LECTURE 14: THE MEASUREMENT OF RSD

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The RSD is much more difficult to measure accurately, simply because it is harder to model the velocity power spectrum properly, even on linear scales. The commonly used model, or template, of the RSD is called the TNS model [4].

$$\begin{aligned} P_{\rm g}(k,\mu,z) =& D_{\rm FOG}\left(k,\mu_2,z\right)\left[P_{{\rm g},\delta\delta}(k,z)\right. \\ &+ 2f(z)\mu^P P_{{\rm g},\delta\theta}(k,z) + f^2(z)\mu^4 P_{\theta\theta}(k,z) \\ &\left.+ A(k,\mu,z) + B(k,\mu,z)\right] \end{aligned} \tag{1}$$

where,

$$\begin{aligned} P_{{\rm g},\delta\delta}(k,z) =& b_1^2(z)P_{\delta\delta}(k,z) + 2b_1(z)b_2(z)P_{{\rm b2},\delta}(k,z) \\ &- \frac{8}{7}b_1(z)\left(b_1(z)-1\right)P_{{\rm bs2},\delta}(k,z) \\ &+ \frac{64}{315}b_1(z)\left(b_1(z)-1\right)\sigma_3^2(k,z)P_m^{\rm L}(k,z) \\ &+ b_2^2(z)P_{\rm b22}(k,z) - \frac{8}{7}\left[b_1(z)-1\right]b_2(z)P_{\rm b2s2}(k,z) \\ &+ \frac{16}{49}\left[b_1(z)-1\right]^2 P_{\rm bs2}(k,z) \end{aligned} \tag{2}$$

$$\begin{aligned} P_{{\rm g},\delta\theta}(k,z) =& b_1(z)P_{\delta\theta}(k,z) + b_2(z)P_{{\rm b2},\theta}(k,z) \\ &- \frac{4}{7}\left[b_1(z)-1\right]P_{{\rm bs2},\theta}(k,z) \\ &+ \frac{32}{315}\left[b_1(z)-1\right]\sigma_3^2(k,z)P_m^{\rm L}(k,z) \end{aligned} \tag{3}$$

$$\begin{aligned} P_{{\rm g},\theta\theta}(k,z) &= P_{\theta\theta}(k,z) \\ D_{\rm FoG}(k,\mu,z) &= \left\{1+\left[k\mu\sigma_v(z)\right]^2/2\right\}^{-2} \\ A(k,\mu,z) &= b_1^3(z)\sum_{m,n=1}^{3}\mu^{2m}\left[f(z)/b_1(z)\right]^n A_{mn}(k,z) \\ B(k,\mu,z) &= b_1^4(z)\sum_{m=1}^{4}\sum_{a,b=1}^{2}\mu^{2m}\left[-f(z)/b_1(z)\right]^{a+b} B_{ab}^m(k,z) \end{aligned} \tag{4}$$

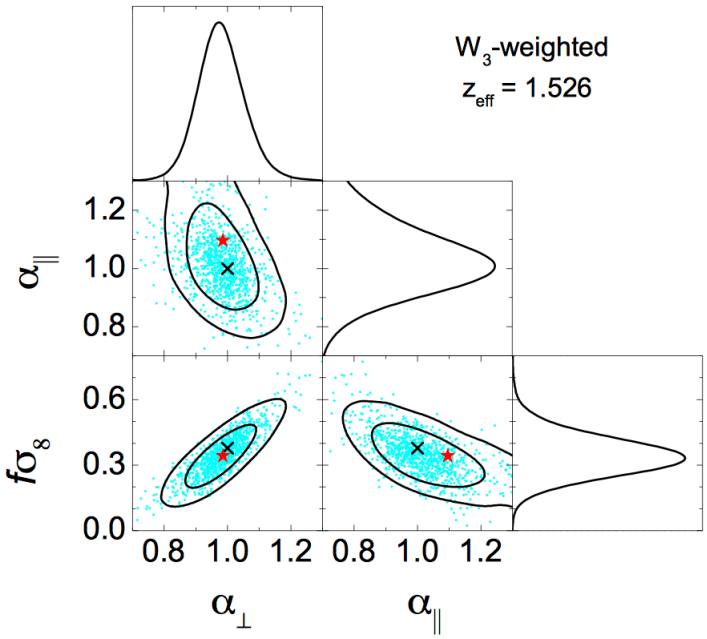

FIGURE 1. The BAO and RSD fit in k-space using BOSS DR14 quasar mock data [5].

$$b_{\rm s2} = -\frac{4}{7}\,(b_1 - 1) \tag{5}$$
$$b_{\rm 3nl} = \frac{32}{315}\,(b_1 - 1)$$

There are two approaches for the full-shape analysis: A) a fixed-template analysis and B) a full-modeling analysis.

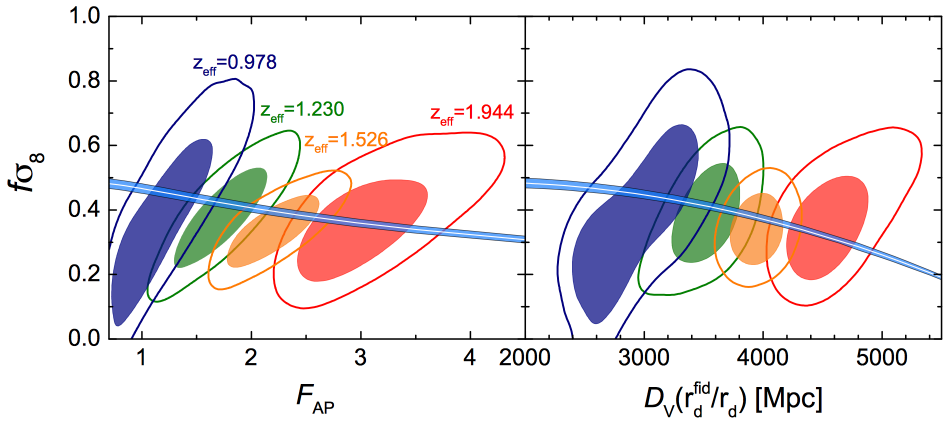

FIGURE 2. The BAO and RSD fit in k-space using the actual BOSS DR14 quasar data [5].

1. A FIXED-TEMPLATE ANALYSIS

A fixed-template analysis means that the 'model' used for the full-shape analysis has a fixed shape, generated using a fiducial cosmology. This is why it is called a 'template' instead of 'model'. Traditional measurements for $f\sigma_8$ follow this approach, including the works in [5, 6, 7].

Recently, a new approach called 'ShapeFit' [8] was developed to extend the applicability of the fixed-template analysis, which can be regarded as an improved version of the fixed-template analysis (but it is still a fixed-template analysis). The new DESI analysis took this approach [9].

2. A FULL-MODELING ANALYSIS

A full-modeling analysis means that the shape of the model varies with cosmological parameters, which is more robust but computationally more expensive. In this approach, the theory model of EFTofLSS [10] is widely used. Recent implications include [9, 11, 12, 13].

Recently, a new method for the RSD measurement is developed by cross-correlating the pre- and post-reconstructed density fields [14]. This is a very efficient way to extract high-order statistics from 2-point statistics.

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