Constraints on the mass of the thermal relic warm dark matter particle

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Key points

We develop an improved method to constrain properties of WDM models using the total satellite galaxy population of MW

Use thermal relic WDM models as test case

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Motivation

Theoretical

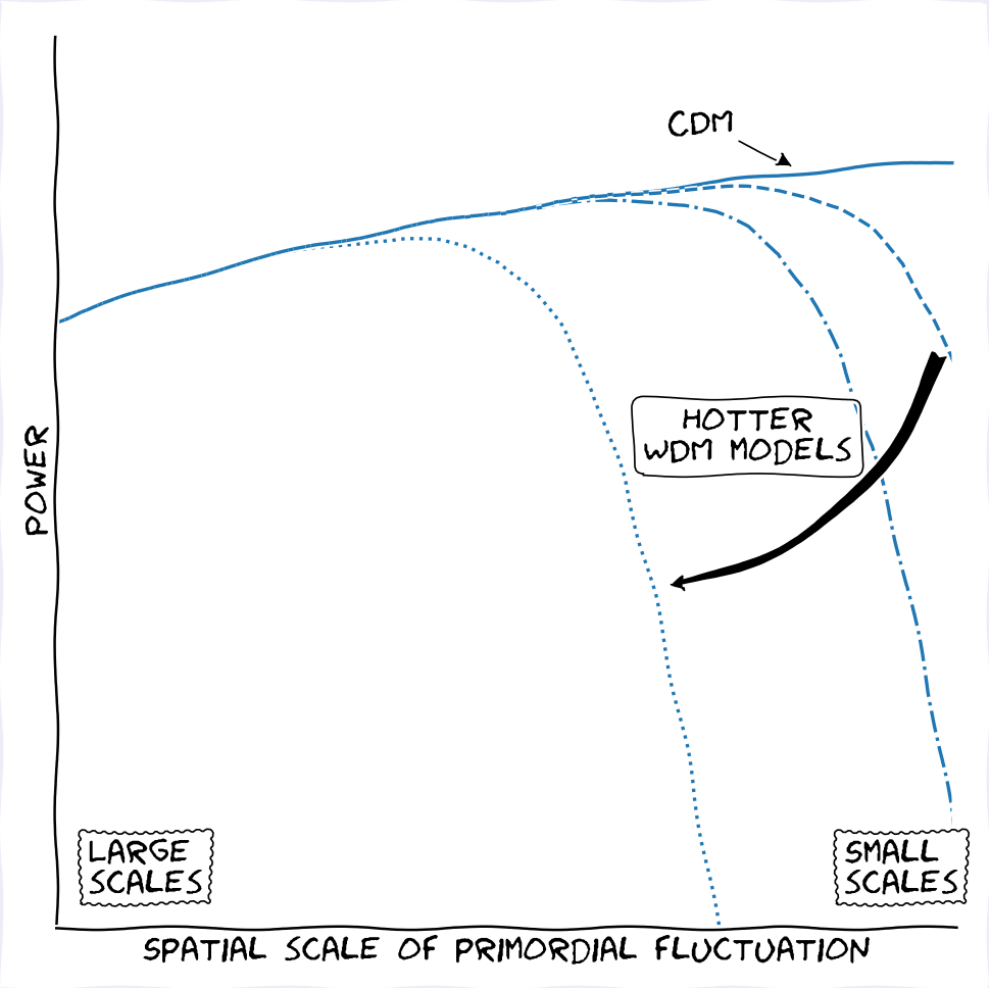
– Small-scale challenges to ΛCDM

Observational

– No ‘CDM’ particle detected yet

– 3.5 keV line

Why Warm Dark Matter?



- WDM particles less massive than CDM counterpart
- WDM models suppress formation of small-scale structure
  - Depends on properties of the WDM
  - Thermal relic WDM very simple model
  - Could manifest as deficit of small galaxies

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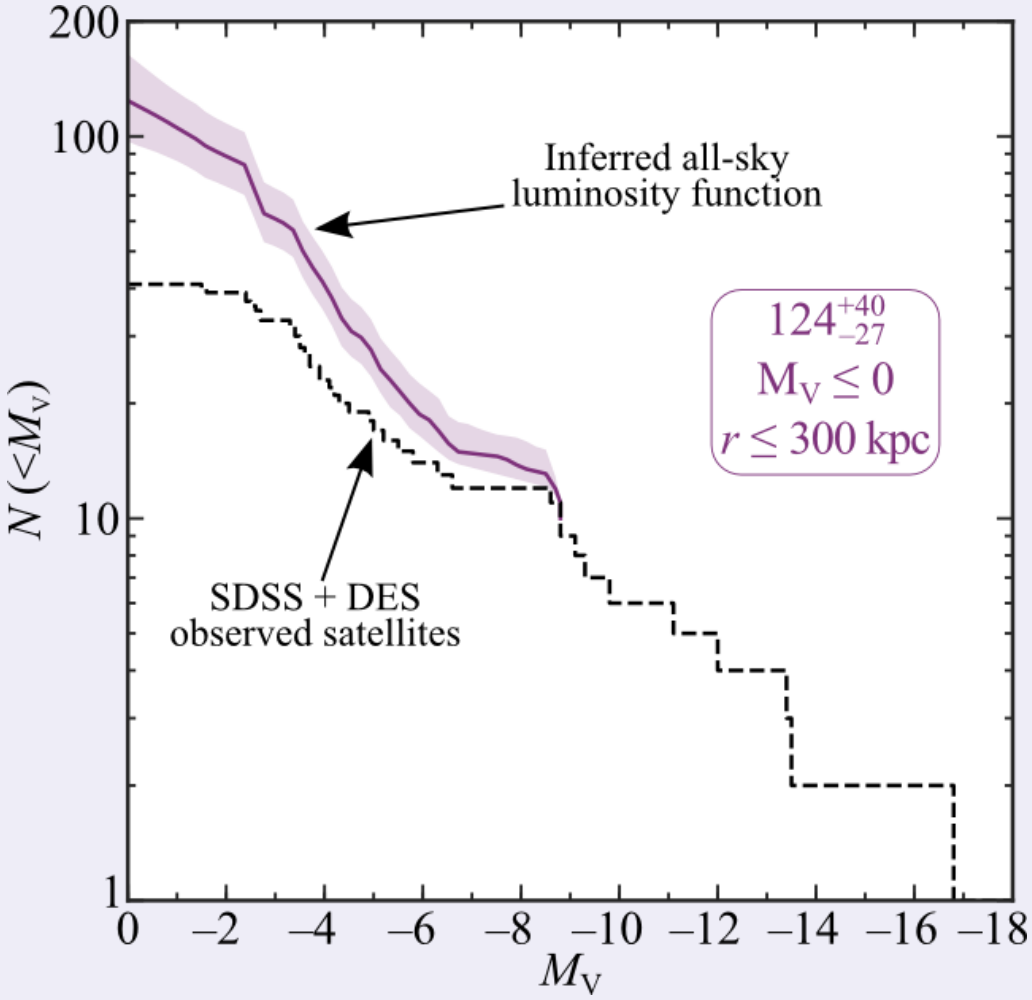
Viability of WDM models

Need two ingredients:

1. Estimate of the MW satellite galaxy luminosity function
2. Predictions of the number of substructures in a given WDM model

How many MW satellites?



Newton+(2018)
MNRAS, **479**, 2853

Estimates of WDM substructure

- Extended Press-Schechter formalism
- Calibrated with COCO haloes corrected for 'missing subhaloes'
  - Structure finders stop tracking them
- MW M_{200} in range $[0.5, 2.0] \times 10^{12}\mathrm{M}_{\odot}$

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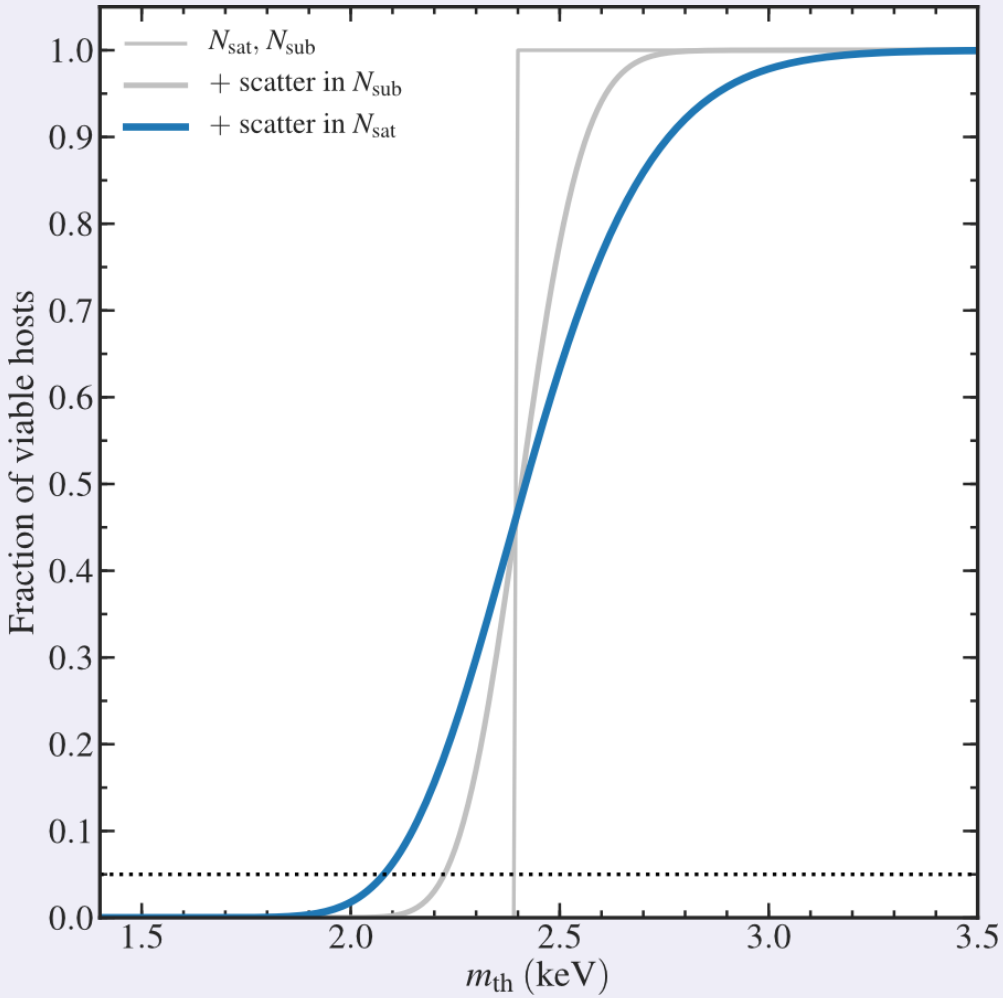
Setting the constraints



- Compare subhalo populations with no. of satellite galaxies
  - Independent of choice of galaxy formation physics
- Rule out WDM models with $f < 0.05$
- Must account for scatter in number of MW satellites

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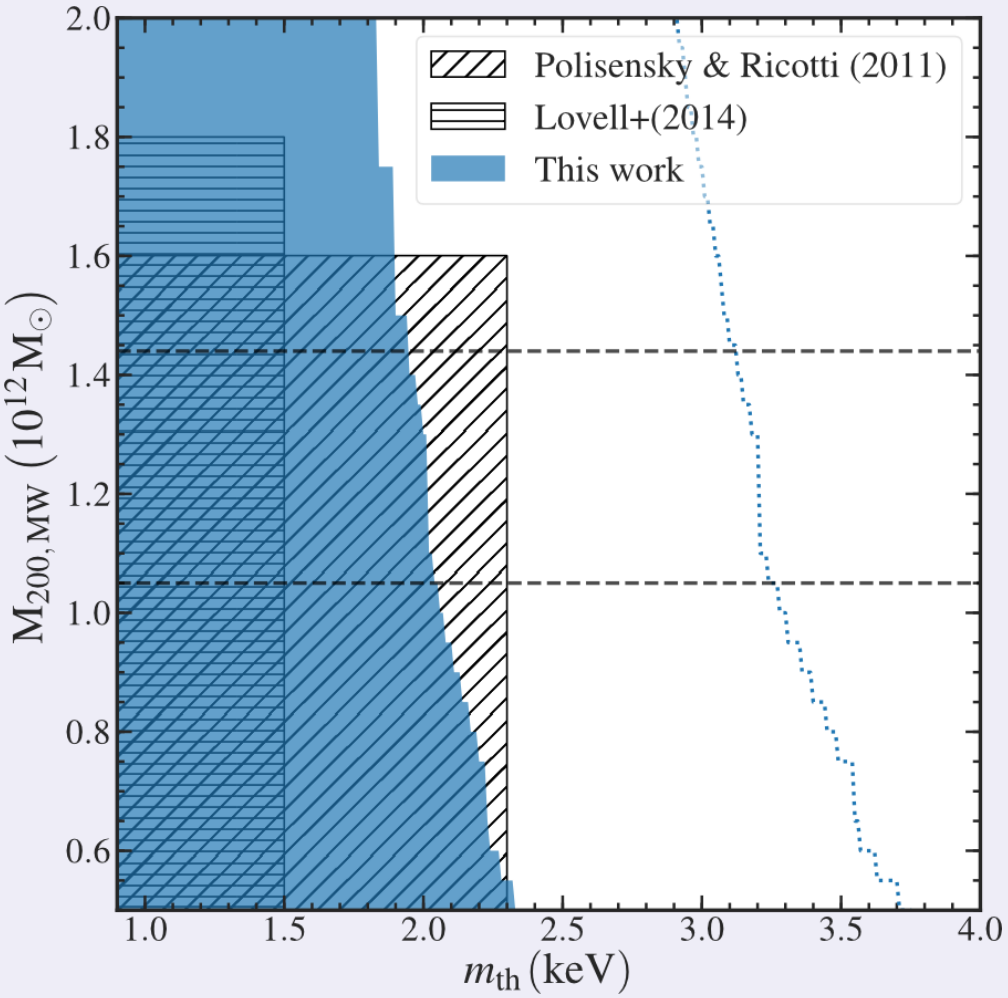
Thermal relic constraints



- Shaded/hashed: models ruled out with 95% confidence
- Dotted line: no correction for resolution effects

Dashed lines: Callingham+(2019)

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Summary

- Developed an improved method to constrain properties of WDM models using the satellite galaxy population of the MW
- Tested this using thermal relic WDM
- Constraints from previous analyses were too restrictive
- We are extending this to other WDM models
- Could use galaxy formation models to improve constraints

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