It's All Relative(istic): Investigating Dark Matter Velocity Distributions and Their Matter Power Spectra

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April 2023

1   Abstract

Density fluctuations of dark matter (DM) are erased on scales smaller than the DM free streaming length, which leads to a cut-off in the matter power spectrum. This cut-off is important for the onset of structure formation in the early universe because it sets the minimum DM halo mass. The shape and location of this cut-off is determined by the velocity distribution of dark matter. In this project, we employ the Cosmic Linear Anisotropy Solving System (CLASS)[1] to investigate how the velocity distributions of warm and cold dark matter are related to their matter power spectra. We examine the transfer function, which is defined as the square root of the ratio of the matter power spectrum to the matter power spectrum assuming perfectly cold DM. We determine that the scale at which the transfer function equals one-half is not set by the median of the DM distribution. However, the median seems to predict the scale at which the transfer function equals 1/7. Additionally, we test the fundamental equation which relates the shape of the matter power spectrum to the DM distribution function proposed by Dienes et al. 2020 [2]. We find that there is a temperature dependence in the Dienes results: increasing the average momentum of a DM particle causes deviation from their proposed analytical relationship between the DM distribution function and the related matter power spectrum.

References

[1] Blas, D., Lesgourgues, J., Tram, T. (2011). The Cosmic Linear Anisotropy Solving System (CLASS). Part II: Approximation schemes. Journal of Cosmology and Astroparticle Physics, 2011(07), 034. https://doi.org/10.48550/arXiv.1104.2932

[2] Dienes, et al. (2001). Deciphering the Archaeological Record: Cosmological Imprints of Non-Minimal Dark Sectors https://arxiv.org/abs/2001.02193