Massive Neutrinos Leave Fingerprints on Cosmic Voids

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Introduction & Simulations

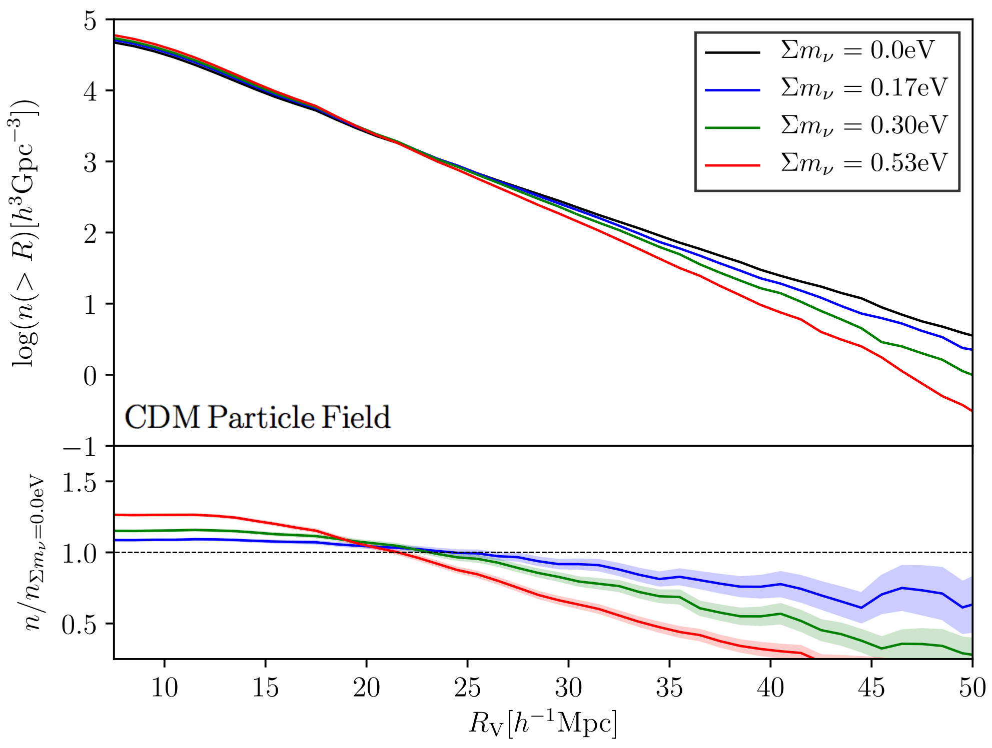
- Cosmology places tight constraints on neutrino properties
- *Planck* TT,TE,EE+lowE+lensing+BAO measurements place the 95% upper bound[1] on the sum of neutrino masses as $\sum m_\nu < 0.12$ eV
- Neutrinos have free-streaming lengths of 130 h^{-1}Mpc (39 h^{-1}Mpc) for $\sum m_\nu = 0.06$ eV ($\sum m_\nu = 0.6$ eV)
- Neutrino free-streaming scales for $\sum m_\nu$ of interest fall within the range of typical void sizes ($\sim 10 - 100\ h^{-1}$Mpc), making voids an interesting tool for studying neutrinos.

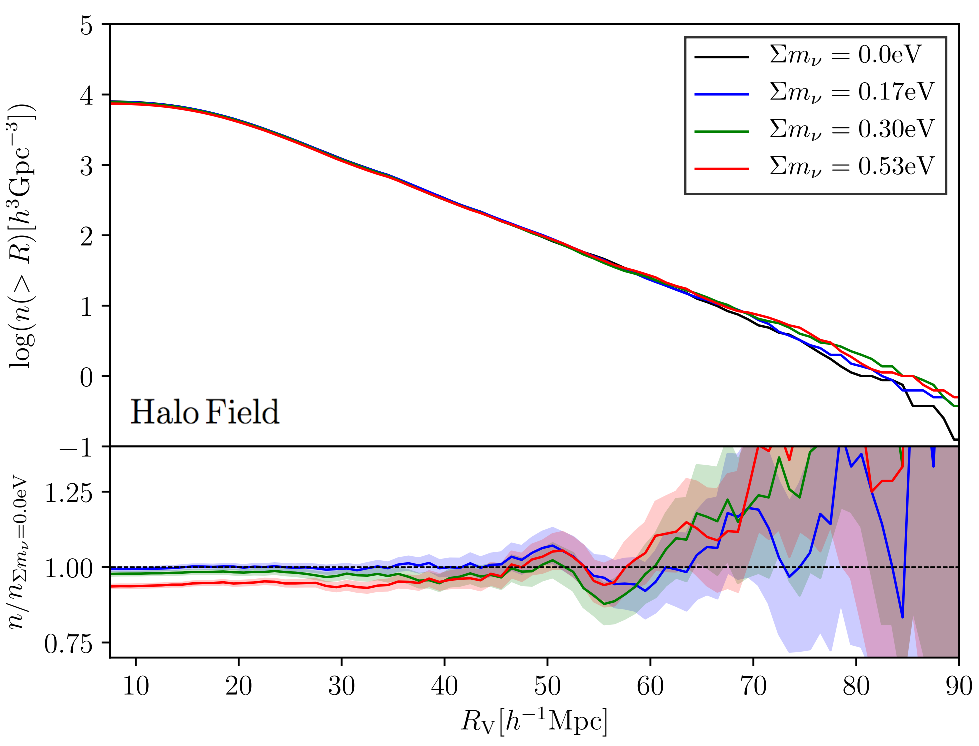
Cosmic voids are:

- Pristine environments: they undergo minimal virialization and maintain initial conditions
- Sensitive to effects like the growth rate of cosmic structure, via redshift space distortions, and dark energy
- A complementary probe to cosmic microwave background and galaxy clustering measurements of neutrino physics

Simulations: DEMNUni (L=2 Gpc h^{-1}, 2048^3 CDM particles), MassiveNuS (L=512 Mpc h^{-1}, 1024^3 CDM particles)

Results





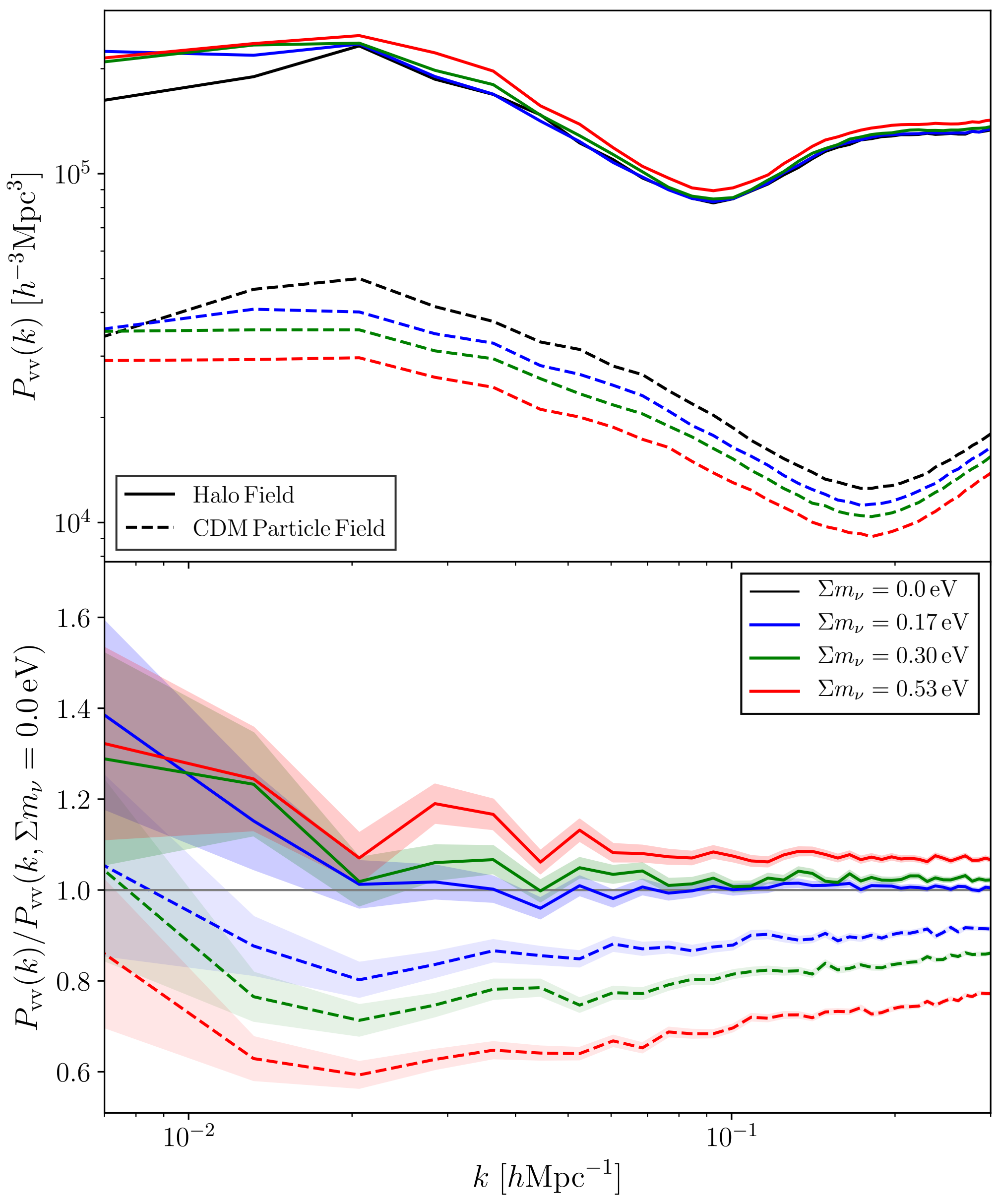
Figures 1, 2 (far left, left): DEMNUni void abundances.

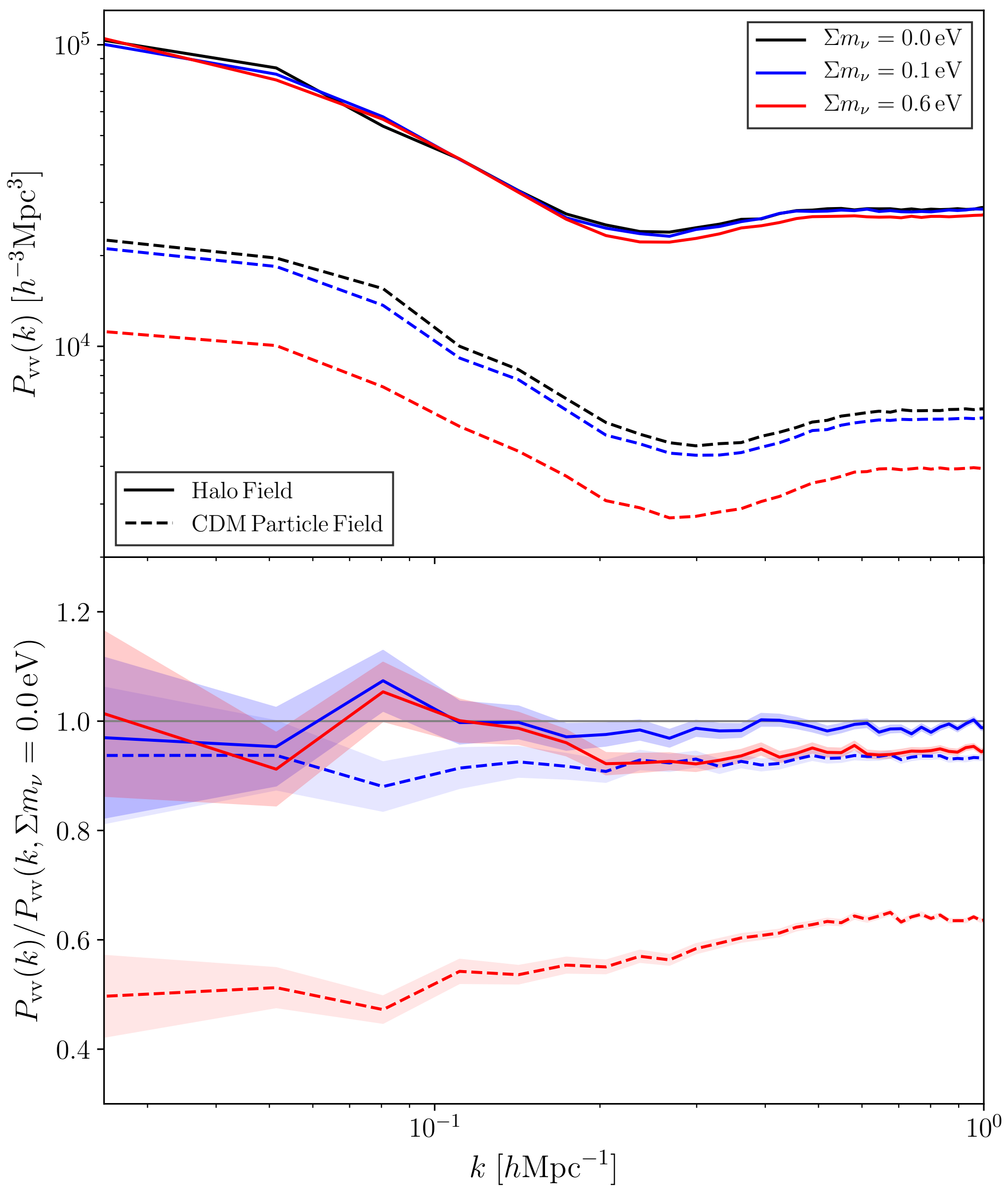
For all plots, $z = 0$ and colors denote the $\sum m_\nu$ in each simulation. Ratios are between void abundance/ power spectra for different $\sum m_\nu$ and the massless neutrino case.

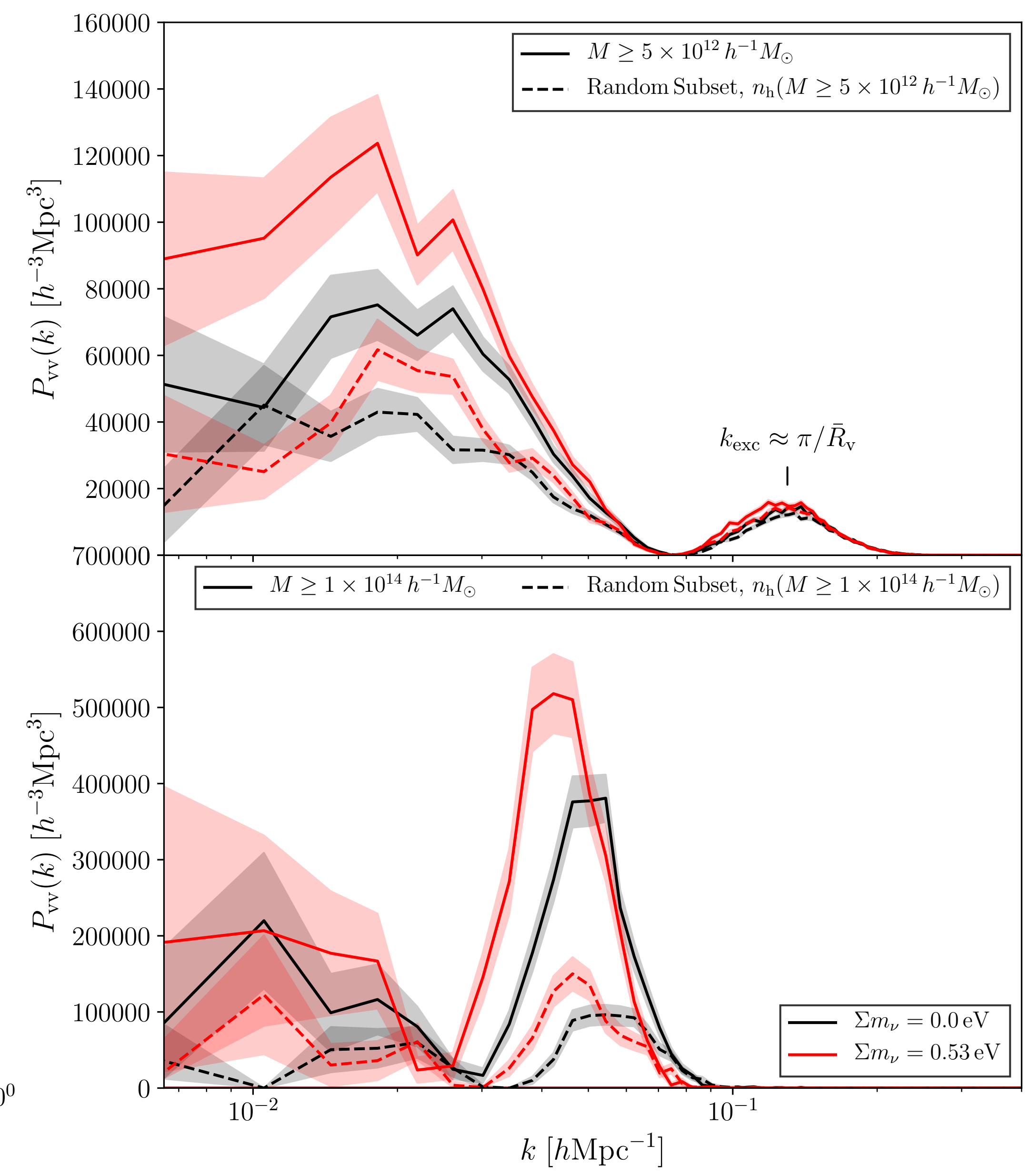
Figure 3 (below): DEMNUni void-void power spectra.

Figure 4 (below): MassiveNuS void-void power spectra.

Figure 5 (below): DEMNUni void-void power spectra (shot noise removed) with the void exclusion scale labelled. Removing shot noise removes the effects of void number density. Dashed lines correspond to randomly subsampling the original halo catalog so its number density matches that of the mass thresholded catalog, removing the effects of tracer density. The impact of $\sum m_\nu$ on void clustering depends on halo bias.







Conclusions

1. As neutrino mass increases, there are more small voids and fewer large voids seen in the CDM field. However, if we use massive, highly biased halos as tracers then there are fewer small voids and more large voids.
2. Neutrinos affect how voids cluster and produce a strong scale dependent trend– this is a distinctive feature.
3. The interplay of these signatures leaves a distinct fingerprint that could be detected with observations and potentially help break degeneracies between different cosmological parameters.

Paper!
arXiv:1808.07464

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[1]Planck Collaboration 2018, ArXiv e-prints, arXiv:1807.06209