DMDE Exercise 2

Tom Carron - tcarron@tcd.ie

November 2021

1 Problem 1: The Matter Power Spectrum

1.1 Part a)

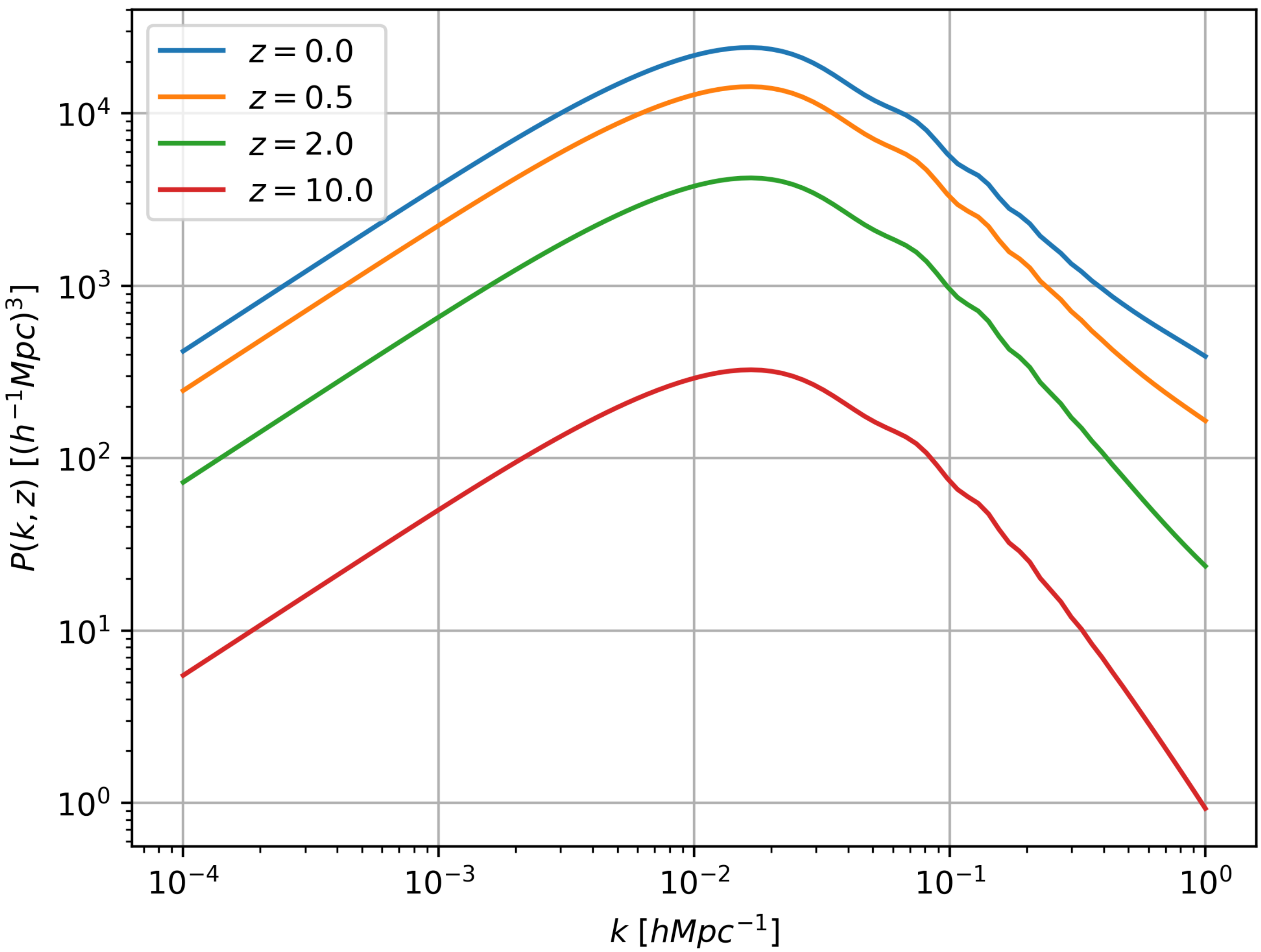

Figure 1: Non-linear matter power spectrum for 4 epochs calculated using CAMB for python.

The matter power spectrum describes the density contrast of the Universe i.e the difference between the local density and mean density at different spatial scales. At higher redshifts, the magnitude of the matter density fluctuations is smaller and at lower redshifts and up to the current epoch, the matter density fluctuations are larger. This is because the matter density fluctuations are dependent on the growth factor which is increasing.

1.2 Part b)

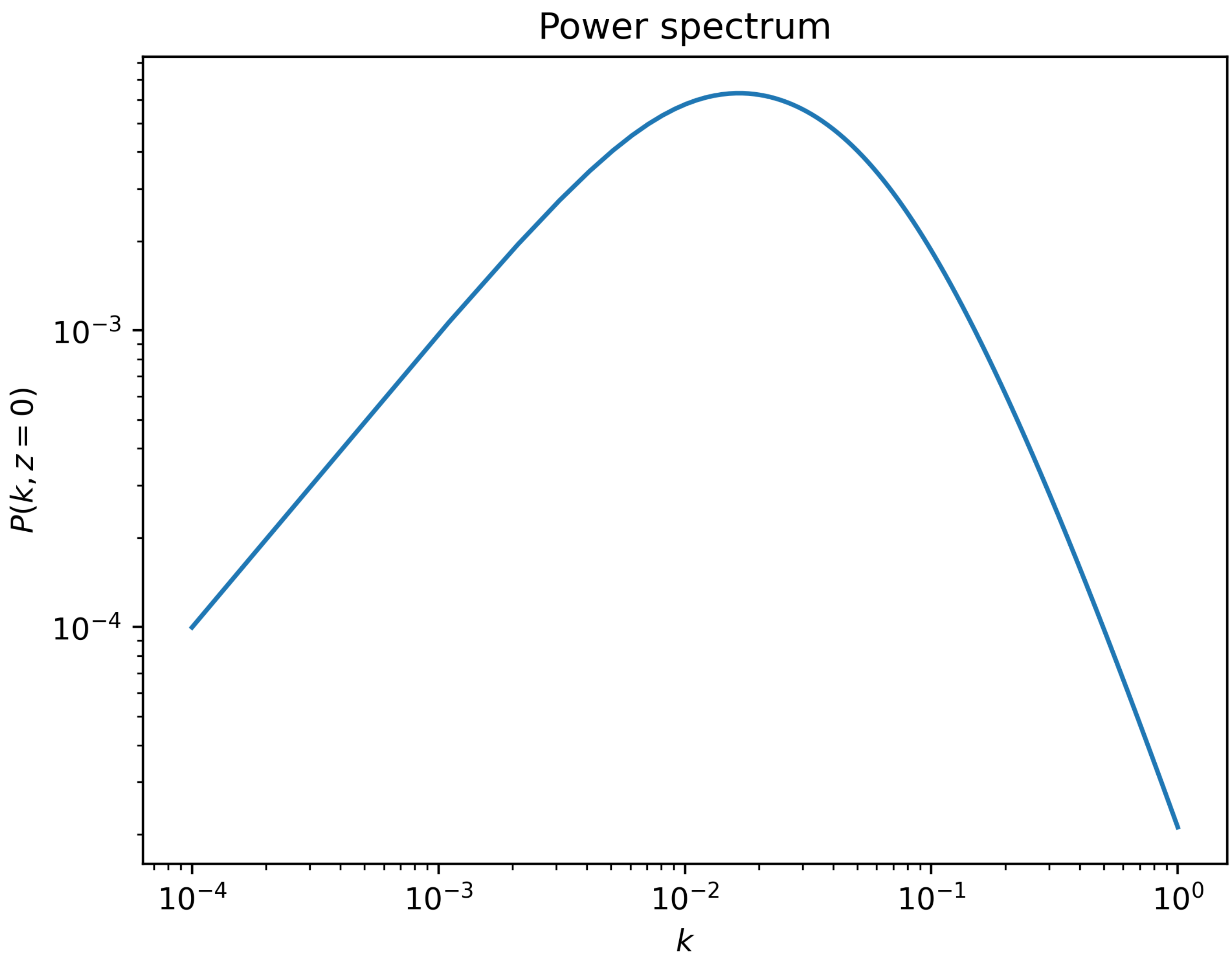

Figure 2: Matter Power spectrum approximated by equations 2.109-2.112

1.3 Part c)

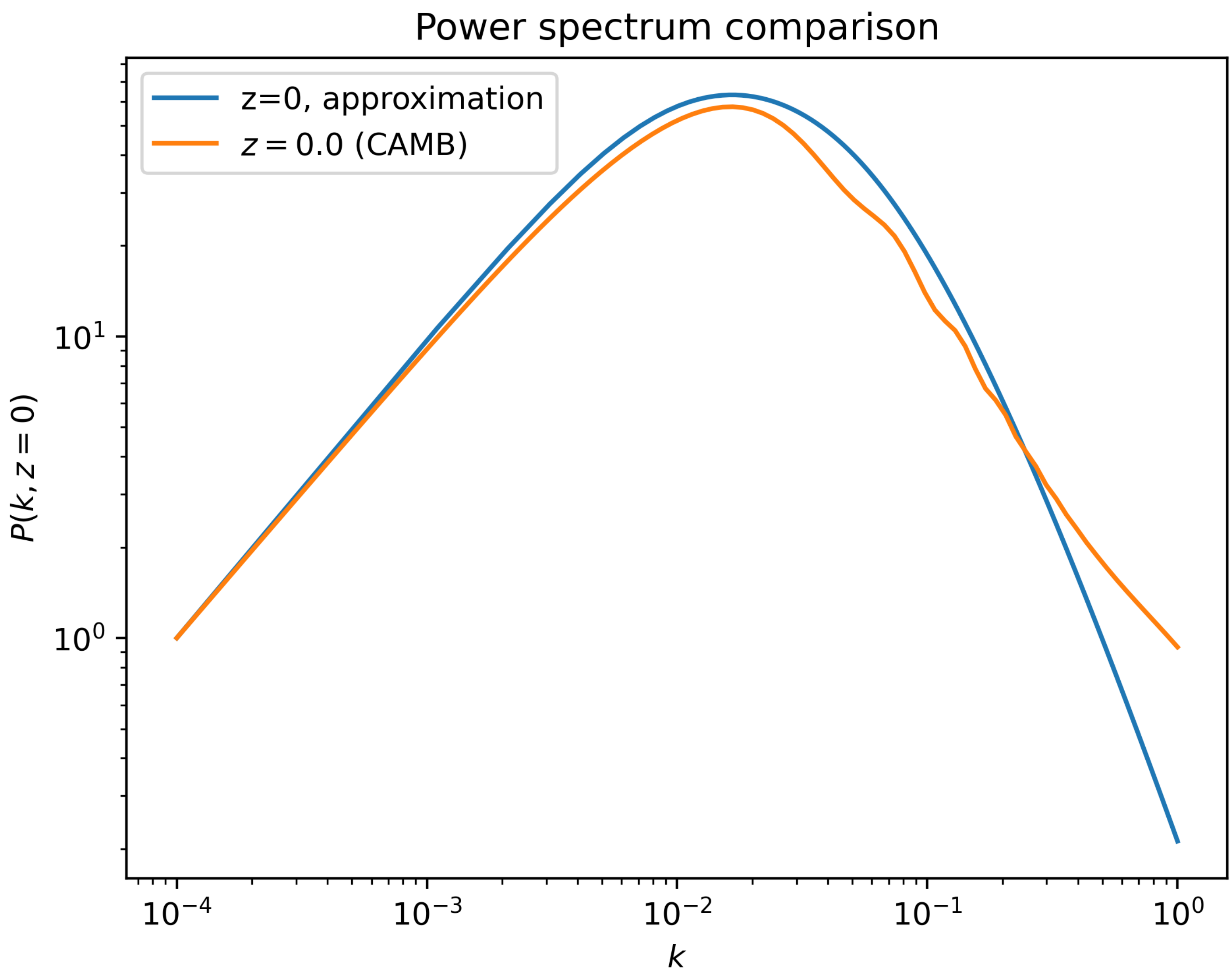

Figure 3: The matter power spectra at the present epoch calculated using the approximation described by equations 2.109-2.112 (blue) and calculated using CAMB (orange). The approximation closely resembles the CAMB calculation at large scales (small k) but at smaller scales the spectrum deviates significantly from the CAMB calculated spectrum.

2 Problem 2: Press-Schechter Mass Function

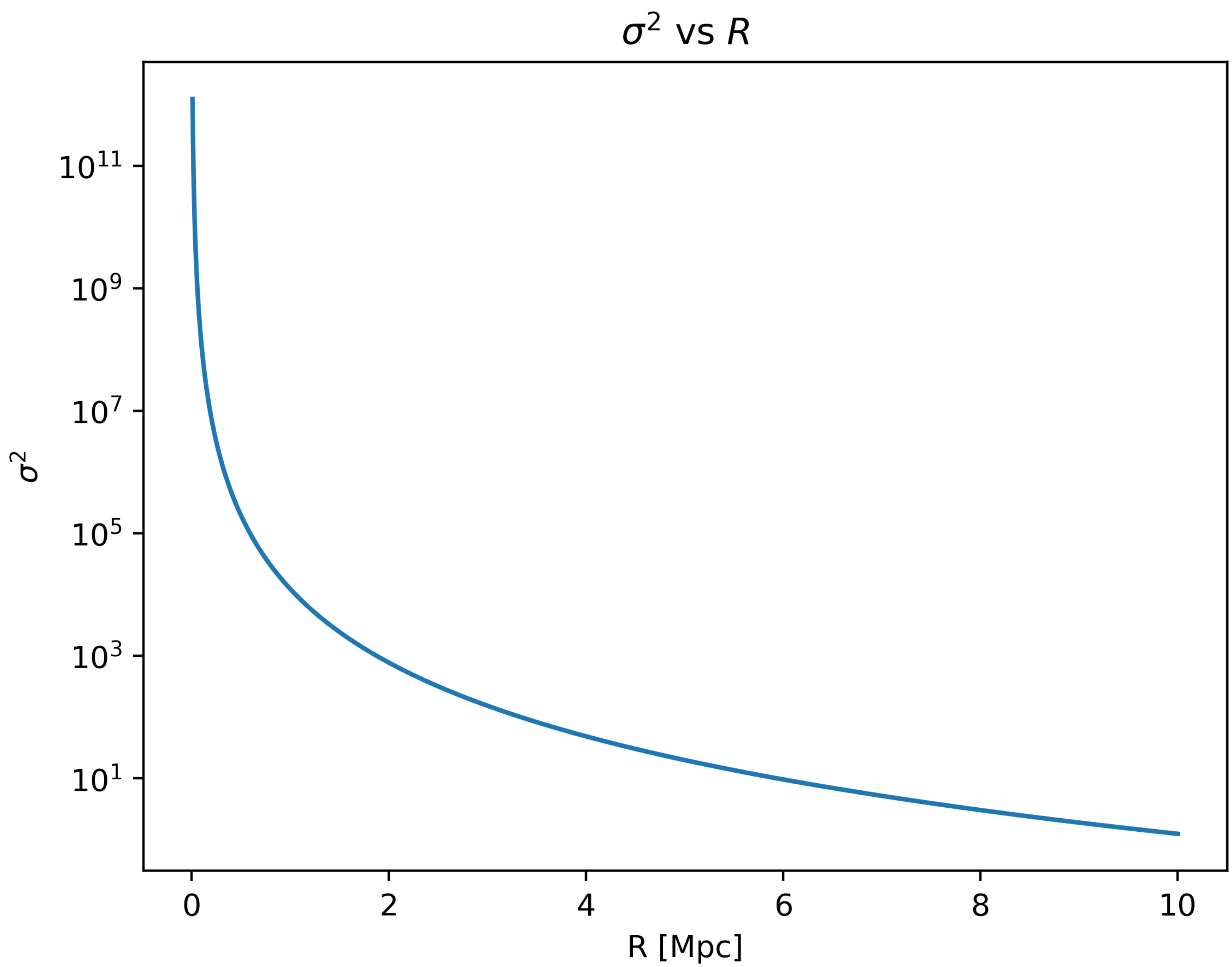

Figure 4: Present variance of the linear mass density fluctuations of a Press-Schechter mass function as a function of Radius. The variance is inversely proportional to R^4, and so the variance in mass density fluctuations decreases significantly with increasing radius.

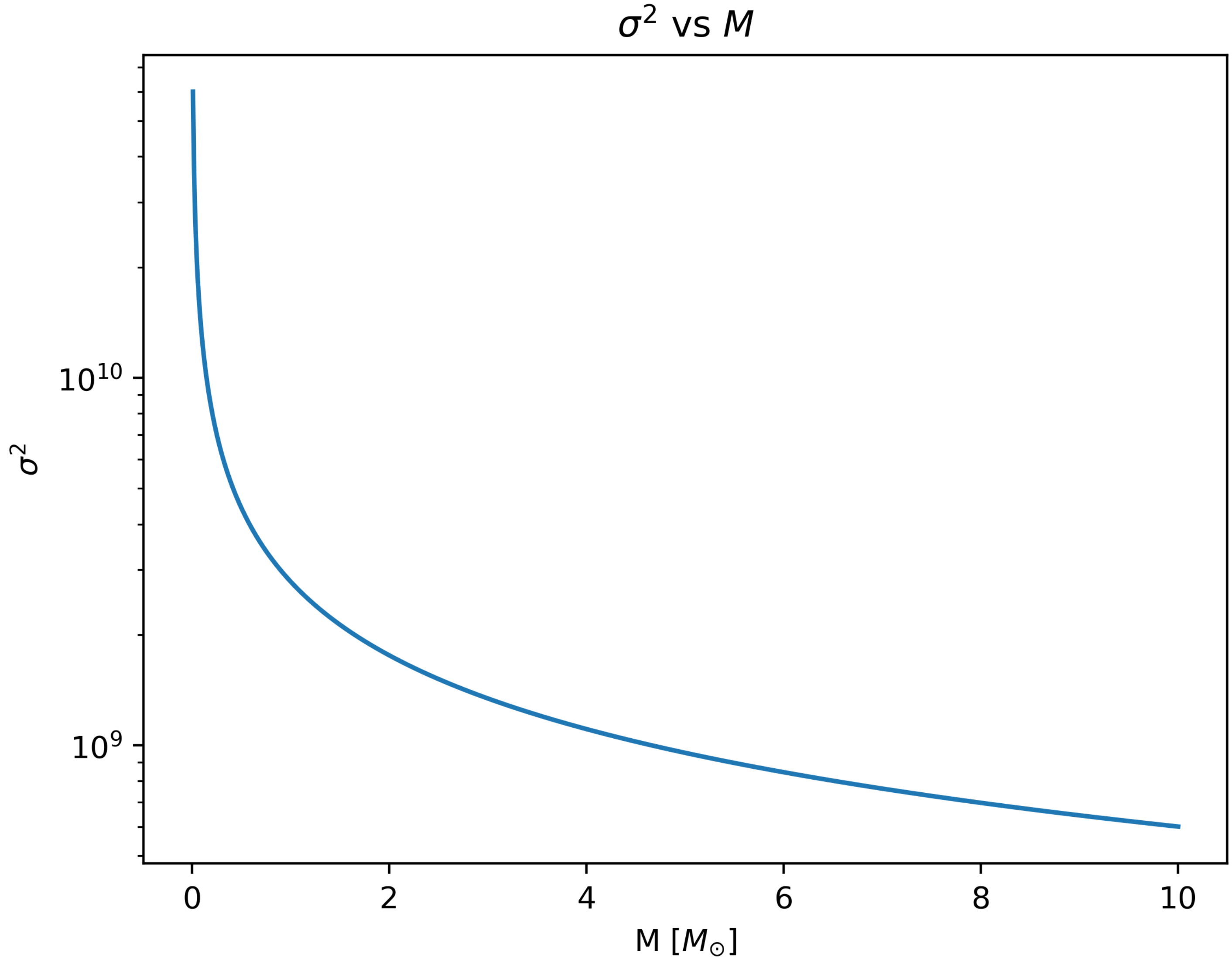

Figure 5: Present variance of the linear mass density fluctuations of a Press-Schechter mass function as a function of Mass. The variance is inversely proportional to $M^{\frac{2}{3}}$, and so the variance in mass density fluctuations decreases significantly with increasing mass.

3 Problem 3: Conceptual Review

3.1 Part a)

What are the two types of Dark Energy tests?

The two types of Dark Energy tests are tests that probe the Hubble parameter $H(z)$, and tests that probe the growth of structure. Examples of tests that probe the Hubble parameter are, supernovae, galaxy clusters, BAOs and weak and gravitational lensing. Tests that probe the growth of structure are clusters, weak lensing, and the matter power spectrum.

3.2 Part b)

What is R_{200} ? Why is R_{200} sometimes taken as an approximation to R_{vir}?

R_{200} is the radius within which the mean density is equal to 200 times the critical density. It is sometimes taken as an approximation to R_{vir} (in the spherical collapse model, the radius of the sphere after it has settled into virial equilibrium). This is because the non-linear density contrast at the time when the sphere has virialised is given by

$$1 + \delta_{nonlin}^{vir} = \frac{(6\pi)^2}{2} \approx 178$$

3.3 Part c)

What are the important parameters of the Press-Schechter mass function?

The important parameters of the Press-Schechter mass function are ones which can be constrained by observations. They are the mean density of the Universe $\bar{\rho}_0$, the amplitude of density fluctuations on scales of $8h^{-1}$ Mpc, σ_8, and the collapse threshold, $\delta_c^0(z)$.

4 Code

The code used for this Exercise is available at `https://github.com/tomcarron/DMDE_Ex2.git`