3D Power Spectra for H1 Intensity with a Scale Dependent Bias

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The premise

The 21cm line for neutral hydrogen is spin flip transition from electrons in the ground state.

- Hydrogen is abundant
- There is neutral hydrogen where galaxies are
- Galaxies are where the matter is
- The redshift of the 21cm line tells us where it came from in redshift space

Mapping out the 21cm line of the universe gives us a 3D map of the matter distribution that allows us to track the late time evolution of the universe.

- Does not require the resolution of individual galaxies

The setup

$$dn_{emit} = \frac{1}{4\pi}\left[(n_1 - 3n_0)N_\gamma + n_1\right] A_{10}\delta(E - E_{21})dEdtd\Omega$$

$$dn_{rec} = \frac{3}{16\pi} n_{HI} A_{10}(1+z)\left|\frac{d\lambda}{dz}\right| dEdtd\tilde{\Omega}d\tilde{A}$$

$$\left|\frac{dz}{d\lambda}\right| = (1+z)^2 H(z) E_{21}$$

$$\bar{T}_b(z) = \frac{3\bar{n}_{HI} A_{10}}{32\pi k_B E_{21}^2 (1+z)^2 H(z)}$$

For the low redshifts we care about we have that

$$T_{CMB} \gg T_{21}, \qquad T_s \gg T_{CMB}$$

Linear Equations

$$ds^2 = a^2(\eta)\left[(1+2\Psi)d\eta^2 - (1-2\Phi)\delta_{ij}dx^i dx^j\right]$$

$$\Delta_{T_b}(z,\hat{n}) = \delta_n - \frac{1}{\mathcal{H}}\hat{n}\cdot(\hat{n}\cdot\nabla\vec{v}) + \left(\frac{d\log\left(a^3\bar{n}_{HI}\right)}{d\eta} - \frac{\dot{\mathcal{H}}}{\mathcal{H}} - 2\mathcal{H}\right)\delta\eta + \frac{1}{\mathcal{H}}\dot{\Phi} + \Psi$$

Newtonian-gauge density of the neutral hydrogen
Redshift space distortions
Terms that have to do with perturbed surface of emission
Last two terms are ISW and SW respectively.

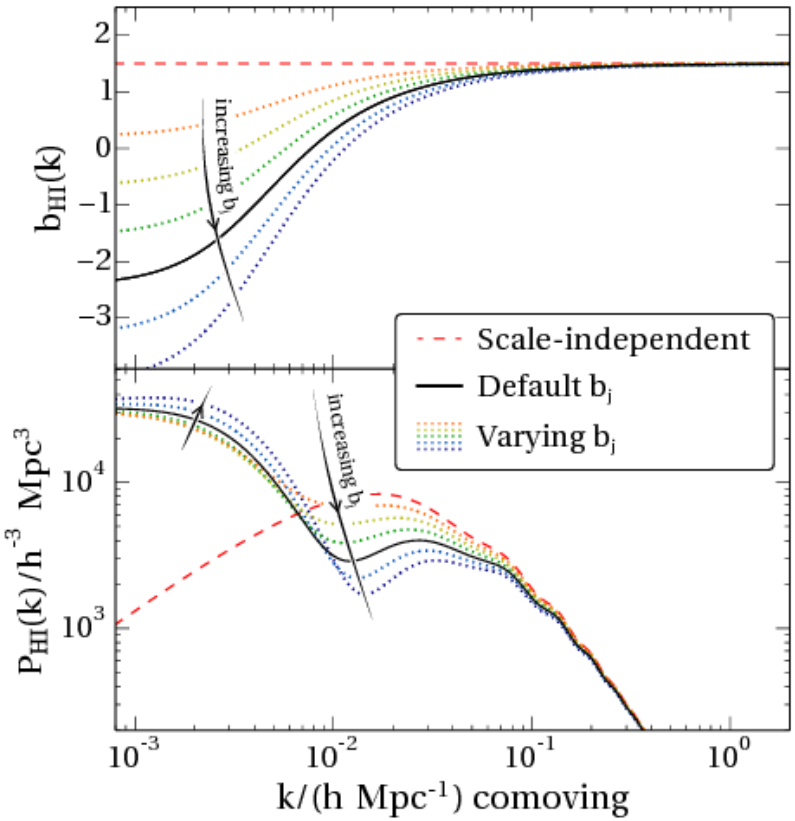
Note: $\mathcal{H} = (1/a)da/d\eta = aH$

Remark: A similar relation exists for galaxy number counts A. Hall et al. Arxiv:1212.0728.

Problems

Scale dependent bias $\delta_n = b_n \delta_g = b_n b \delta_m$?

We know that there should be no neutral hydrogen in the IGM. Is this scale relevant enough to care about (BAO peak?).



A. Pontzen, Arxiv:1402.0506

Plans

21cm emission provides us with (many) new modes/bits of new independent information of the universe, but only if we know what we are looking at.

- Want to systematically characterize the power in auto and cross correlations of all the terms in

$$\Delta_{T_b}(z,\hat{n}) = \delta_n - \frac{1}{\mathcal{H}}\hat{n}\cdot(\hat{n}\cdot\nabla\vec{v}) + \left(\frac{d\log\left(a^3\bar{n}_{HI}\right)}{d\eta} - \frac{\dot{\mathcal{H}}}{\mathcal{H}} - 2\mathcal{H}\right)\delta\eta + \frac{1}{\mathcal{H}}\dot{\Phi} + \Psi$$

- We can learn about the different populations of hydrogen (shielded clumps and ionization equilibrium)
- We can also potentially learn about the structure of galaxies and the IGM via cross-correlation with Damped Lyα systems.