



# Jupiter is a Leptophilic Dark Matter Refrigerator

Thong T.Q. Nguyen



# 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.)

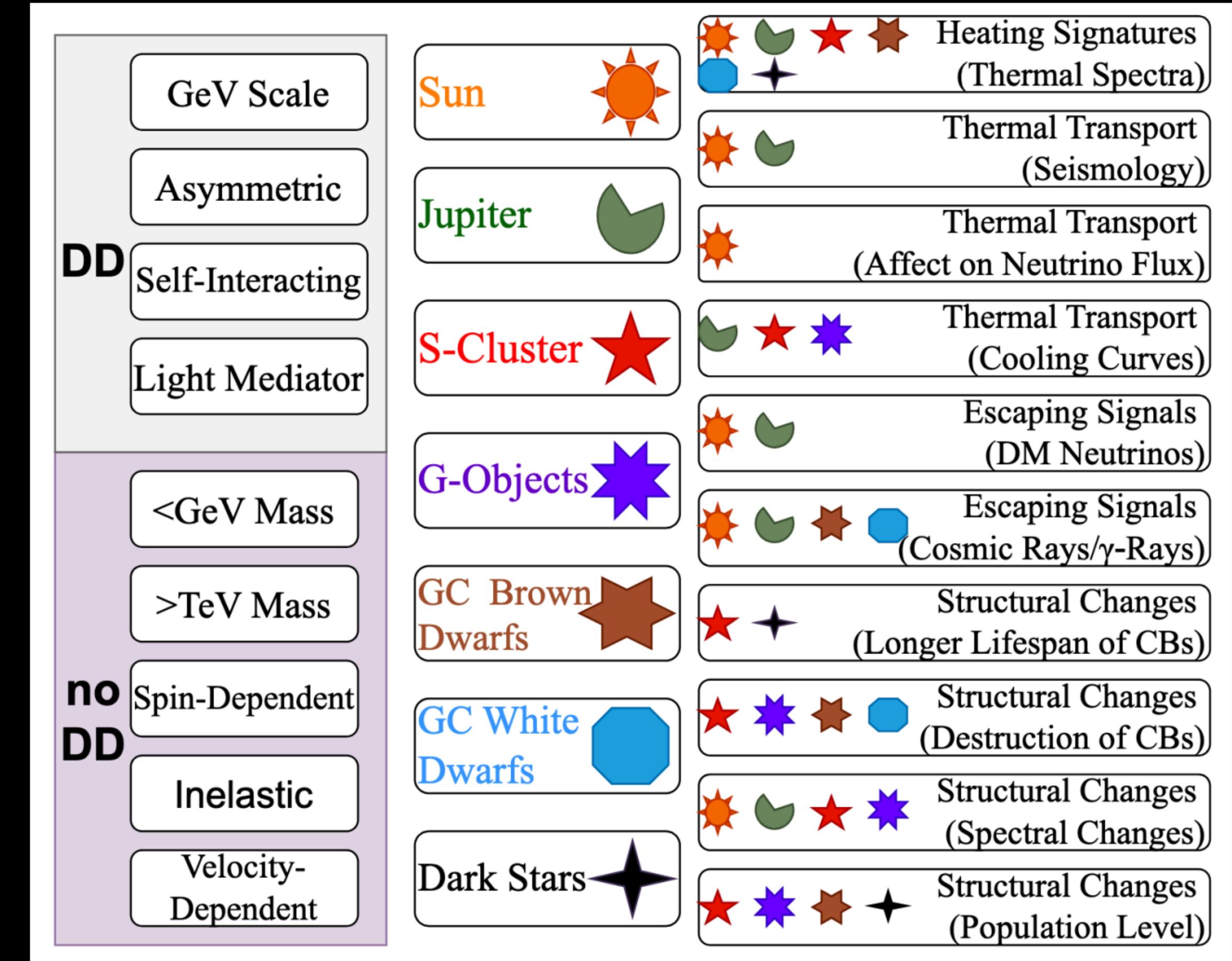


Rebecca Leane  
(SLAC)

# 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

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

Thong T.Q. Nguyen,<sup>1,\*</sup> Tim Linden,<sup>1,†</sup> Pierluca Carenza,<sup>1,‡</sup> and Axel Widmark<sup>1,2,§</sup>

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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<sup>a</sup>

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](https://arxiv.org/abs/2507.08457) [hep-ex]

Experiments: ICECUBE

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



PROCEEDINGS  
OF SCIENCE

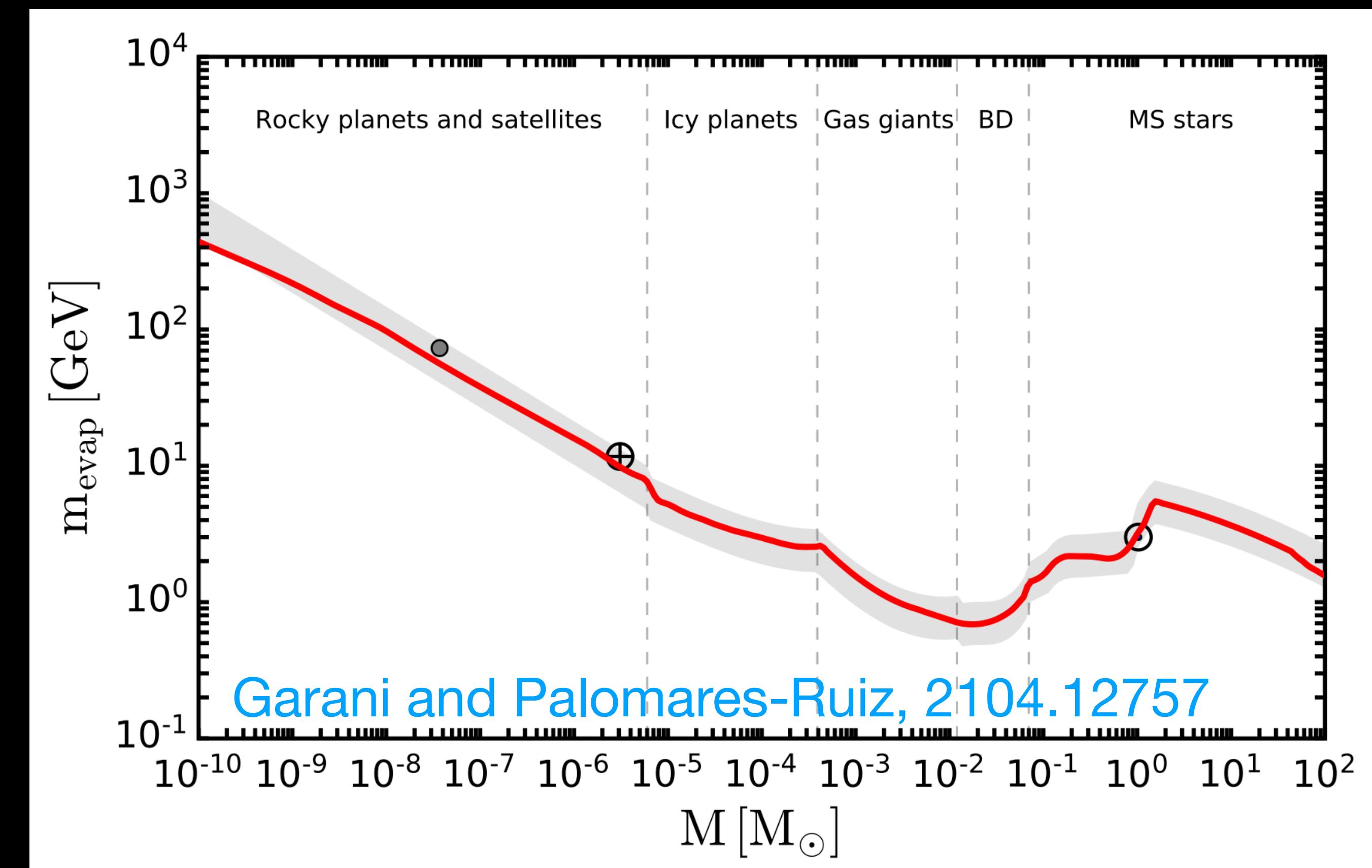
Chiara Poirè<sup>a,\*</sup> and Juan García Mendéz<sup>b</sup> on behalf of the ANTARES  
Collaboration

Thong Nguyen, Stockholm University

# Dark matter evaporation!

## The challenge in dark matter capture scenario

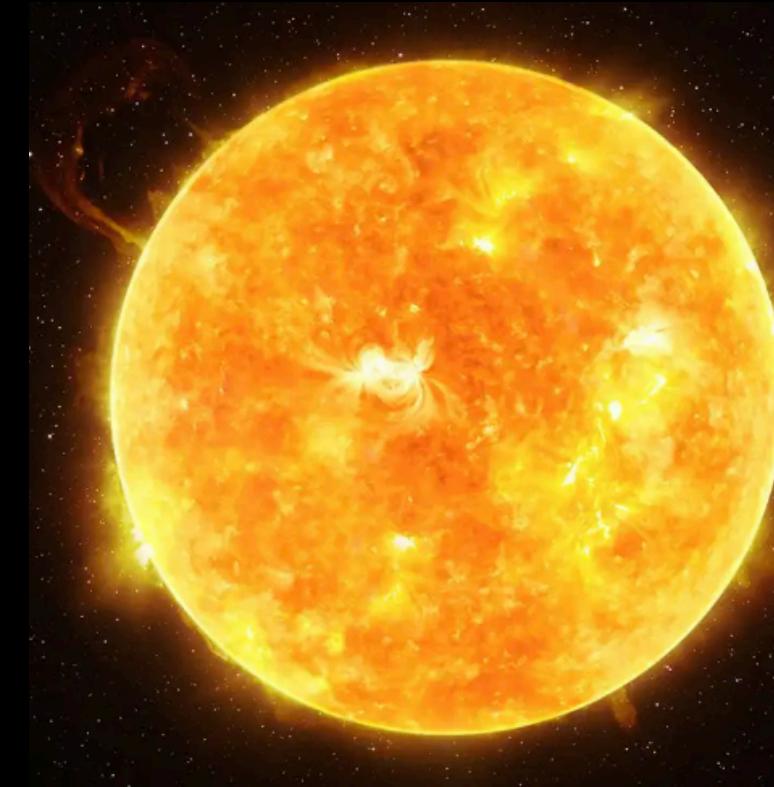
- Trapped DM can be up-scattered again by nucleon/electron.
- DM gains kinetic energy.
- Light DM can escape the object!
- There are lower limits for dark matter mass to be captured!



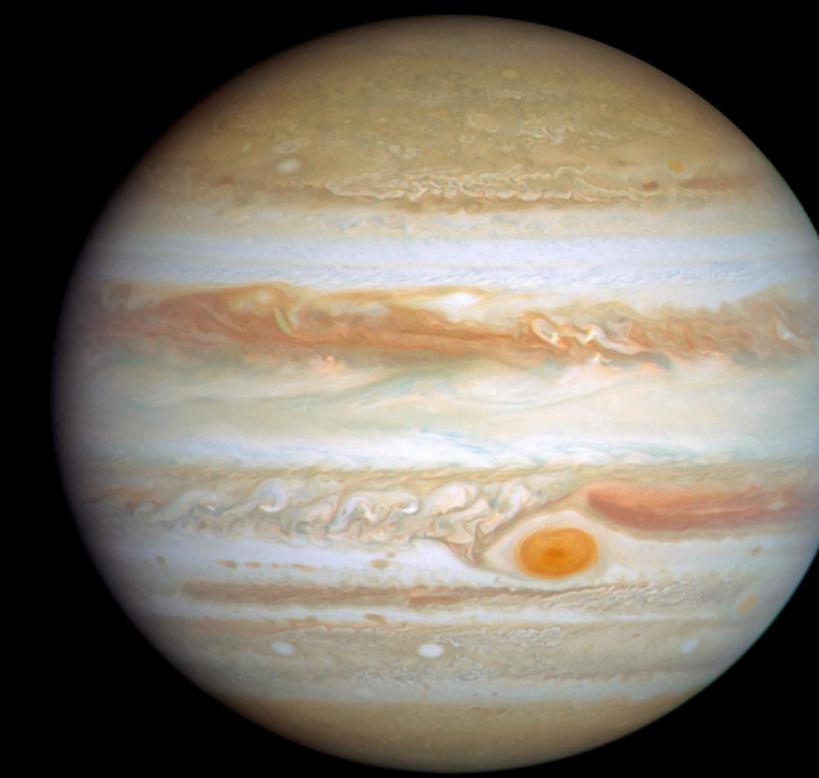
# The challenge in dark matter capture scenario

## Summary the DM mass limits in DM capture scenarios

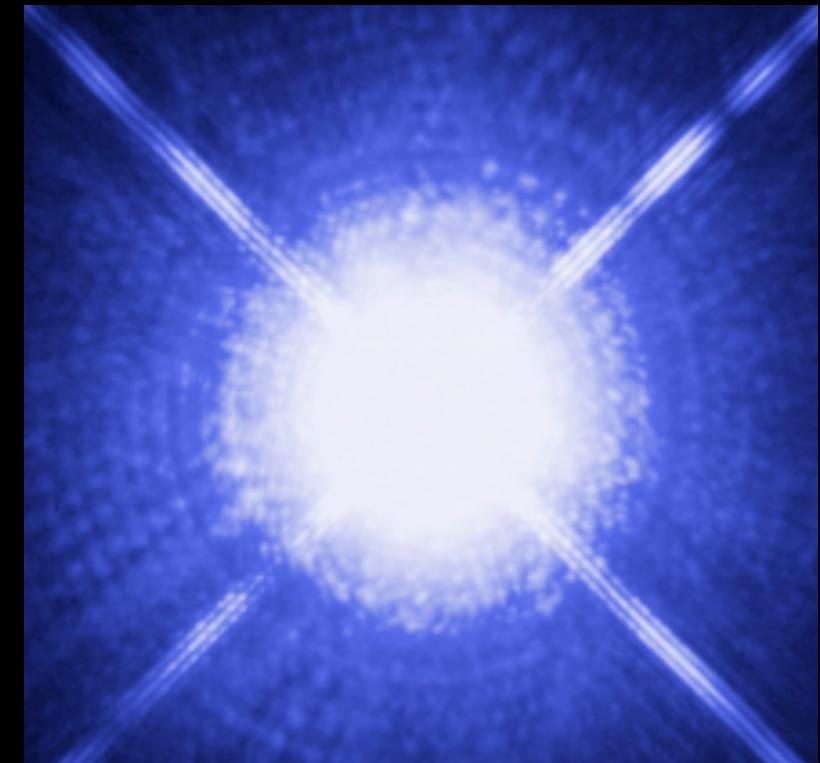
Here come the Sun!



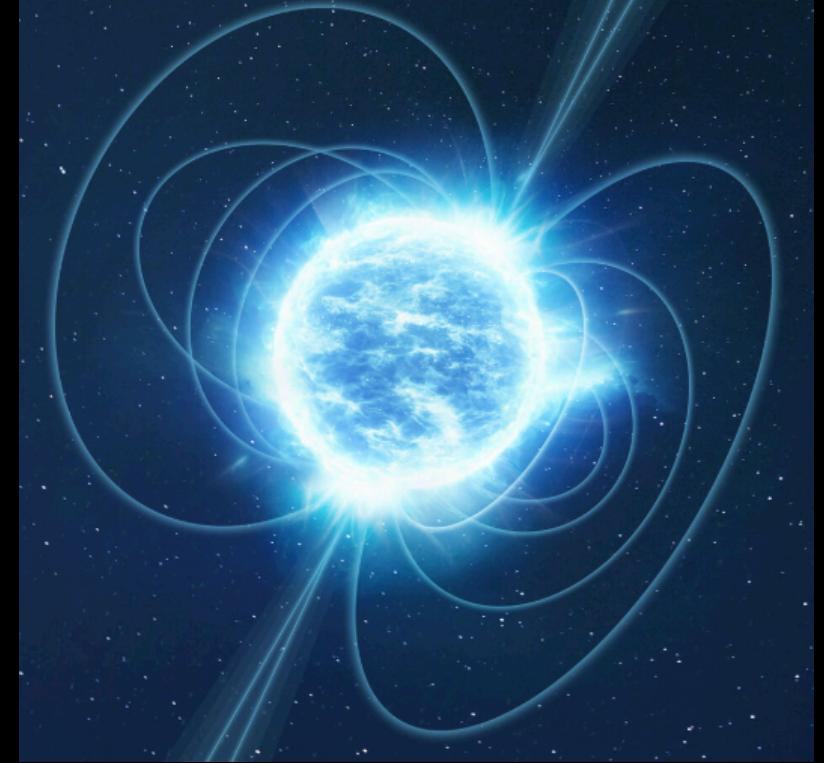
Jupiter



White Dwarfs



Neutron Stars



4 GeV

Nucleon + electron  
Scattering

1 GeV

Nucleon Scattering

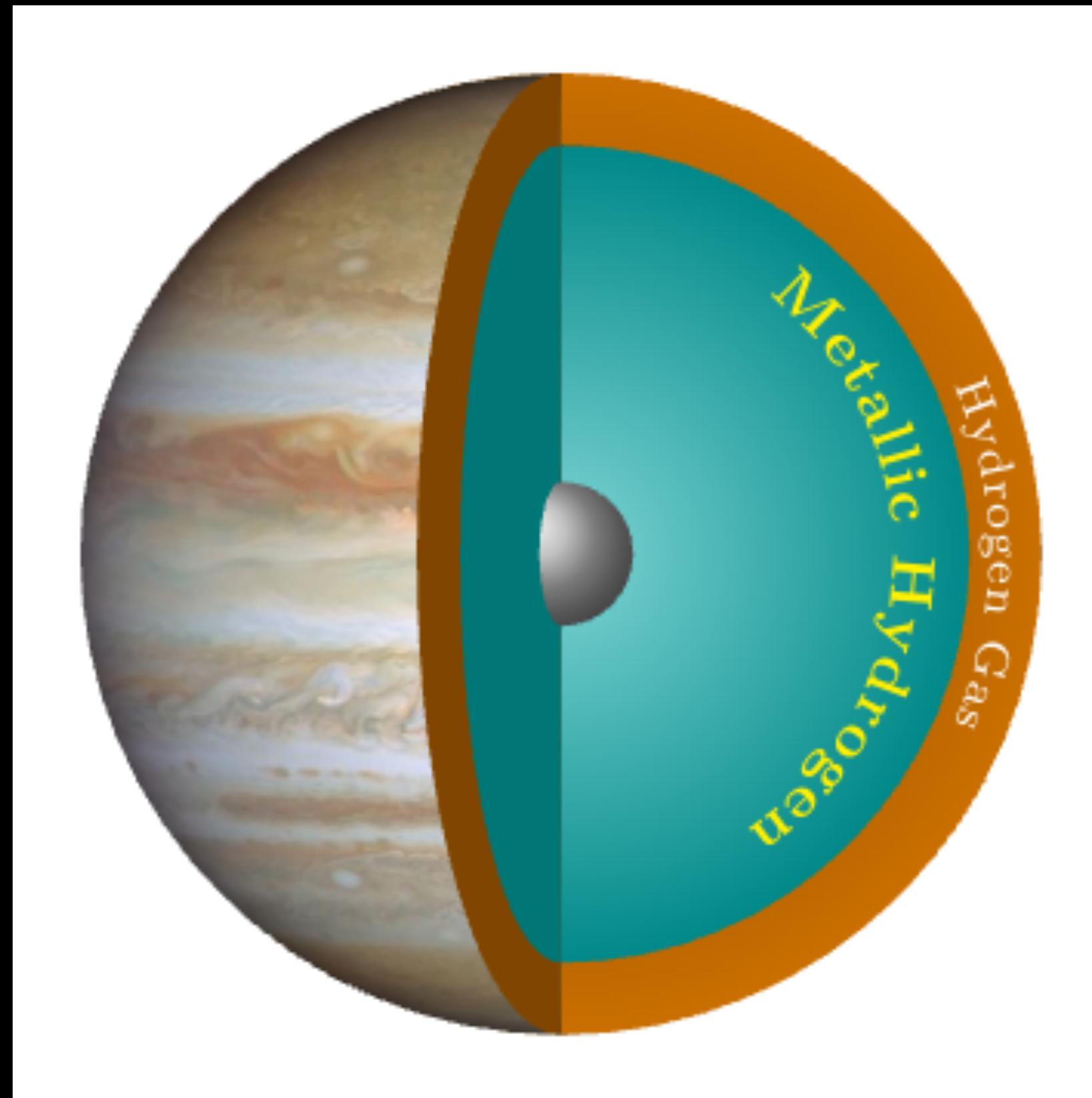
MeV

Assuming targets follow the Boltzmann distribution!

keV

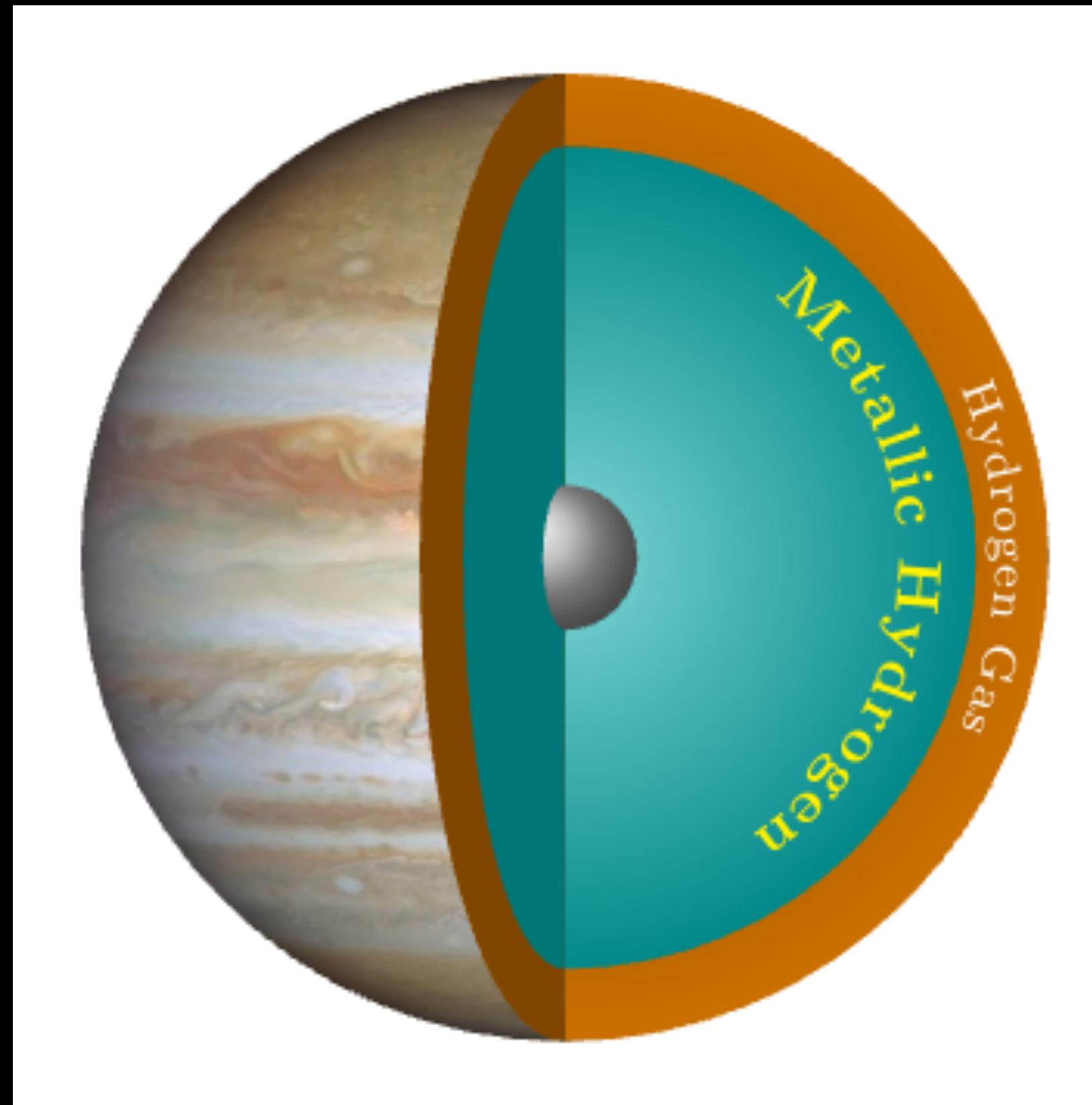
# How about DM-electron scattering in Jupiter? (The curious case of Leptophilic DM)

# 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/w/index.php?title=Metallic_hydrogen&oldid=96311000) ::

## Metallic hydrogen

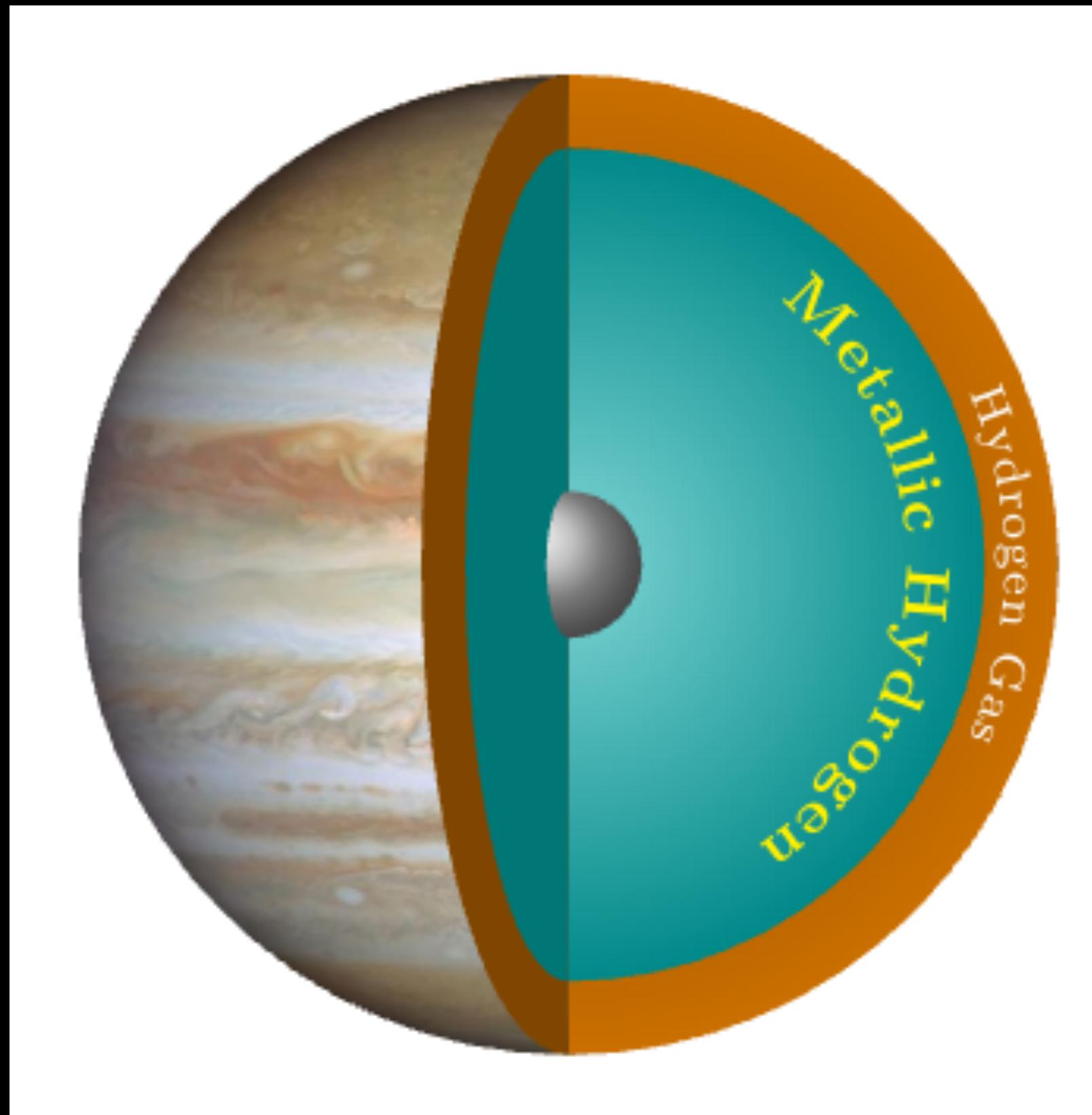
Metallic hydrogen is a phase of hydrogen in which it **behaves like an electrical conductor**. This phase was predicted in 1935 on theoretical grounds.

[Solid hydrogen](#) [Supersolid](#) [Diamond anvil cell](#)



# Jupiter has a lot of Metallic Hydrogen

Wikipedia also said so!



Wikipedia  
[https://en.wikipedia.org/w/index.php?title=Metallic\\_hydrogen&oldid=963011110](https://en.wikipedia.org/w/index.php?title=Metallic_hydrogen&oldid=963011110) ·

## Metallic hydrogen

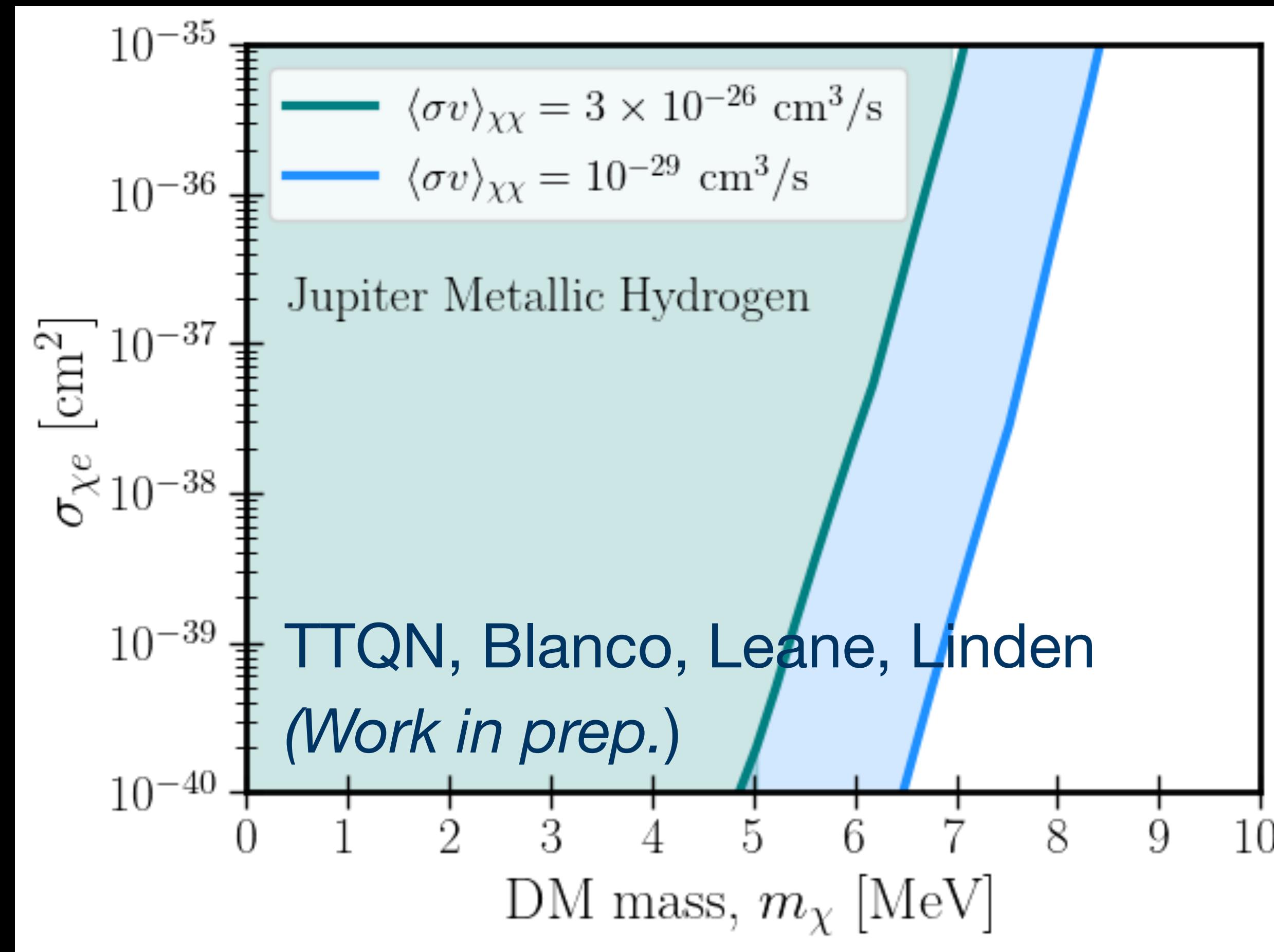
Metallic hydrogen is a phase of hydrogen in which it **behaves like an electrical conductor**. This phase was predicted in 1935 on theoretical grounds.

Solid hydrogen · Supersolid · Diamond anvil cell

- Jupiter'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

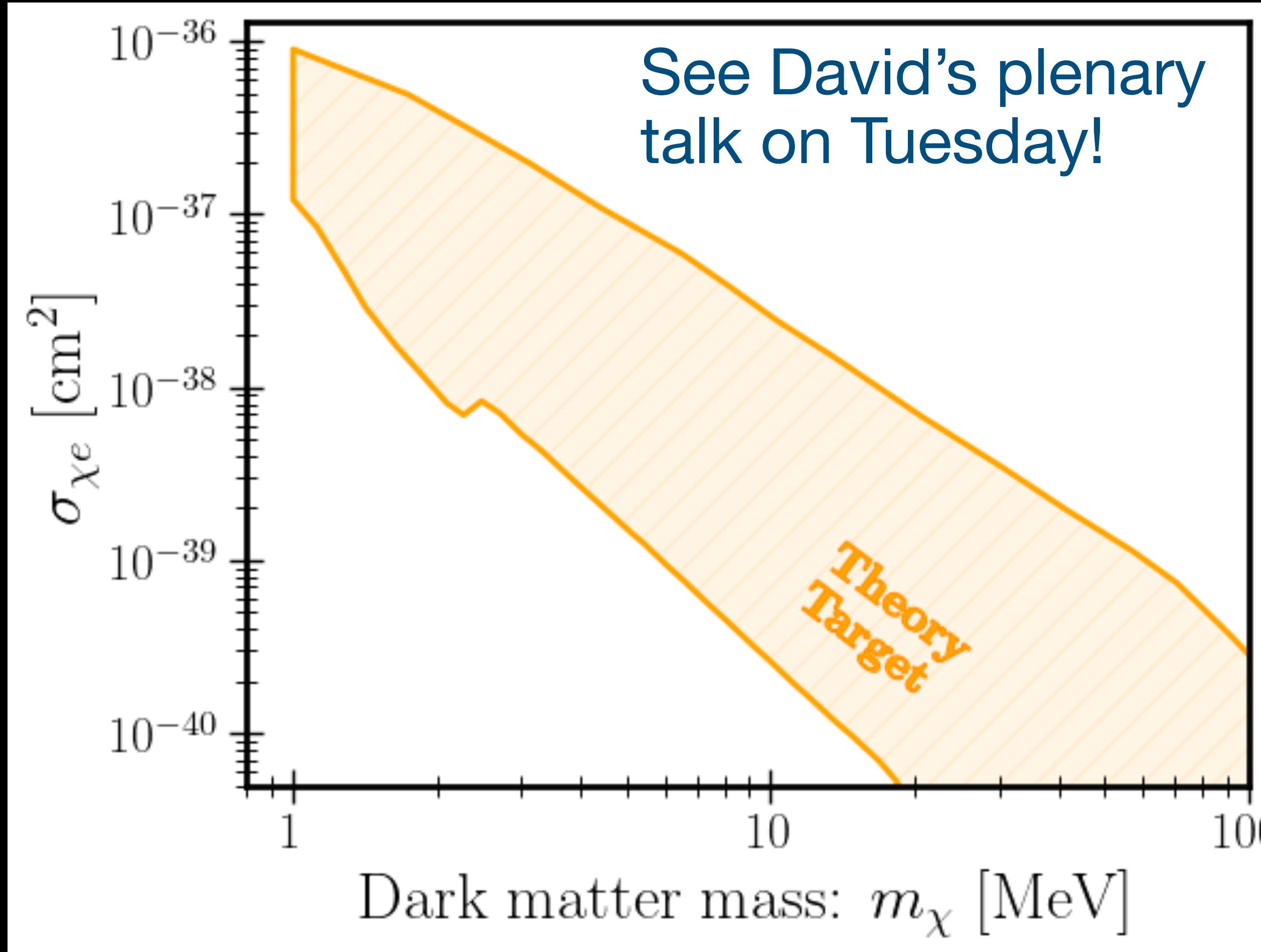
We find the minimum DM mass that can survive in Jupiter:  
around 5 - 8 MeV

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

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

Coordinators:

Rouven Essig<sup>1</sup>, Graham K. Giovanetti<sup>2</sup>, Noah Kurinsky<sup>3</sup>, Dan McKinsey<sup>4,5</sup>,

Contributors:

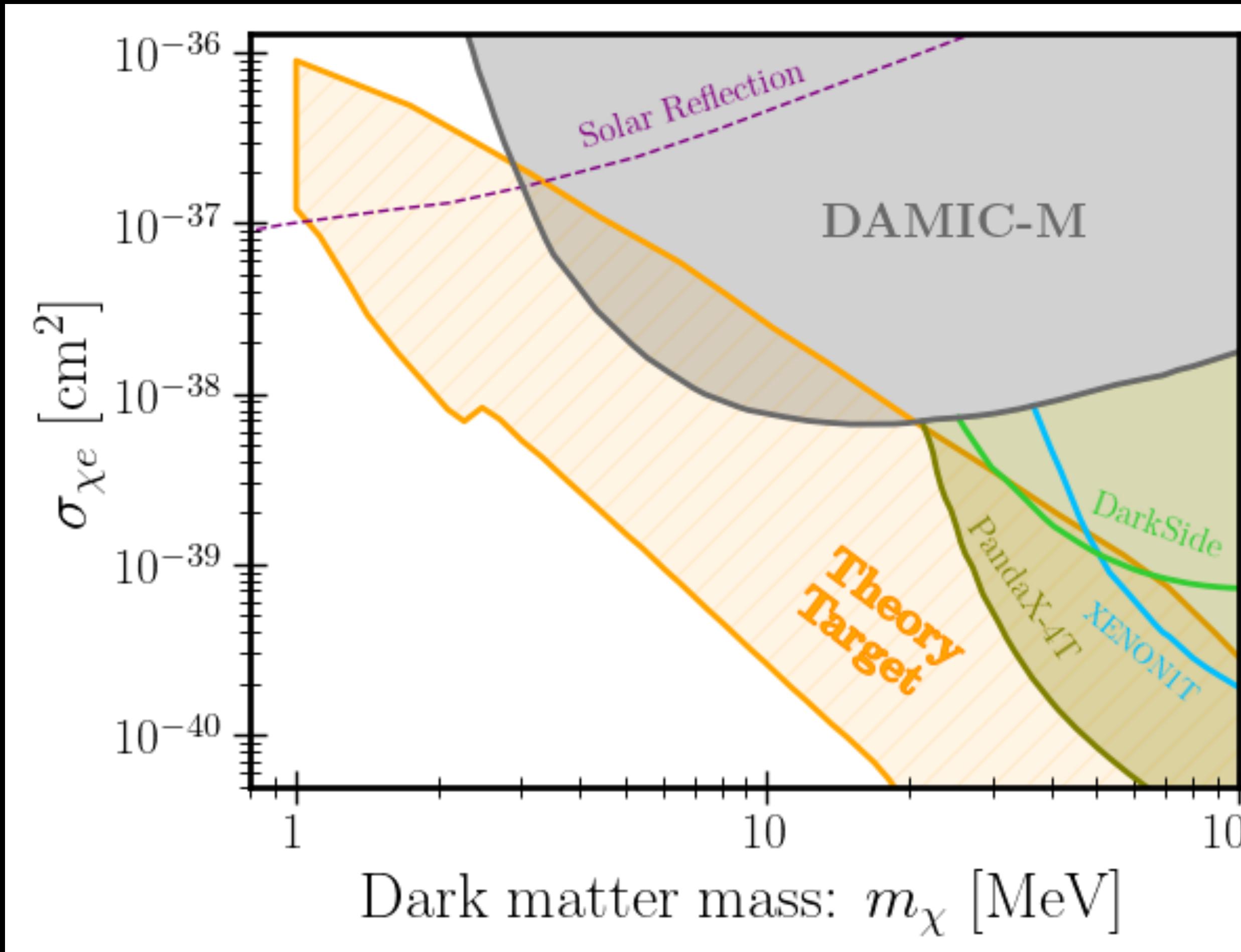
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I. T. Lawson<sup>52</sup>, B. V. Lehmann<sup>53</sup>, T. Lin<sup>54</sup>, J. Liao<sup>95</sup>, S. A. Lyon<sup>55</sup>, P. M. Majewski<sup>56</sup>,  
C. A. Manzari<sup>57</sup>, J. Monroe<sup>58</sup>, M. E. Monzani<sup>59, 60, 61</sup>, D. E. Morrissey<sup>62</sup>, D. Norcini<sup>63</sup>,  
A. Orly<sup>64</sup>, A. Parikh<sup>65</sup>, J.-C. Park<sup>66</sup>, P. K. Patel<sup>67</sup>, S. Paul<sup>95</sup>, J. Pérez-Ríos<sup>68</sup>, A. Phipps<sup>69</sup>,  
A. Pocar<sup>70</sup>, A. Ritz<sup>71</sup>, Y. Sarkis<sup>72</sup>, P. Schuster<sup>73</sup>, T. Schwetz<sup>74</sup>, S. Shaw<sup>75</sup>, S. Shin<sup>76</sup>,  
A. Singal<sup>77</sup>, R. Singh<sup>78</sup>, O. Slone<sup>79</sup>, P. Sorensen<sup>80</sup>, C. Sun<sup>81</sup>, M. Szydagis<sup>82</sup>, D. J. Temples<sup>83</sup>,  
G. Testera<sup>84</sup>, K. Thieme<sup>85</sup>, N. Toro<sup>86</sup>, T. Trickle<sup>87</sup>, S. Uemura<sup>88</sup>, V. Velan<sup>89</sup>, E. Vitagliano<sup>90</sup>,  
F. Wagner<sup>91</sup>, G. Wang<sup>92</sup>, S. Westerdale<sup>93</sup>, and K. M. Zurek<sup>94</sup>

# DM-electron cross section

Very competitive target in the DM community!



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

K. Aggarwal<sup>1</sup>, I. Arquist<sup>2</sup>, N. Avalos<sup>3</sup>, X. Bertou<sup>4,5</sup>, N. Castelló-Mor<sup>6</sup>, A. E. Chavarria<sup>1</sup>, J. Cuevas-Zepeda<sup>7</sup>, A. Dastgheibi-Fard<sup>8</sup>, C. De Dominicis<sup>5</sup> et al. (DAMIC-M Collaboration)

Show more ▾

See Sravan Munagavalasa's talk!

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

## 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](https://arxiv.org/abs/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,<sup>1,\*</sup> Pablo Figueroa,<sup>2,†</sup> Gonzalo Herrera,<sup>3,‡</sup> and Ian M. Shoemaker<sup>3,§</sup>

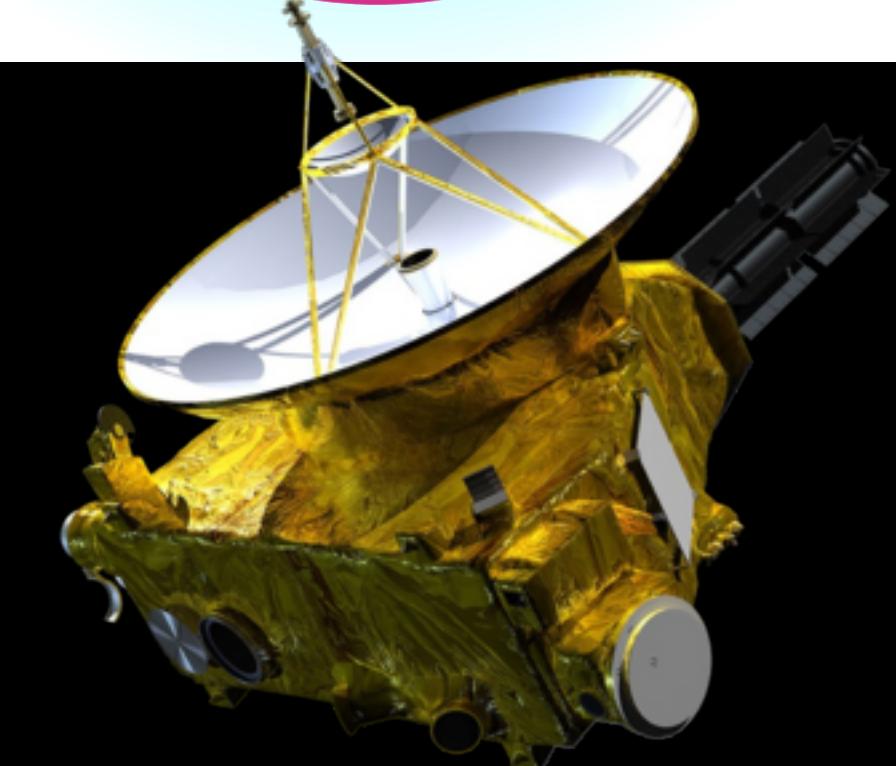
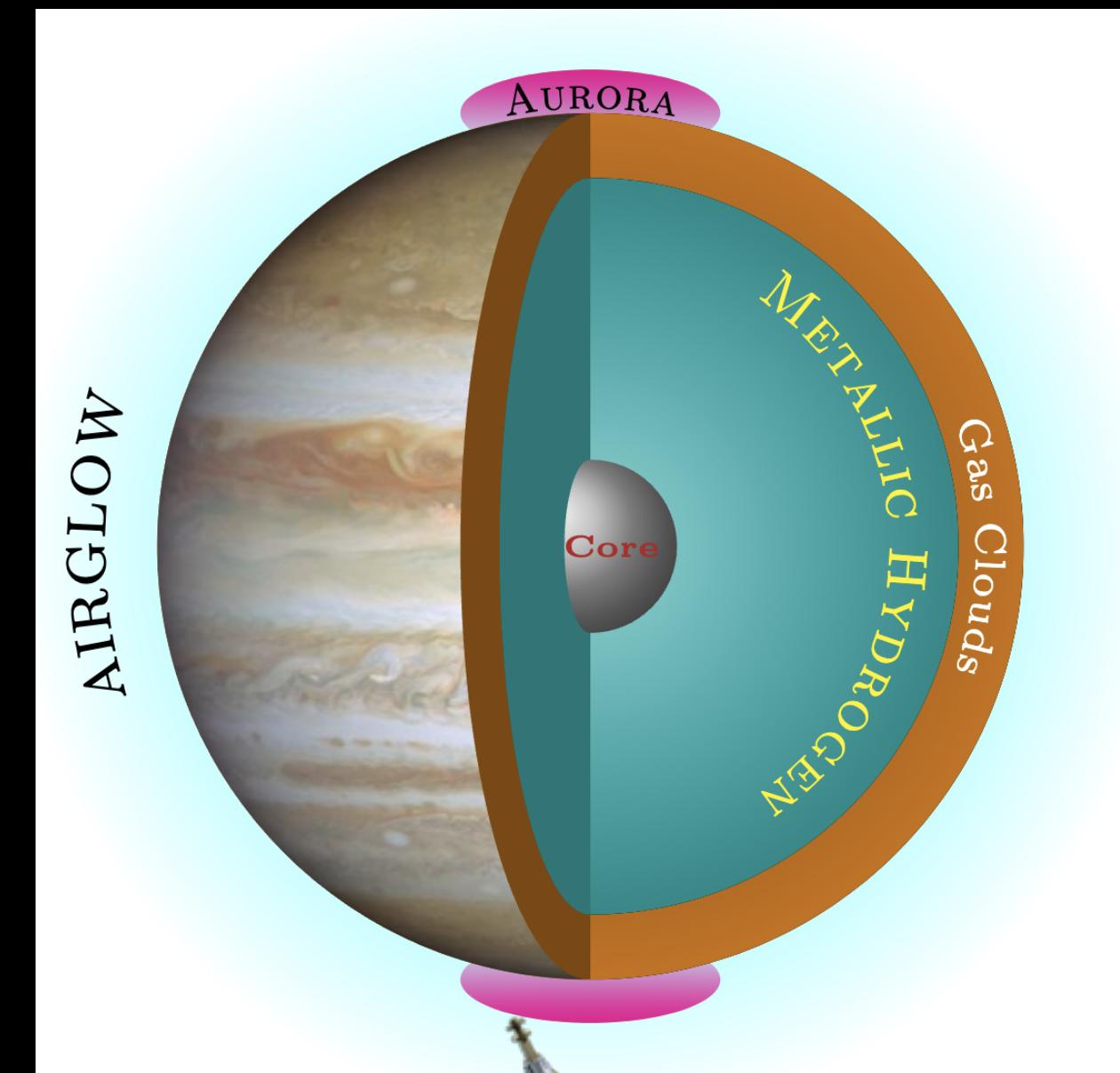
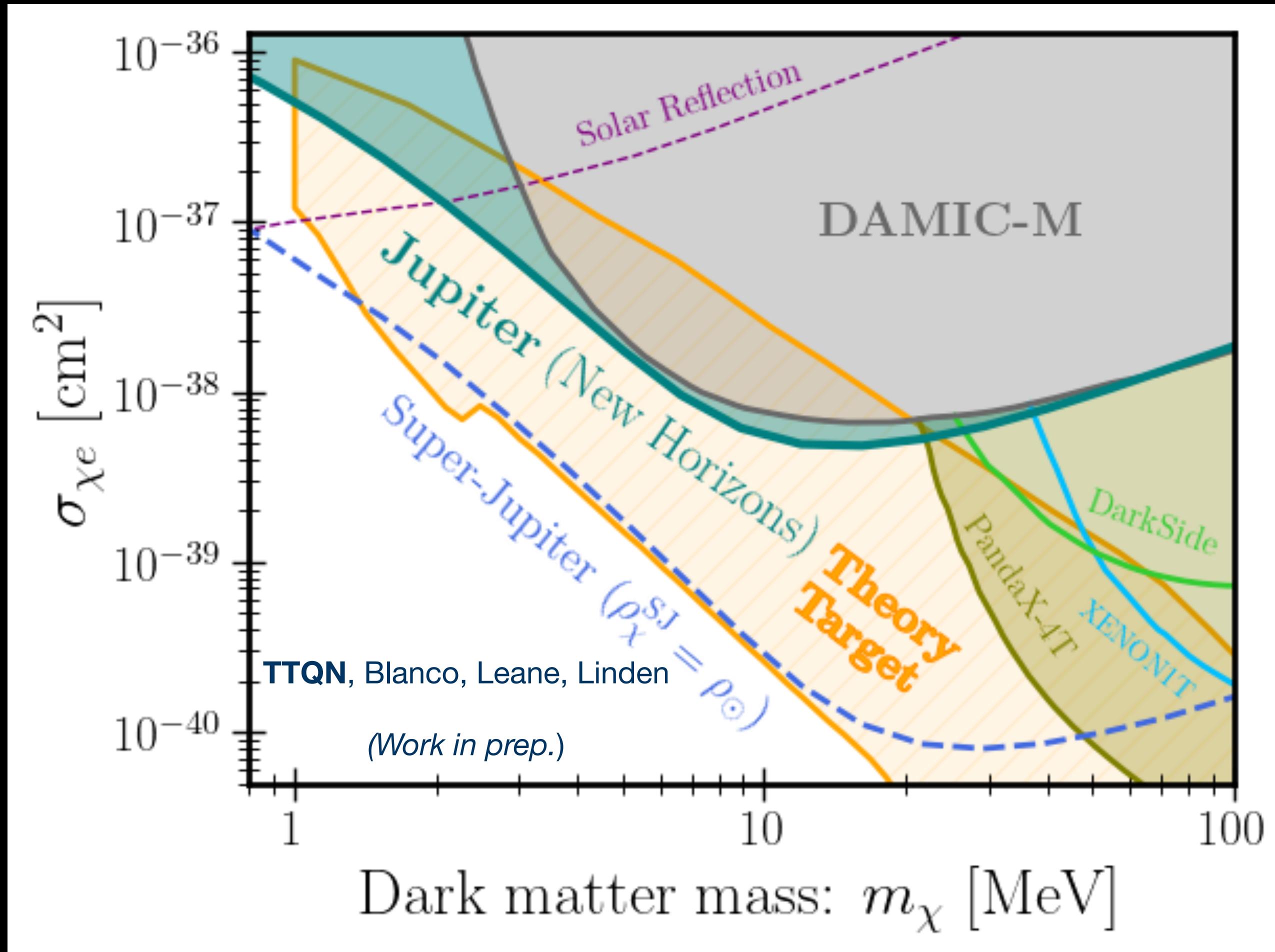
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<sup>3</sup> Center for Neutrino Physics, Department of Physics,  
Virginia Tech, Blacksburg, Virginia 24061, USA

# 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!

