Universality of subhalo accretion in WDM and CDM cosmologies

work in progress

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Question

1. What is the privileged infall direction in WDM and CDM cosmologies?
2. Is this the same in both?
3. If yes, is there a scale where this universality breaks?

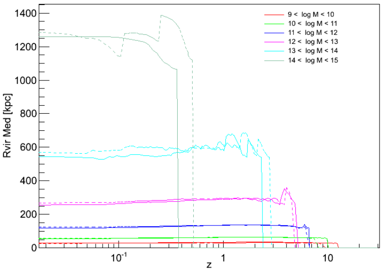
1. Take two simulations: CDM only, WDM 1 keV sterile neutrino (Gadget2)
2. WM3: $\Omega_\Lambda = 0.76$, $\Omega_m = 0.24$, $H_0 = 73$km/s/Mpc. $\sigma_8 = 0.75$
3. $64h^{-1}$ Mpc box, 1024^3 particles
4. compare their infall pattern
5. continuation of N. Libeskind, Knebe A. Y. Hoffman, S. Gottl ber MNRAS 2, 443, 2014

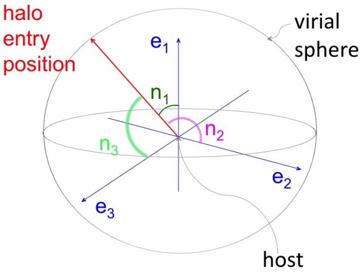
Method - 1. define the eigenframe for each host

1. velocity shear field

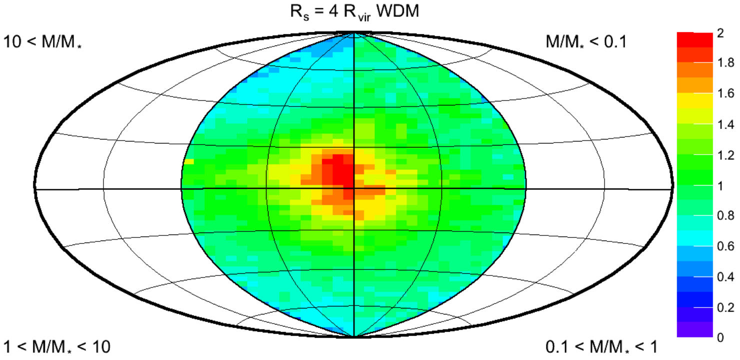
$$\Sigma_{ij} = -\frac{1}{2H(z)}\left(\frac{\partial v_i}{\partial r_j} + \frac{\partial v_j}{\partial r_i}\right) \quad (1)$$

2. at each z host haloes divided into five mass bins
3. $R_{\rm vir}$ - median virial radius per bin computed
4. gaussian smoothing of the shear field → 4,8,16 $\times R_{\rm vir}$





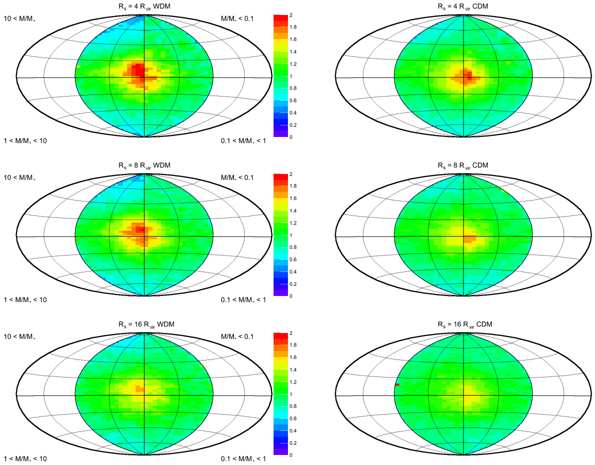
- shear tensor → eigenframe for each halo
- $\mathbf{e}_1$- fastest collapse, $\mathbf{e}_3$- slowest collapse.
- Is there a preferential direction for the infall?



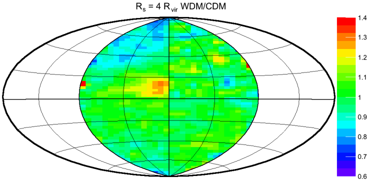
- host haloes divided into four mass bins according to $\tilde{M} = M_{\rm host}/M_\star$,
- $M_\star(z) \equiv$ overdensity variance within a sphere of radius $R(z) = (3M_\star(z)/4\pi\rho_{\rm crit})^{1/3}$ which should be equal to the square of the critical density = mass of a typically collapsing object at a given redshift
- number of entry points divided by that expected from a uniform distribution

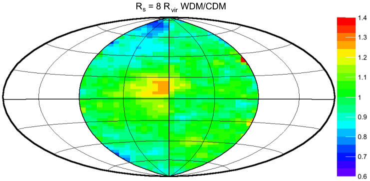
Aitoff projections for all mergers

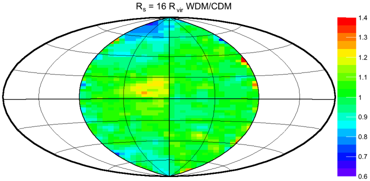
- strong tendency for the accretion to occur along $\mathbf{e}_3$ regardless of the host halo mass in both cosmologies
- effect greatest for the most massive host haloes, progressively weaker as host mass decreases



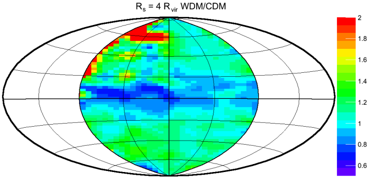
- WDM accrete substructures more anisotropically than CDM independently of the smoothing scale

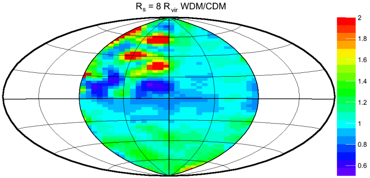


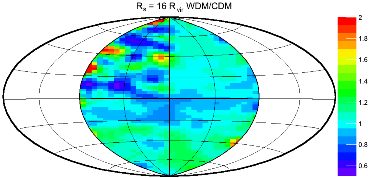




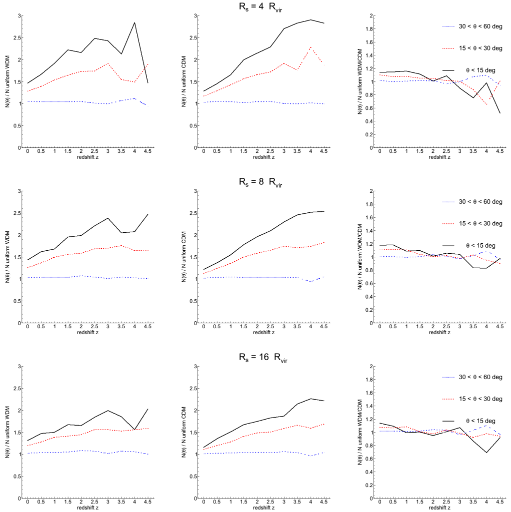
- subhalo accretion anisotropy much more pronounced in CDM cosmology for heavy mergers



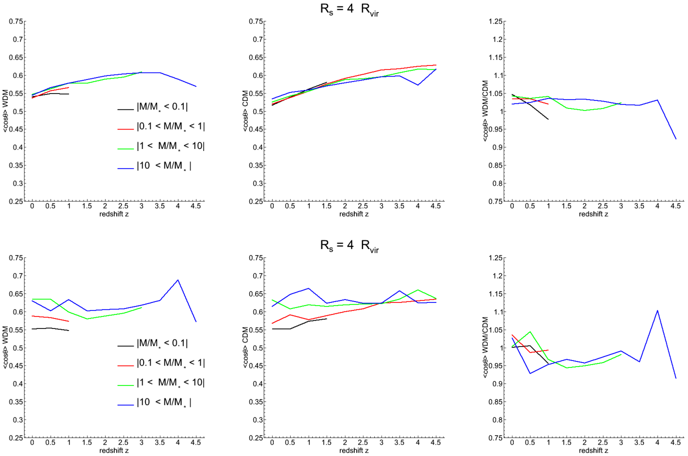




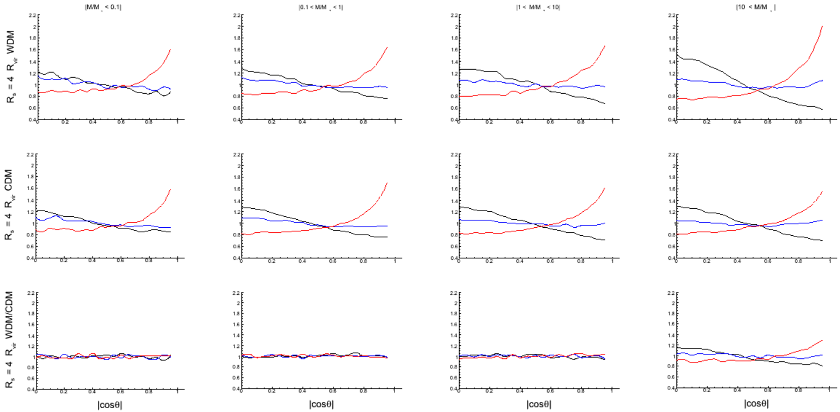
- accretion at high z is more aligned with $\mathbf{e}_3$, than low z
- at high z accretion anisotropy in WDM is lower than that in CDM



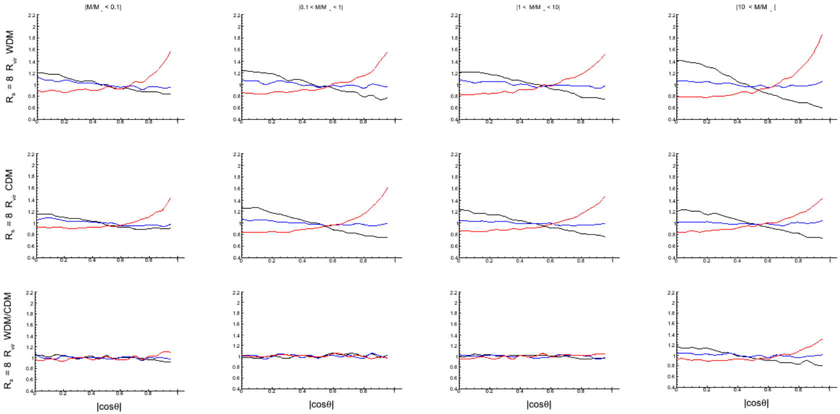
- average angle between the position vector of a given subhalo at the moment of accretion and $\mathbf{e}_3$



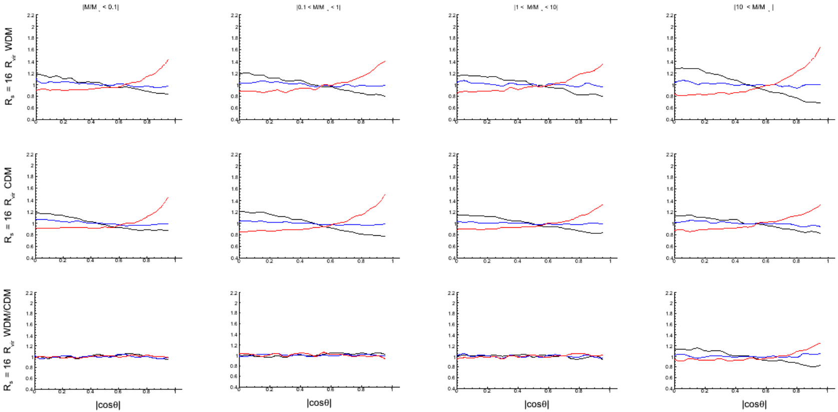
- average angles $r\mathbf{e}_1$, $r\mathbf{e}_2$, $r\mathbf{e}_3$ $\quad R_{\rm smooth} = 4R_{\rm vir}$



- average angles $r\mathbf{e}_1$, $r\mathbf{e}_2$, $r\mathbf{e}_3$ $\quad R_{\mathrm{smooth}} = 8R_{\mathrm{vir}}$



- average angles $r\mathbf{e}_1$, $r\mathbf{e}_2$, $r\mathbf{e}_3$ $\quad R_{\mathrm{smooth}} = 16 R_{\mathrm{vir}}$



Summary

- In both cosmologies:
  1. The statistical tendency of subhalos to be accreted preferentially along the direction that corresponds to slowest collapse extends to different cosmologies regardless of the host and halo mass in both cosmologies.
  2. effect greatest for the most massive host haloes, progressively weaker as host mass decreases (at least in WDM, issue in CDM)
  3. effect weakens as the gaussian smoothing kernel is increased (LSS homogenization)
  4. accretion at high redshift is more aligned with $\mathbf{e}_3$, than accretion at low redshift for all mass bins

- Differences between WDM and CDM:
  1. WDM accrete substructures more anisotropically than CDM for heavy host mass independently of the smoothing scale
  2. subhalo accretion anisotropy much more pronounced in CDM cosmology for heavy mergers
  3. redshift dependence: the accretion anisotropy in WDM cosmology is lower than that in CDM at high redshifts