Appendix B

Definitions of Terms and Symbols

To aid in understanding, I have provided a list of important terms with definitions. Following the list of terms is two lists of symbols (one Roman and one Greek) with definitions.

B.1 Terms

brute force: Introduced in Chapter 1. The brute force method, commonly used in analysis of CMB fluctuations, assumes that the density is Gaussianly distributed. It also assumes a Gaussian likelihood function. These methods work best on the largest scales: where the fluctuations are likely to be Gaussian and the computation costs are the least.

classical method: Introduced in Chapter 1. Introduced by Feldman et al. (1994), classical methods of analyzing redshift surveys require the position and the wavelength of the fluctuation to be measured simultaneously. It implies a weight scheme that depends only on the local density. Classical methods work best on size scales that will comfortably fit within the survey.

decorrelation: Introduced in Section 2.3. Decorrelation is the process of creating statistically uncorrelated parameters. That is to say, recombine a set of parameters in such a way that the new parameters have covariances of zero. Decorrelation is especially useful if the data is going to be used in some sort of least-squares fit.

Fisher matrix: Introduced in Chapter 2. The inverse of the full covariance matrix for all parameters. The Fisher matrix is generated using a prior guess as to the values of all measured parameters. If the prior guess is similar to the measured value then the Fisher matrix describes the amount of information a particular data set has about the set of measurable parameters.

linear (regime): Introduced in Chapter 2. Refers to size scales which are large enough that overdensities (or underdensities) are small compared to the mean density. In linear regime, overdensities grow linearly without change of shape.

non-linear (regime): Introduced in Chapter 2. Refers to size scales where overdensities can become comparable to or larger than the mean density. The fact that density cannot become negative causes underdense regions to expand and overdense regions to collapse.

pair weight method: Introduced by this thesis. The pair weight method is a general method of analyzing redshift surveys. The pair weight method weights each pair of overdensities by a weight that is determined by the survey itself (and the prior power spectrum). The pair weight method is not limited by the shape or complexity of the survey nor is it limited to testing models which are Gaussian. The primary limitation of the pair weight method is the computational expense.

power spectrum: Introduced in Chapter 1. The power spectrum is the covariance, expressed in Fourier space, of fluctuations. It is a function of wavenumber k. The shape and amplitude of the power spectrum can be used to measure several cosmological parameters.

prior: Introduced in Chapter 2. The prior includes all prior assumptions including *e.g.,* homogeneity and isotropy. In particular, the prior often refers to the prior guess for the power spectrum.

selection function: Introduced in Chapter 1. The expected number of galaxies at a particular location given the selection criteria of the survey.

B.2 Symbols

b**:** Introduced in the Abstract. b is the linear bias parameter. b is the ratio of galaxy overdensities to matter overdensities ($\delta_{\rm gal} = b\delta_{\rm mass}$). If $b = 1$ then galaxies are an unbiased tracer of the density.

$B_{\alpha ij}$**:** Introduced in Section 2.1.2. The shape function. In the case with no redshift distortions this restricts the separation of parcels i and j to be r_α. In the more general case, $B_{\alpha ij}$ also includes a shape (contained within the index α) which describes one of the components of the redshift distortions.

$C_{ab(,\alpha)}$**:** Introduced in Chapter 2. The covariance of the modes a and b. If there are indices $,\alpha$ then it is the derivative of the covariance of the modes with respect to the parameter α.

$\mathcal{C}_{ab}$**:** Introduced in Section 4.3.5. This is the band power matrix which disentangles $P(k)$ from $\beta P(k)$ from $\beta^2 P(k)$ and correlates neighboring points within each of the power spectra.

$\mathfrak{C}_{ijkl}$**:** Introduced in Section 2.1.2. The covariance of the correlation functions $\langle \Delta\xi_{ij} \Delta\xi_{kl} \rangle$. In the most general, non-Gaussian, case this can depend on 3-point terms and 4-point terms as well as 2-point terms (in the general case $\mathfrak{C}_{ijkl}$ depends on the locations of parcels i, j, k, and l as well as their separations). For most of the Dissertation this is reduced to the more restricted Gaussian case where $\mathfrak{C}_{ijkl} = C_{ik}C_{jl} + C_{il}C_{jk}$.

$D_{\rm dist}$**:** Introduced in Chapter 4. This is the distortion operator. It describes the manner in which overdensities in real space translate into overdensities in redshift space.

$\mathcal{D}_{ab}$**:** Introduced in Section 4.3.5. This is the band-power matrix which disentangles $P(k)$ from $\beta P(k)$ from $\beta^2 P(k)$ and decorrelates neighboring points of each (however, at each k the three different power spectra are correlated). Same as $\mathcal{C}$ except decorrelated not correlated.

f: Introduced in Chapter 1. $f(\approx \Omega_m^{0.6})$ is the linear growth rate. It is the ratio of the velocity of a parcel of matter to the comoving distance it has traveled (in Hubble units).

$F_{\alpha\beta}$: Introduced in Section 2.1.1. The Fisher matrix. See Tegmark et al. (1997) for a nice explanation. This is the inverse of the covariance matrix with parameters α and β. The Fisher matrix is also called the Fisher information matrix because it is a measure of how much information is contained within the data set about the particular set of parameters.

$\mathcal{F}$: Introduced in Section 4.3.5. This matrix is used to correlate and disentangle the power spectra ($P(k)$, $\beta P(k)$, and $\beta^2 P(k)$).

$G_{\alpha\beta}$: Introduced in Section 2.3.1. This is the scaled Fisher matrix. That is to say that it is the Fisher matrix multiplied by the prior values of ξ_α and ξ_β.

h: Introduced in Chapter 1. The Hubble constant H_0 in units of $100\,\mathrm{km\,s^{-1}\,Mpc^{-1}}$.

H_0: Introduced in Chapter 1. H_0 is the Hubble constant at the present epoch. The Hubble constant is a measure of the rate of expansion of the universe.

$\breve{j}_i(kr_{12})$: Introduced in Chapter 4. The generalized Fourier transform window. These are the window functions necessary to transform $\breve{\xi}_i(r)$ to $g_i(\beta)P(k)$. For indices 0, 2, and 4 the generalized window is just the spherical Bessel function j.

$J_{3\alpha}$: Introduced in Section 2.3.1. The volume integral of the two-point correlation function out to radius r_α. In other words, the number of additional galaxies surrounding a galaxy than would be expected if galaxies were uniformly distributed. This is used as an FKP constant for the separation r_α.

$\mathcal{L}$: Introduced in Section 2.1.1. The likelihood function. The likelihood function is high where the data fits the model and low where the data does not fit very well.

$\bar{n}_i$: Introduced in Chapter 2. The expected density of galaxies (in the absence of fluctuations) at location $\mathbf{r}_i$. Also referred to as the selection function.

K_{ab}: Introduced in Section 2.1.2. The integral of the covariance of correlation functions weighted by window functions a and b.

$M_{\alpha\beta}$: Introduced in Chapter 2.1.2. A matrix defined in introducing the Pair Weight method. It becomes clear that M is, in fact, the Fisher matrix (F).

$\mathcal{M}$: Introduced in Section 4.3.5. This matrix is used to disentangle the power spectra ($P(k)$, $\beta P(k)$, and $\beta^2 P(k)$) while decorrelating neighboring points of each of the power spectra.

n_s: Introduced in Chapter 1. The "tilt" of the power spectrum.

P_k: Introduced in Chapter 1. The power spectrum at wavenumber k.

^{r}: Superscript r shows a quantity that is in real space.

^{s}: Superscript s shows a quantity that is in redshift space.

W: Introduced in Equation 2.1. A window function. In Equation 2.1 the indices of W_{ij} refer to the locations of the two positions. Thereafter, the first index (usually a or b) refers to the window number. In particular, there may be separate windows for different separations and, within those windows, there may be different windows for different shape functions. The following indices (usually some combination of i, j, k, and l) refer to locations. In general, the windows are chosen to try to make the best use of the data.

$\hat{x}$: Introduced in Chapter 2. A mode amplitude. This is the overdensity weighted by a linear window function. The hat signifies that it is a measured quantity.

$\hat{X}$: Introduced in Chapter 2. A quadratically weighted mode. This is the overdensities weighted by a quadratic window (one with two indices of location). The hat signifies that it is a measured quantity.

B.3 Greek Symbols

α: Introduced in Chapter 4. This quantity ($\alpha = \partial \ln r^2 \bar{n} / \partial \ln r$) is $2+$ the partial derivative of the logarithm of the selection function with respect to the logarithm of the distance. It determines how radial variations of the selection function affects redshift distortions.

β: Introduced in the Abstract. $\beta (= f/b)$ is the amplitude of the linear redshift distortions.

δ_i: Introduced in Chapter 2. The overdensity (of galaxies) at location $\mathbf{r}_i$. (If $\delta_i = 1$ then that means the density at $\mathbf{r}_i$ is twice the mean density.)

δ_{ij}: Used in Chapter 2. This is a 3-dimensional delta-function.

ξ: Introduced in Chapter 2. The 2-point correlation function in some space. In k-space this is the power spectrum.

- **ξ^r:** Introduced in Chapter 4. This is the correlation function in real space.
- **ξ^s:** Introduced in Chapter 4. This is the correlation function in redshift space.
- **$\hat{\xi}_\alpha$:** Introduced in Section 2.1.1. The hat indicates that this is a measurement of the quantity rather than a prior guess of the quantity.
- **$\breve{\xi}$, $\bar{\xi}$, and $\bar{\bar{\xi}}$:** Introduced in Chapter 4. Averages of the two point correlation function over different functions of r. These averages become interesting due to redshift distortions.
- **$\check{\xi}$:** Introduced in Chapter 4. Measurable quantities in the case of redshift distortions. Each contains a function g of β and a Ξ. Each $\check{\xi}$ can be Fourier transformed into $g(\beta)P(k)$ (using the proper generalized Fourier transform window).

Ξ_i**:** Introduced in Chapter 4. Functions of ξ, $\breve{\xi}$, $\bar{\xi}$, and $\bar{\bar{\xi}}$ produced by redshift distortions. Each of the Ξ_i's can be Fourier transformed into $P(k)$ (using the proper generalized Fourier transform window).

ρ_a**:** Introduced in Chapter 1. The density of constituent a.

ρ_{crit}**:** Introduced in Chapter 1. The critical density of the Universe. If the sum of the densities of the sum of all constituents is the critical density then the universe is flat.

Ω_a**:** Introduced in Chapter 1. The ratio $\rho_a/\rho_{\mathrm{crit}}$ of the density of constituent a (ρ_a) to the critical density ρ_{crit}.

Ω_b**:** Introduced in Chapter 1. The ratio $\rho_b/\rho_{\mathrm{crit}}$ of the density of baryons to the critical density ρ_{crit}.

Ω_Λ**:** Introduced in Chapter 1. The ratio $\rho_\Lambda/\rho_{\mathrm{crit}}$ of vacuum energy density to the critical density ρ_{crit}.

Ω_m**:** Introduced in the Abstract. The ratio $\rho_m/\rho_{\mathrm{crit}}$ of the density of matter to the critical density ρ_{crit}.