Dark Matter Velocity Distributions and the Matter Power Spectrum

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The matter power spectrum describes density fluctuations on different spatial scales. Dark matter particles with some random thermal motion erase density fluctuations on length scales smaller than the distance they can traverse—a process known as 'free-streaming.' This phenomenon causes a small-scale cut-off in the matter power spectrum, suppressing fluctuations on scales smaller than the free-streaming length. While the connection between the cut-off scale and dark matter temperature is well understood for thermal dark matter distributions, determining this relationship for more exotic distributions resulting from non-thermal dark matter production remains elusive. This work explores the connection between these non-thermal distributions and their resulting matter power spectra. We utilize the Cosmic Linear Anisotropy Solving System (CLASS) to analyze a collection of distributions with a shared cut-off in their matter power spectra and test the relationship proposed by Dienes et al. (2020). While no definitive connection between the velocity distributions and their matter power spectra was found, the method proposed by Dienes et al. was refined by optimizing parameters for the set of distributions.