

2019年华中师大－中国科大宇宙学青年学术研讨会

Alleviating the Small-scale Crisis **without**
introducing New Physics

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Recently, a new centre for astronomy research has been built at YNU:

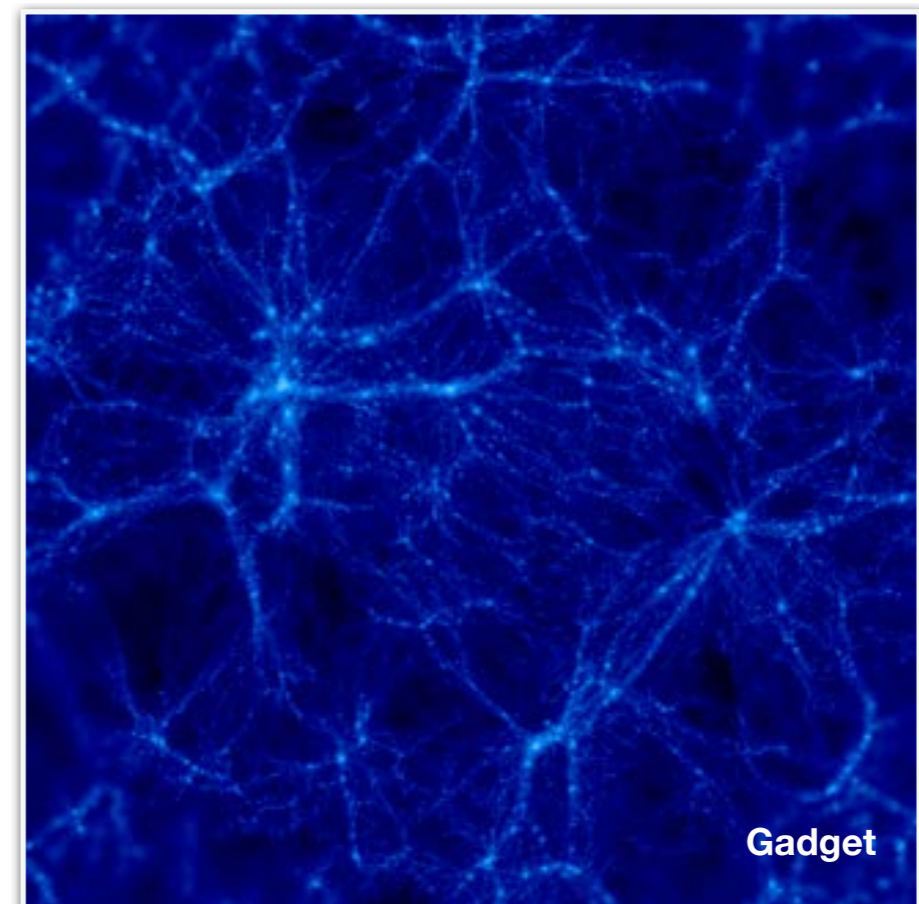
- **Astronomy Department**
- **South-Western Institute For Astronomy Research**

I am assigned to Astro from Phys.

So I have a chance to ask my new colleagues who study astronomy:

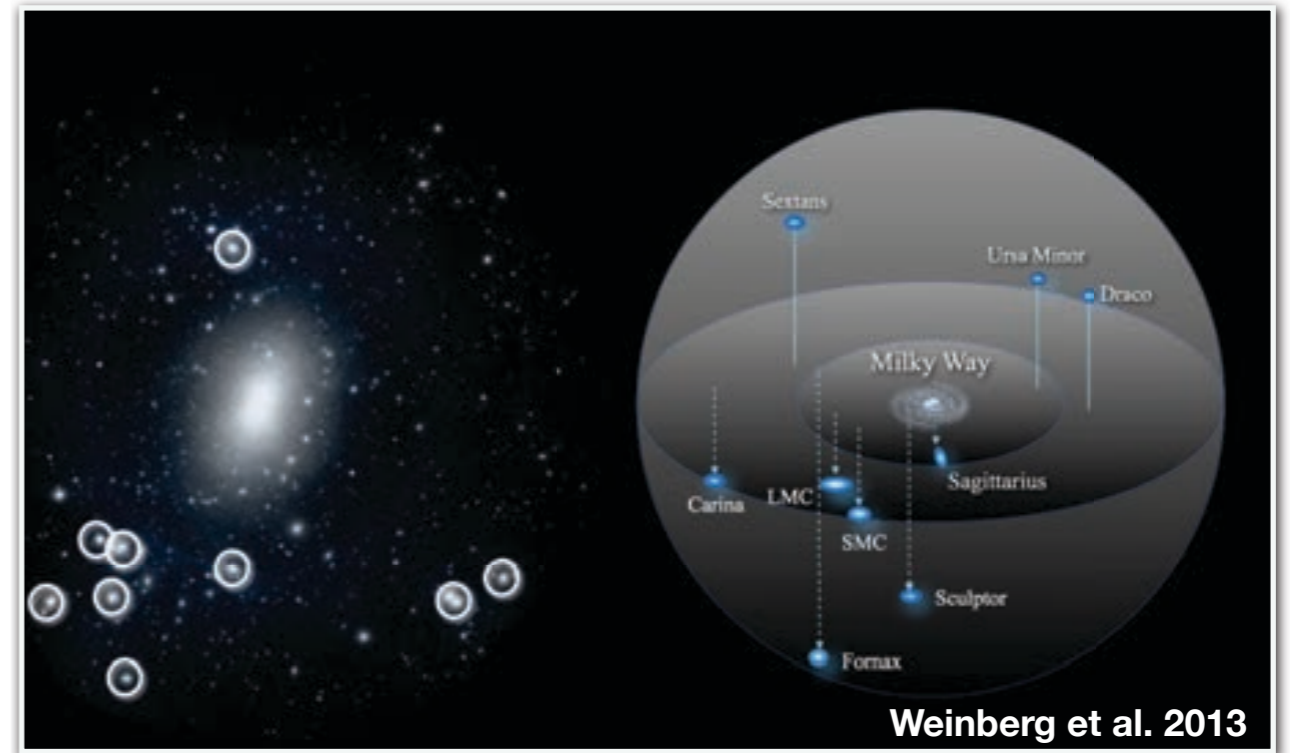
Is any severe **tension** between the cosmological predictions and the astronomical observations?

They told me: **the Small-scale Crisis.**



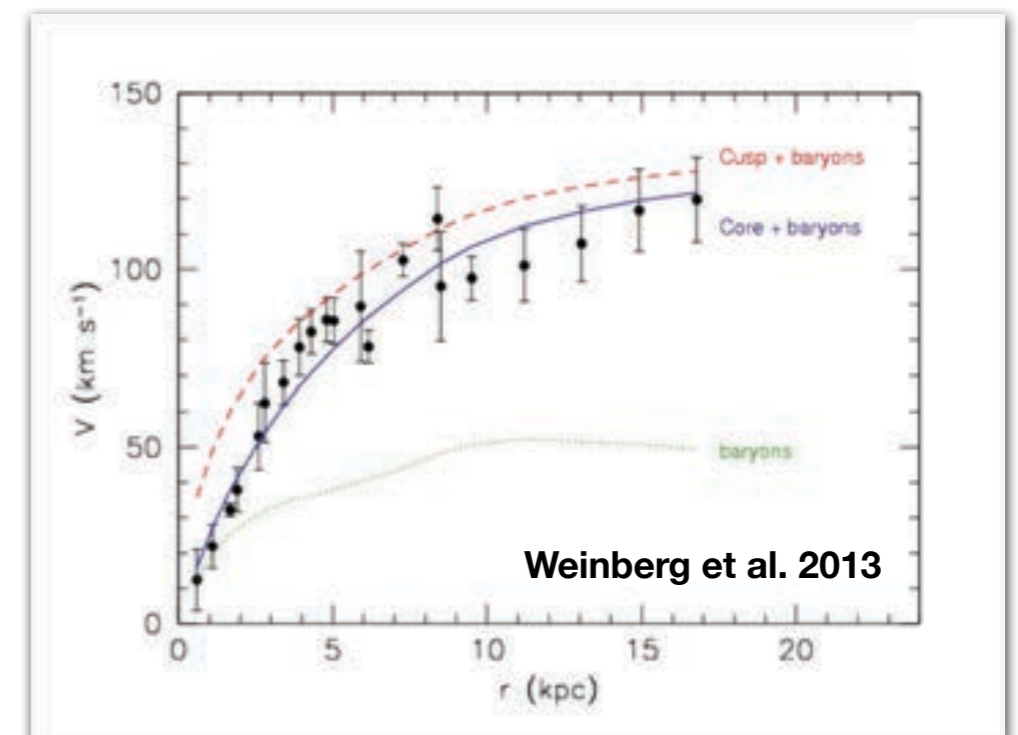
The Puzzles: the **discrepancies** between **observations** and **N-body numerical simulation** on **small scale**.

- **Missing Satellite Problem**
- **Cusp v.s. Core Problem**
- **Too-big-to Fail Problem**



CDM predict halos with abundant substructure and central densities that are **too high to match** constraints from **galaxy dynamics**.

A **suppression** of (dark) **matter perturbation** on **small scale**



*How to **realize** a suppression of matter perturbation on small-scale:*

- Exotic(Warm) DM Models
- Broken-scale-invariance Inflation

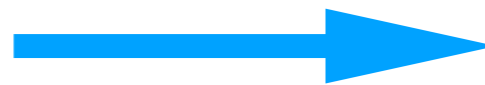
Crisis – Such discrepancies seems hard to be resolved by the two basic assumptions:

- Dark Matter is **Cold**
- Inflation is **Simple**

Can we solve this Crisis without introducing New Physics?

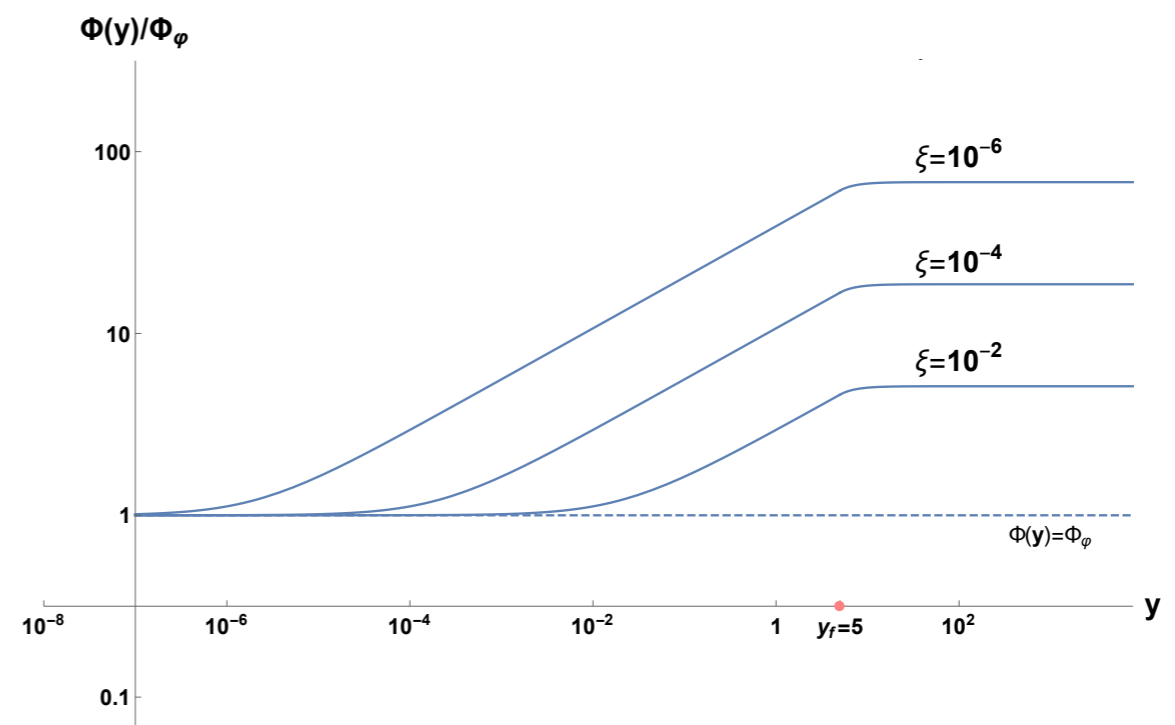
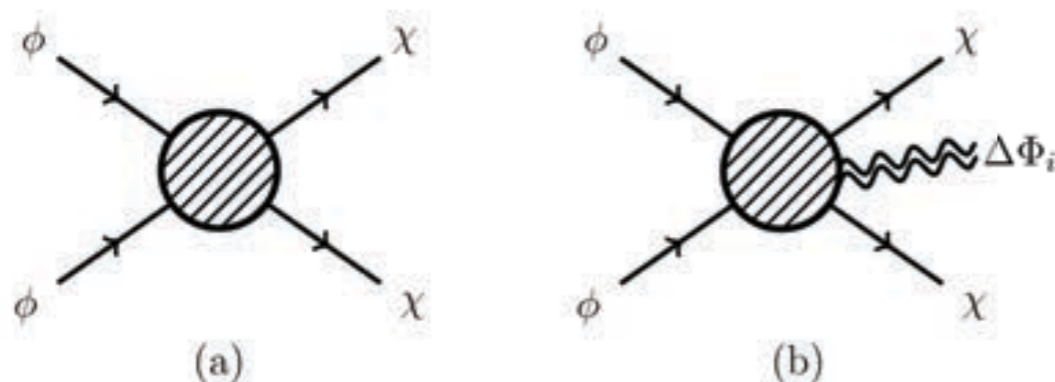
The amplitude of **matter perturbation** on **small scale** relying on the **normalization** of its spectra on **large scale**.

Larger on Large Scale



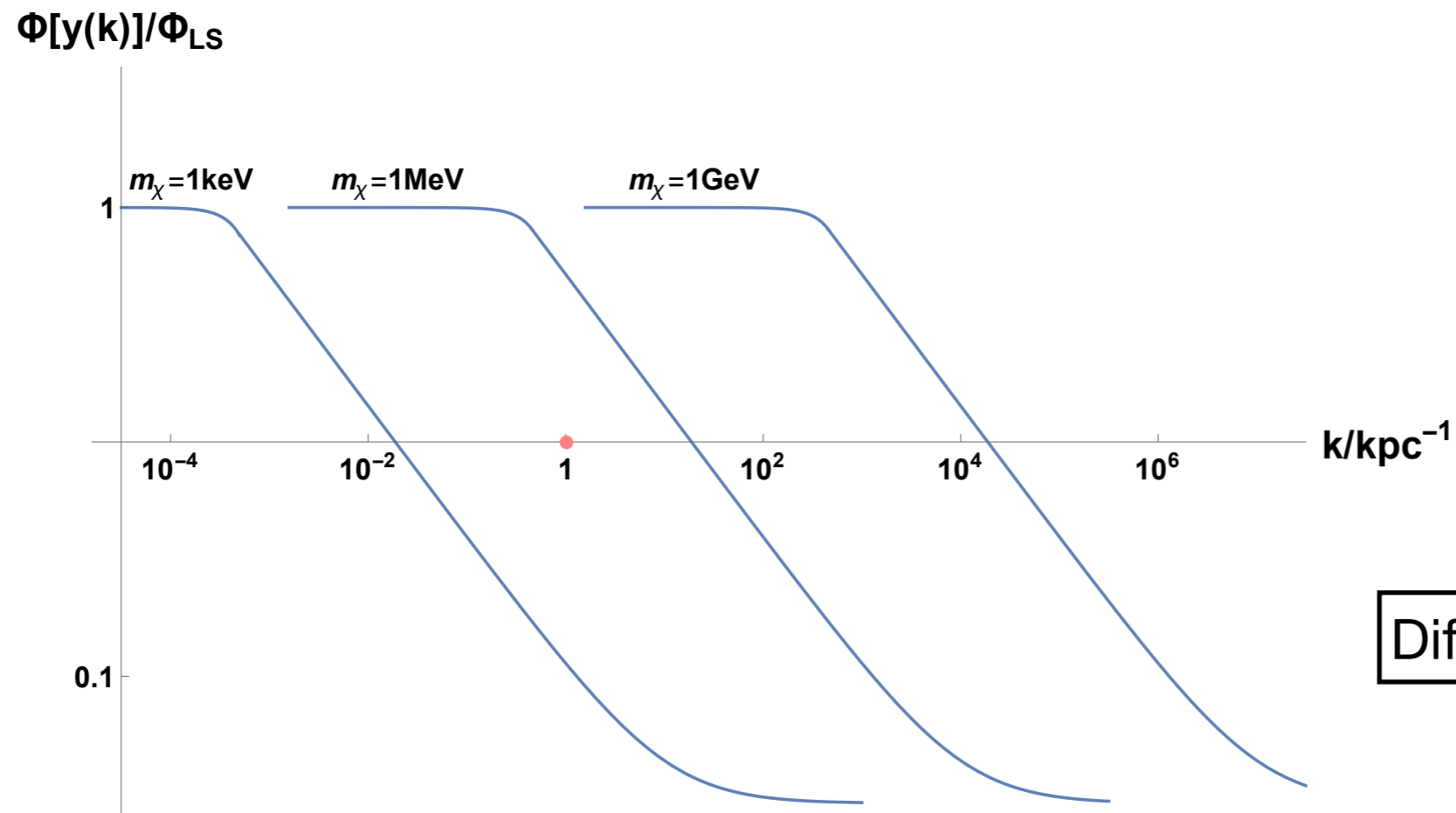
Smaller on Small Scale

*In the framework of **simple** inflation, **cold** DM production after inflation can amplify the amplitude of metric(matter) perturbations.*



Shorter wavelength modes (**small scale**) of metric (matter) perturbation re-entering horizon earlier with **less** amplification.

$k\eta(k) = 1$: Time ➔ Space



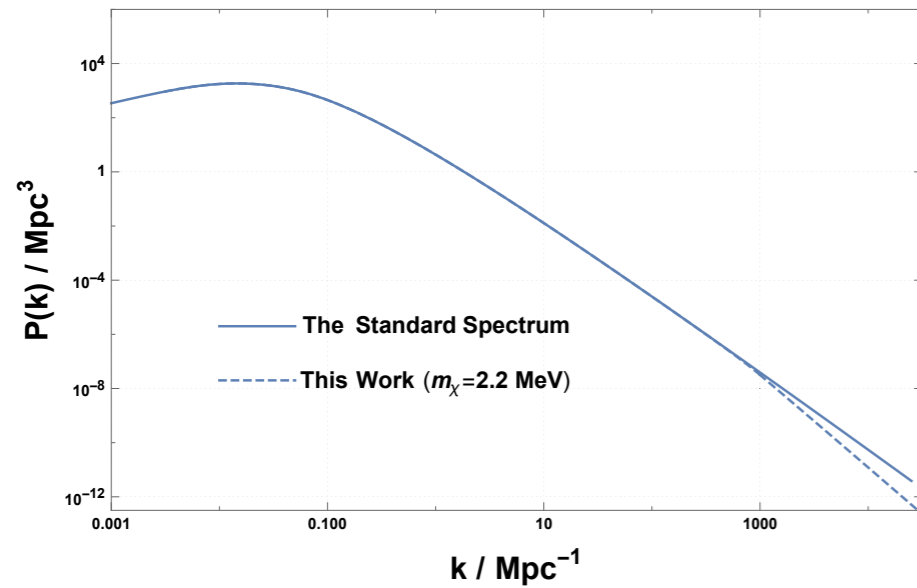
Different DM mass



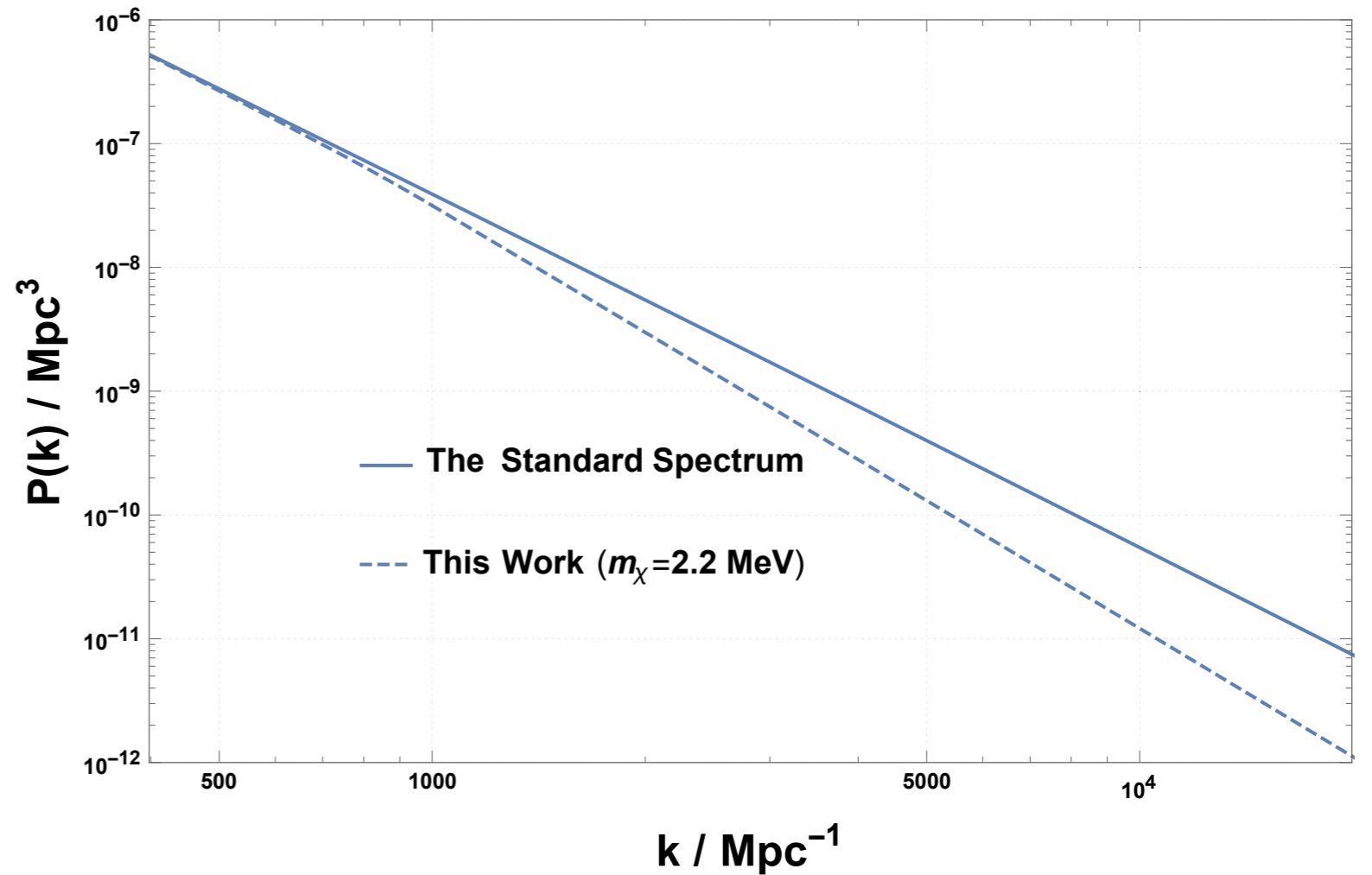
Different Suppression scale

Critical scale	➔	DM mass
$k_{\star}^{-1} = 1 \text{ kpc}$		$m_{\chi} = 2.2 \text{ MeV}$

Matter perturbation:



Global spectrum



High resolution on small scale

Summary:

- The small-scale crisis can be alleviated by considering the production of DM — Inflation is simple & DM is cold.
- DM candidate discussed in this talk is **cold**,

$$L_{free-streaming} = 0.05 \text{ kpc} \ll k_{\star}^{-1}$$

- **New** “Early-time suppression” mechanism: after inflation and before horizon re-entering.
- **Alleviating** rather than **resolving** the small-scale crisis

$$k_{SSC}^{-1} \simeq \mathcal{O}(100) \text{ kpc} \gg k_{\star}^{-1}$$

Thank you!