Update from group C02: Cosmic structure formation

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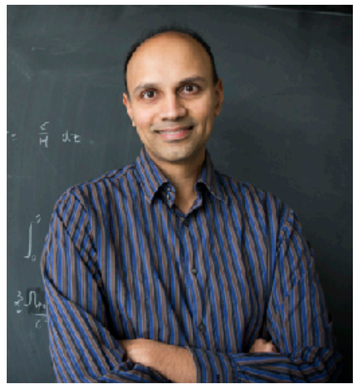
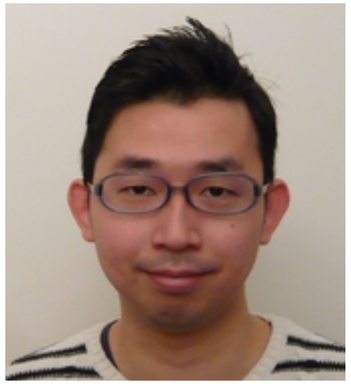
C02: Members

PI + co-I

Shin'ichiro Ando



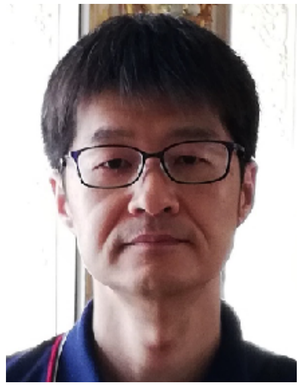
Neal Dalal



Takahiro Nishimichi

Takashi Okamoto

Masato Shirasaki



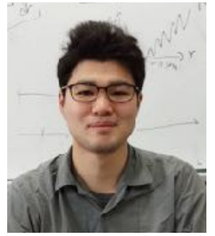
Atsushi Taruya

Project postdocs

Shunichi Horigome

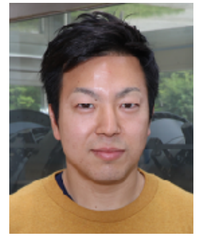
Satoshi Tanka

Collaborators



Y. Enomoto

N. Hiroshima



K. Hayashi

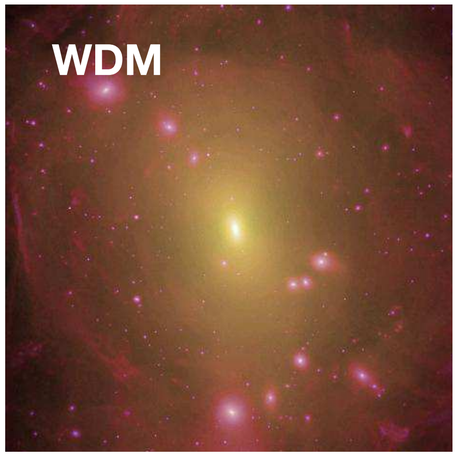
T. Ishiyama

M. Ono

Goals: Small scale structure

- Cusps in density profiles
- Very many small (sub)structures

WIMPs, axions, ALPs, PBHs

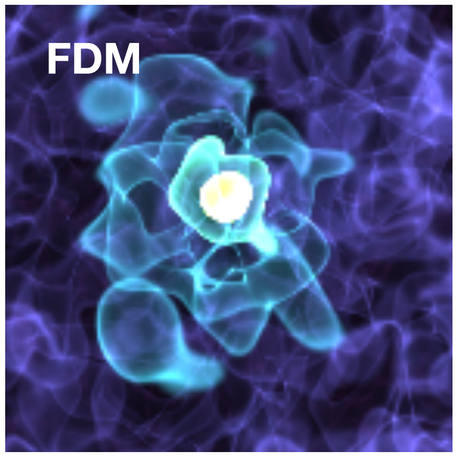


- Cutoff at sub-galaxy scale in the power spectrum

Sterile neutrinos

- Cores in density profiles induced by self scattering

SIMPs, dark atoms



- Pattern induced by de Broglie length at sub-galactic scales

Ultralight bosons

Output: Small scale structure

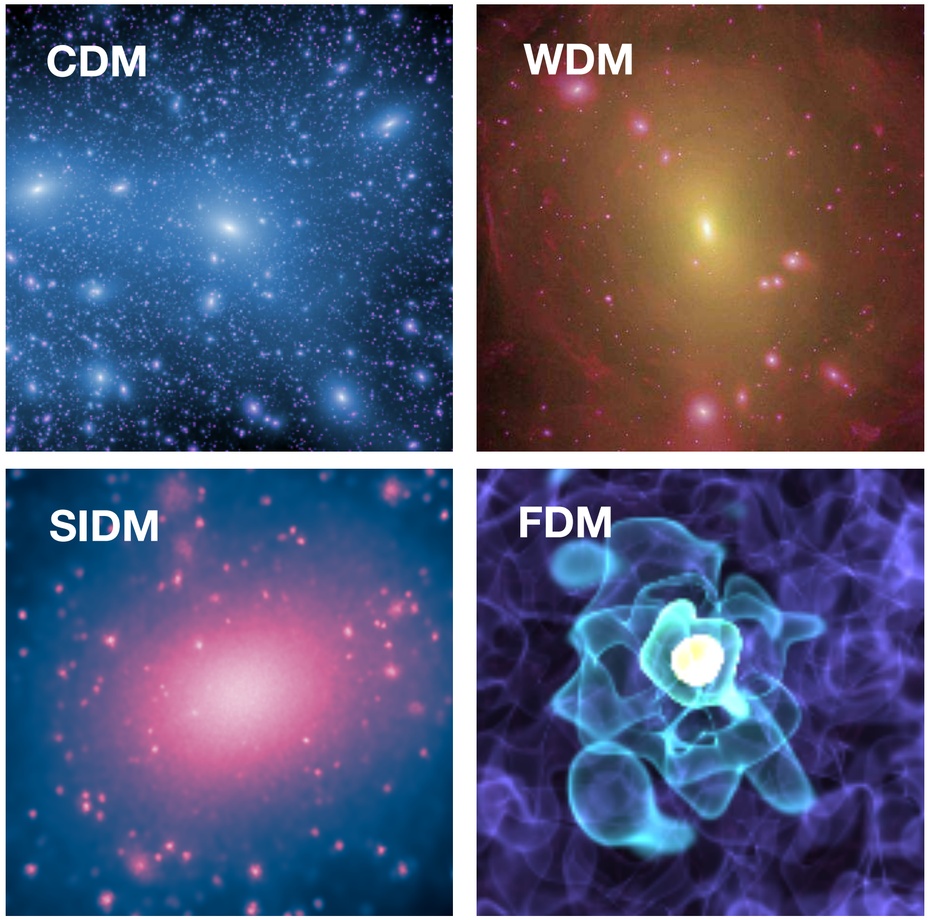
✓ Release of public codes (Ando et al.)

✓ Dwarf galaxies (Horigome et al.)

✓ Galaxies and dark matter structure classification (Inoue, Okamoto et al.)

✓ Phase-space structure (Enomoto, Nishimichi, Taruya)

- **Primordial power (Tanaka, Nishimichi, Hiroshima)**



✓ Numerical simulations of WDM halos and subhalos (Okamoto, Inoue et al.)

✓ Developing semi-analytical models (Ando et al.)

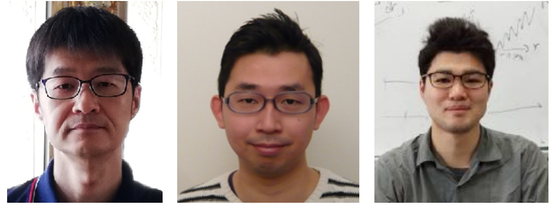
- **Phase-space structure (Enomoto, Nishimichi, Taruya)**
- **Calibration of semi-analytical models using numerical simulations (Ono, Okamoto, Ando)**
- **Novel approach using Vlasov equations (Tanaka, Taruya, Nishimichi)**

✓ Simulation of SIDM subhalos falling onto the SIDM halo (Shirasaki, Okamoto et al.)

- **Semi-analytical models of SIDM subhalos (Horigome, Ando)**
- **SIDM modeling against cosmological simulations (Shirasaki, Horigome , Ando)**

✓ Tight constraints using stellar motion in ultrafaint dwarf galaxies (Dalal)

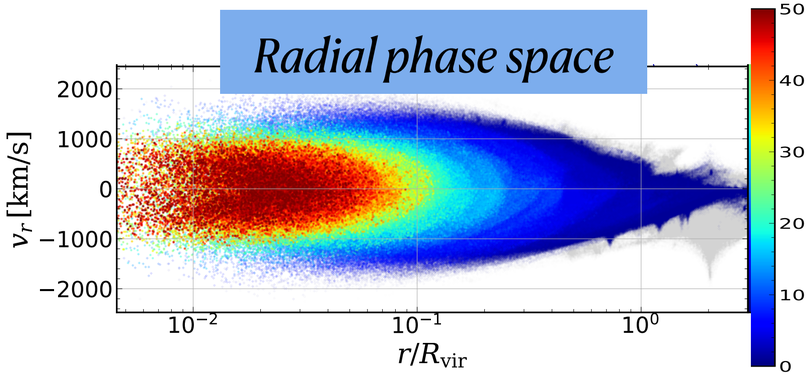
- **Estimates of density profiles of dwarf galaxies (Horigome, Ando)**



Multi-stream radial structure of CDM halos

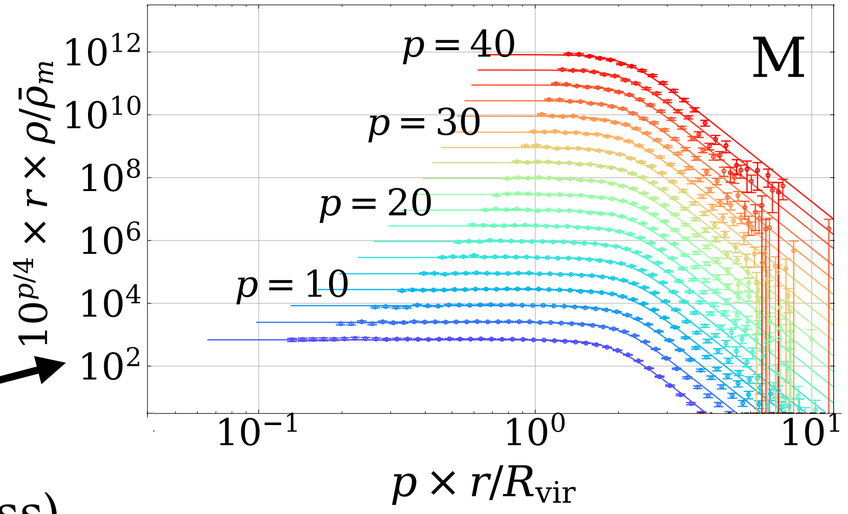
Enomoto, Nishimichi & Taruya, ApJ Lett. 950, L13 ('23), arXiv:2302.01531

MNRAS 527, 7523 ('24), arXiv:2309.13560



# of apocenter passages

P



Universal double power-law nature found here

also seems to persist in warm dark matter (in progress)

Searching for axion DM from PEM data of gravitational wave (GW) detectors

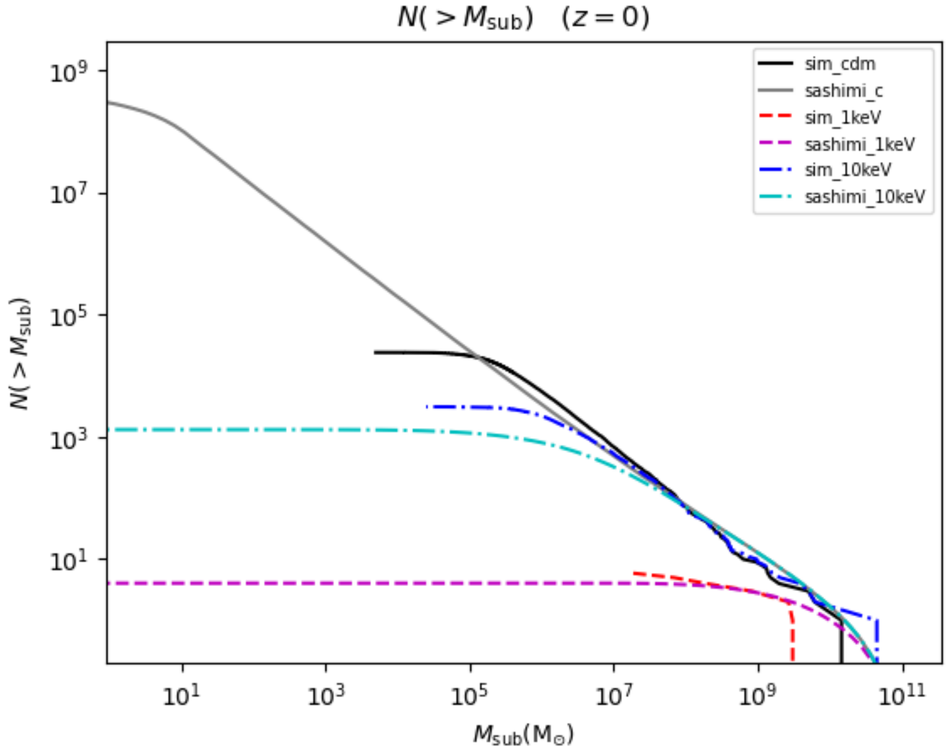
Physical Environment Measurement (Work in progress)

Axion DM of $m_{\rm DM} \sim 10^{-13}$ eV can produce low-freq. B-fields ($f \sim 10$ Hz) in the presence of geomagnetic field → PEM data of GW detectors helps to constrain axion-photon coupling (would be tighter than the CAST experiment)

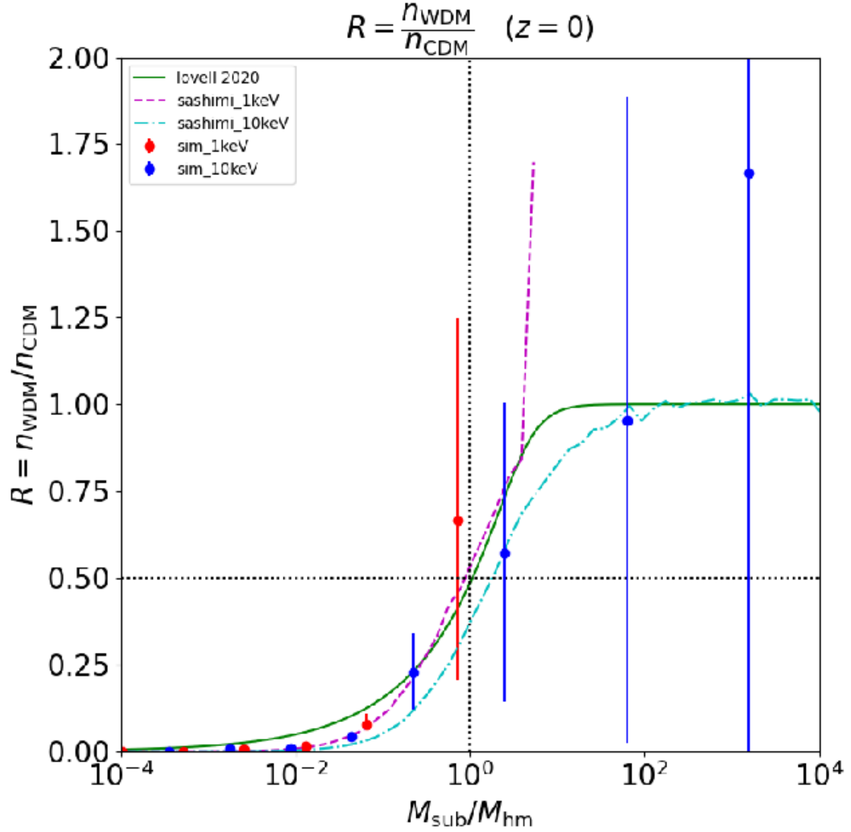
WDM simulations v.s. semi-analytic modelling

Mizuki Ono, Takashi Okamoto, Shin'ichiro Ando

Cumulative subhalo mass functions



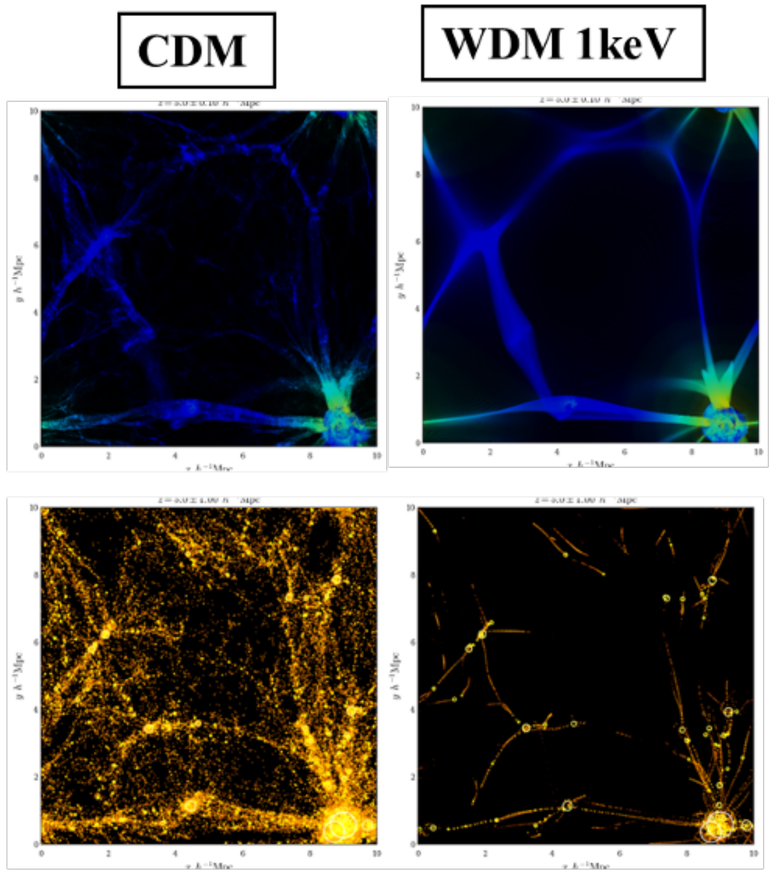
Ratio of differential mass functions of WDM to that of CDM



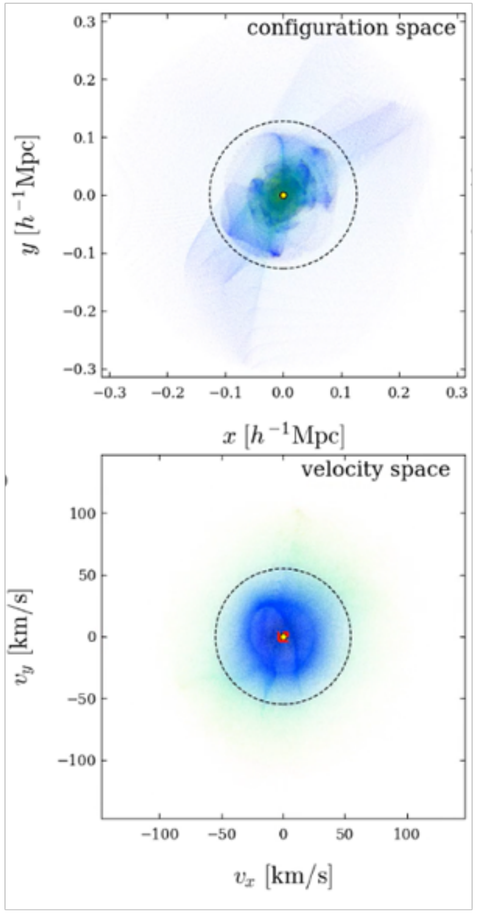
Vlasov-Poisson Simulation for Warm Dark Matter Halos

Confirmation with N-body simulation

Satoshi Tanaka, Atsushi Taruya,
Yohsuke Enomoto, Takahiro Nishimichi

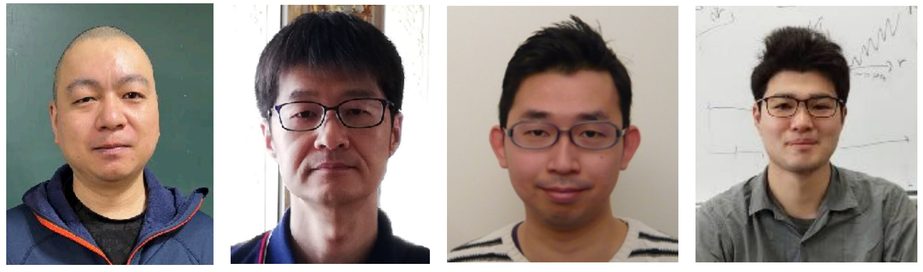


N-body simulation



Phase space of WDM halo

- Difficult to calculate N-body simulations to account for WDM velocity dispersion.
- We investigated conditions suitable for Vlasov simulations by the phase space from N-body simulations.
- Vlasov simulation may be able to handle the effects of WDM velocity dispersion until the halo prompt cusp is formed.

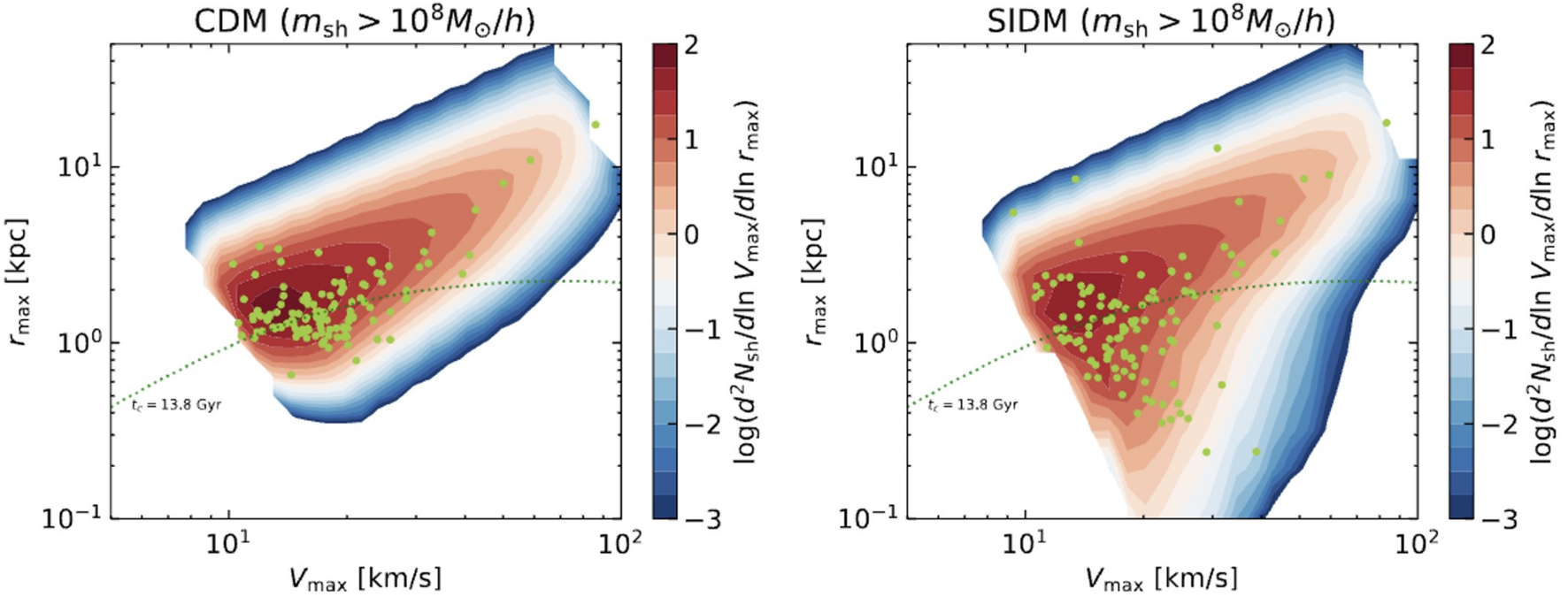


SIDM halo structure and evolution: Semi-analytical and effective models

S. Ando, S. Horigome, E. O. Nadler, D. Yang, H.-B. Yu [in prep.]

SASHIMI-SIDM: Semi-analytical approach to simulate SIDM models

- Quick calculation of SIDM halo properties and subhalo mass functions



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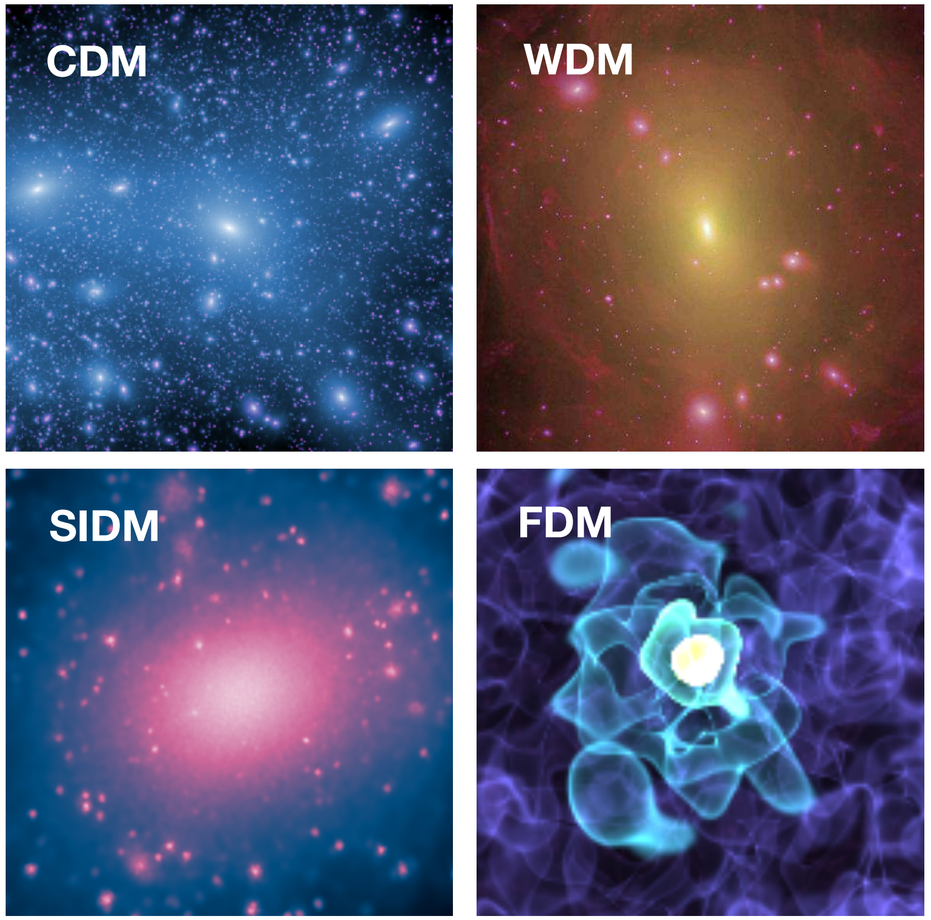

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