IllustrisTNGから解析する太陽系近傍の暗黒物質

Evaluation of Local Dark Matter Based on the IllustrisTNG Simulation

Hatsume Chujo (Speaker),[1] Shogo Masaki,[2] Keiko I. Nagao,[1] Takuho Nakabayashi[3]

[1] Okayama University of Science, [2] Chukyo University, [3] SOKENDAI

1. Introduction

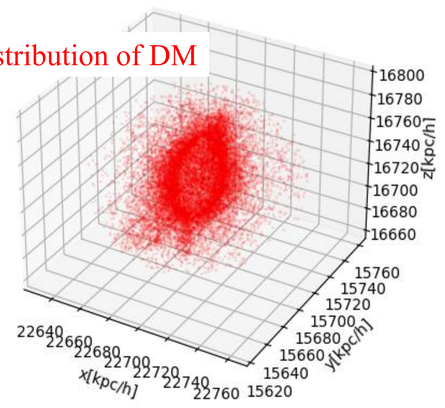
The local dark matter (DM) density is estimated to be about 0.4 GeV/cm^3, and its speed distribution is often assumed to follow an isotropic Maxwellian distribution. Both quantities are subject to significant astrophysical uncertainties in direct detection of DM.

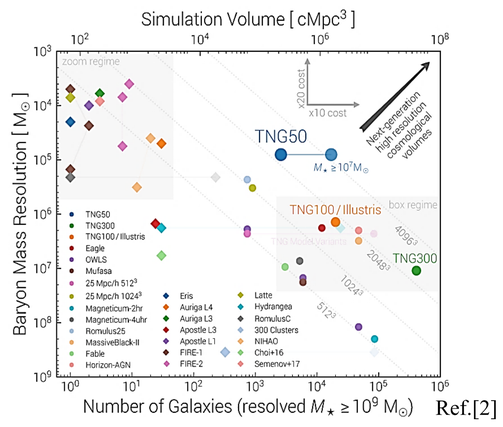
This study aims to evaluate the local DM density and speed distribution using data from IllustrisTNG simulation.

2. IllustrisTNG [2]

- IllustrisTNG is one of the cosmological hydrodynamical simulations.
- IllustrisTNG has data on stars, gas, and DM.
- We use the publicly data from the highest-resolution simulation, TNG50.

3D distribution of DM





Ref.[2]

3. Extraction DM in the Solar-neighborhood–like region

We define a region similar to the Solar neighborhood according to the following criteria.

① Selection of Milky Way-like galaxies:

- Galactic total mass: $0.83 \times 10^{12}\,M_\odot - 2.0 \times 10^{12}\,M_\odot$
- Bulge-to-total mass ratio (B/T): 0.131 – 0.178

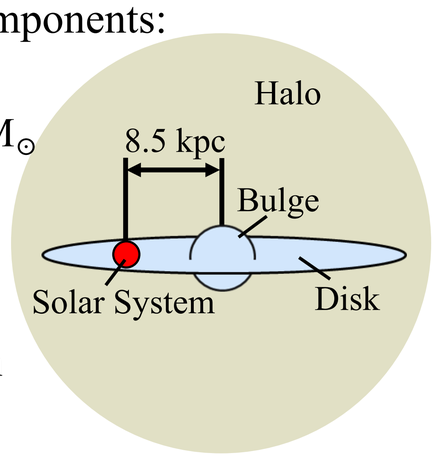
② Extraction of the Solar-neighborhood–like region:

- Galactic Center-Solar System: 7 – 9 kpc
- The Galactic disk

→ We analyze DM that satisfies criteria ① and ②.

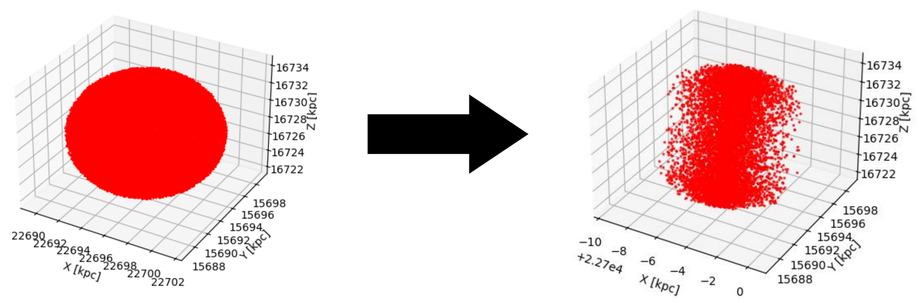
A) The structure of the Milky Way

- The Milky Way has three structural components: bulge, disk, and halo.
  - Total mass of Milky Way: $1.15 \times 10^{12}\,M_\odot$
  - B/T: 0.150
- The Solar System is located in the Galactic disk.
- It is at a distance of about 8.5 kpc from the center of the Milky Way.



B) 3D distribution of Local DM

- We extracted DM in the ring component between 7 and 9 kpc.



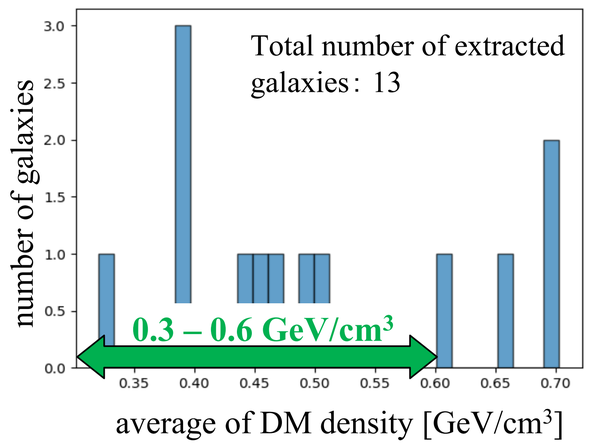
4. Results

- **Local DM density:**

We calculate the DM density in the Solar-neighborhood-like region selected in Section 3. The density is first computed for each extracted galaxy, and then averaged over all galaxies.

- Average of local DM density: **0.501 ± 0.119 GeV/cm^3**

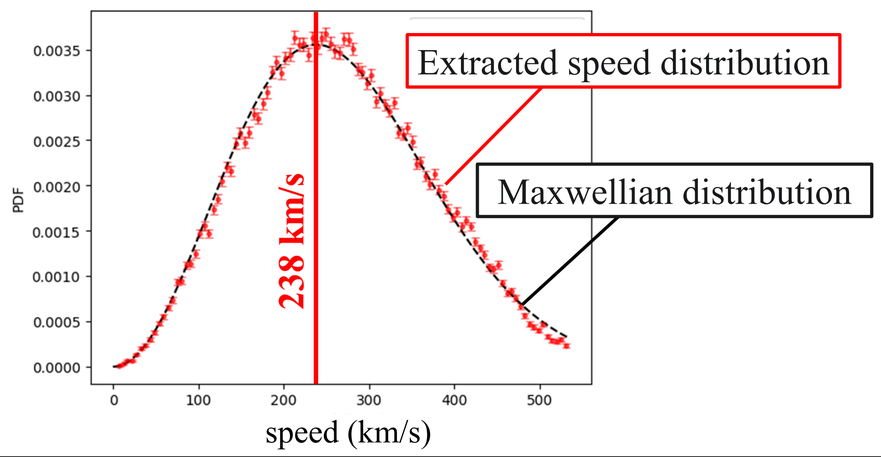
  (Consistent with the values suggested by observations.)
- Average of maximum values: 1.176 ± 0.295 GeV/cm^3
- Average of minimum values: 0.154 ± 0.031 GeV/cm^3



- **Speed distribution of local DM:**

We fit the extracted speed distribution with a Maxwellian distribution.

- Peak of speed distribution: **238 km/s**



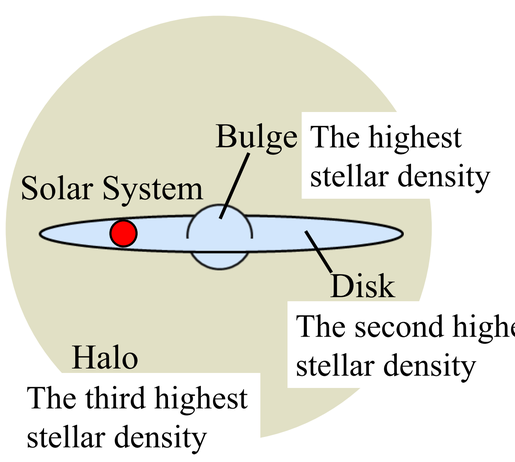
5. Summary and future work

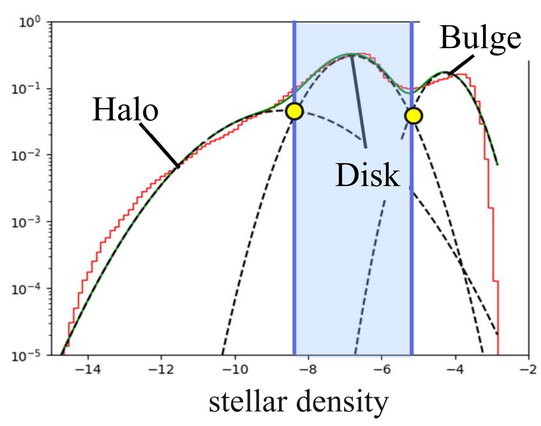
- We evaluated the local DM density and speed distribution based on IllustrisTNG data.
- Average the DM density is **0.501 ± 0.119 GeV/cm^3**.
- We fit the extracted speed distribution with a Maxwellian distribution.
- The peak of speed is **238 km/s**.

□ Evaluation of the anisotropy in the velocity distribution.

C) Extraction of Galactic disk data

- To extract the Galactic disk region, we decompose the stellar density into three components using Gaussian distributions.
- The region between the intersections of each component (shown in blue) is defined as the galactic disk.





References

[1] P. F. de Salas and A. Widmark, Reports on Progress in Physics, Vol. 84, No. 10 (2021)
[2] IllustrisTNG project: https://www.tng-project.org/
[3] M. A. Aragon-Calvo, J. Silk, and M. Neyrinck, Monthly Notices of the Royal Astronomical Society: Letters, Vol. 520 (2022)
[4] T. C. Licquia and J. A. Newman, Astrophysical Journal, Vol. 806 (2015)