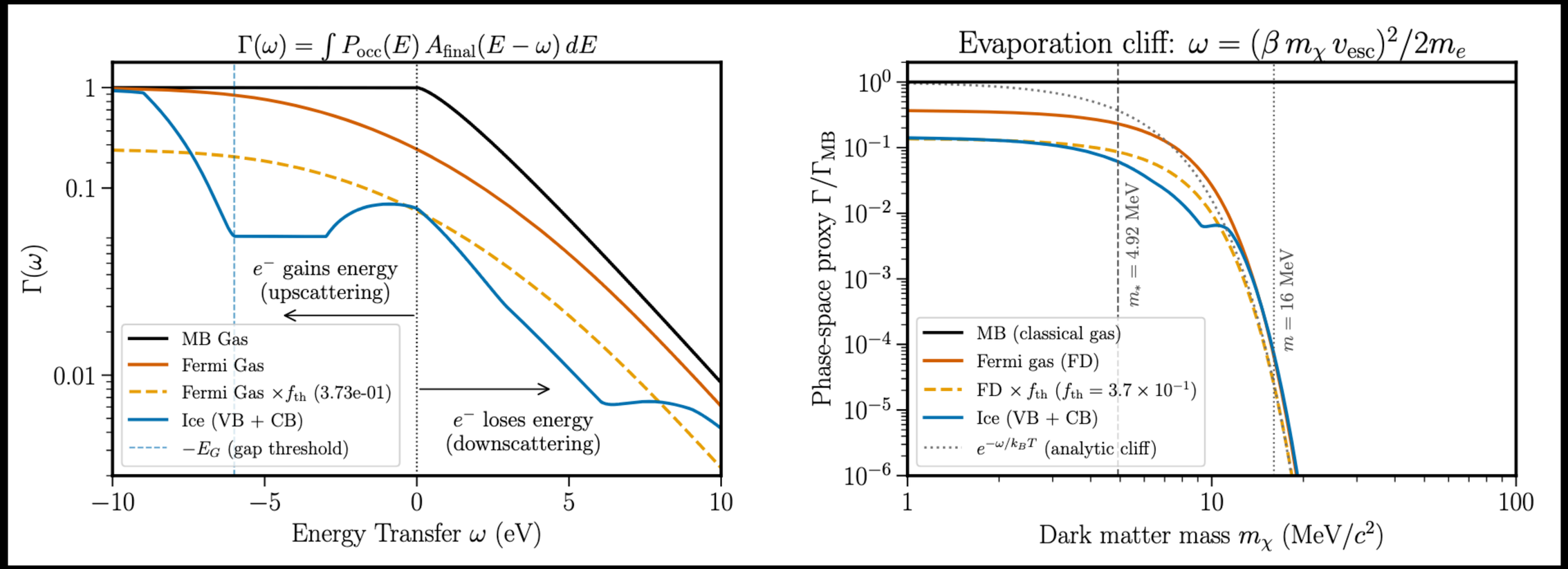
Jupiter Model

Jovian J11-4a Interior Model



Fermi-Dirac Suppression

Compare to Maxwell-Bolzmann



Consider different core models

Same suppression behaviour at O(10) MeV