Notes: Error on the Power Spectrum

Sahba Yahya

July 3, 2014

1 Analytic solution

$$F^*_{ij} = V_{\rm sur}\int_{k_{min}}^{K_{max}} \frac{2\pi k^2 dk}{2(2\pi)^3}\left[1+\frac{1}{nP}\right]^2 \tag{1}$$

where,

$$P(k,\mu) = R(\mu,k)P_{lin}(k)\left[\frac{g(z)}{g(z_{in})}\frac{(1+z_{in})}{(1+z)}\right]^2 b^2, \tag{2}$$

$$R(\mu,k) = 1. \tag{3}$$

and

$$V_{\rm sur} = \left(\frac{\pi}{180}\right)^2 \; S_{\rm area}\int_{z_{\rm max}}^{z_{\rm min}} \frac{dV}{dz}, \tag{4}$$

where $z_{\rm min} = 0.9$, $z_{\rm max} = 1.1$ and $S_{\rm area} = 30000$ deg^2. dV/dz defined as:

$$dV/dz = (1+z)^2 D_A^2 \frac{c}{H_0}\frac{1}{h}$$

The units for the $V_{\rm sur}$ is h^{-3}Mpc^3.

Setting $n \sim \infty$

$$F^*_{ij} = V_{\rm sur}\int_{k_{min}}^{K_{max}} \frac{2\pi k^2 dk}{2(2\pi)^3} \tag{5}$$

solve the integral

$$F^*_{ij} = V_{sur}\frac{1}{(24\;\pi^2)}\left[k^3_{max} - k^3_{min}\right] \tag{6}$$

Arbitrary choices, $k_{min} = 0.001$, $k_{max} = 0.1$ and $V_{\rm sur} = 3e10$ for z=1, and survey area is 30000 [deg^2]:

$$F^*_{ij} = 5.25512\times 10^{-7} V_{\rm sur} = 8554, \tag{7}$$

$$\frac{\delta P}{P} = \sqrt{(F^*_{ij})^{-1}} = 0.011, \tag{8}$$

Fig. 1 shows $\frac{\delta P}{P}$ for $S_{rms} = 7.3$ and the analytic solution proven above.

2 Euclid

Fig. 2 shows Euclid $\frac{\delta P}{P}$ produced using the definition in Bull et al 2014, not this figure shows produced with z =1, the bias = $\sqrt{(1+z)}$ =1.41421, $k_{\max}$ = 0.16926 hMpc^{-1}, the survey volume has been calculated using Eq. 4 and the Survey area is 15000 deg^2.

Fig. 3 shows the binned k Mpc^{-1}h. To check with Phil Bull results, we run camb with Plank's best fit parameters (see Fig. 4):

```
# Planck best-fit parameters
cosmo = {
    'omega_M_0':        0.316,
    'omega_lambda_0':   0.684,
    'omega_b_0':        0.049,
    'N_eff':            3.046,
    'h':                0.67,
    'ns':               0.962,
    'sigma_8':          0.834,
    'gamma':            0.55,
    'w0':               -1.,
    'wa':               0.,
    'sigma_nl':         7.,
```

3 Fractional error on DA and H

Fig. 5 shows the errors on $\sigma_H/H\%$ and $\sigma_{D_A}/D_A\%$ using wiggles only method.

$$\left(\frac{\delta P}{P}\right)^2 = \left[V_{\rm sur}\int_{k_{min}}^{K_{max}} \frac{2\pi k^2 dk}{2(2\pi)^3}\left(1+\frac{1}{nP}\right)^2\right]^{-1} \tag{9}$$

4 Binning the Power spectrum

Binning primary goal is to reduce the effects of minor observation errors. The original data values which fall in a given small interval (bin) replaced by a value usually in the middle of that interval.

Combining Eq. 4 and Eq. 10 and replacing $k_{\min}$ and $k_{\max}$ by k and $k+\Delta k$ respectively, we get:

$$F^*_{ij} = V_{sur}\frac{1}{(24\ \pi^2)}\left[k^3-(k+\Delta k)^3\right] \tag{10}$$

$$F^*_{ij} = V_{sur}\frac{1}{(24\ \pi^2)}\left[2k^3+3k^2\Delta k+3k\Delta k^2+\Delta k^3\right] \tag{11}$$

Choosing the size and the width of the bin is essential, from Eq. 11, choosing wider bins will make $\delta p/p$ smaller than choosing finer bins.

5 Baryon Power spectrum

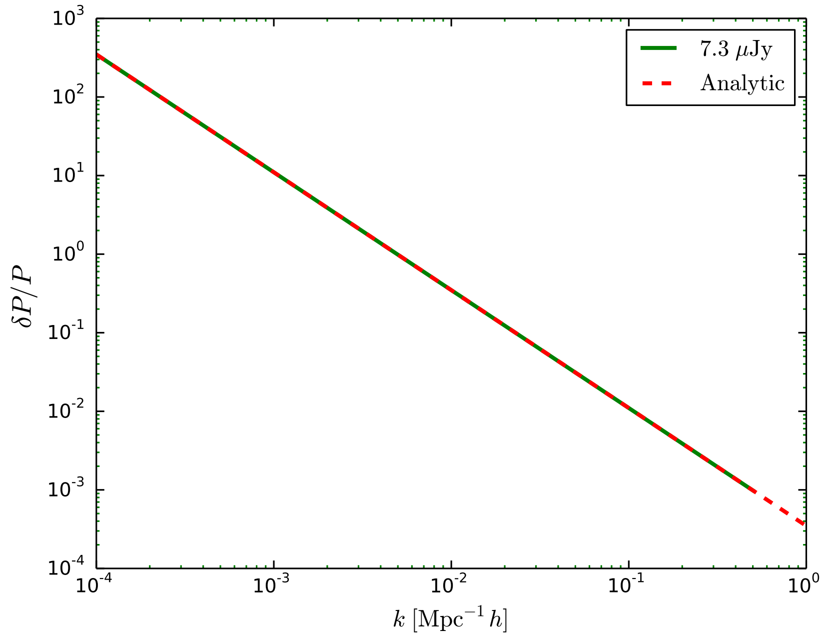


Figure 1: The Figure shows $\delta P/P$ where n is very large (using Eq. 10). The red dot point represent the analytic solution, for red-shift 1 and the corresponding bias=1.4.

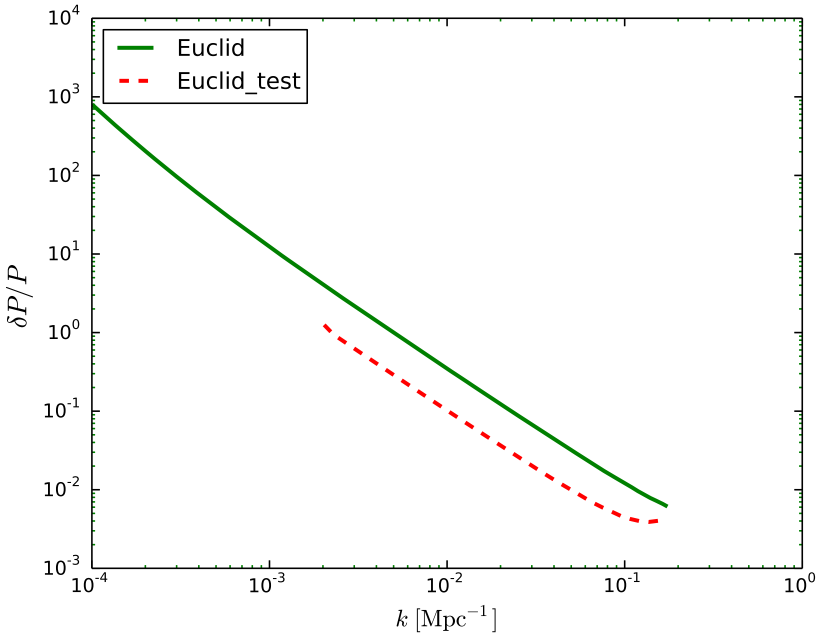


Figure 2: The Figure shows $\delta P/P$ for Euclid, for red-shift 1 and the corresponding bias=1.5.

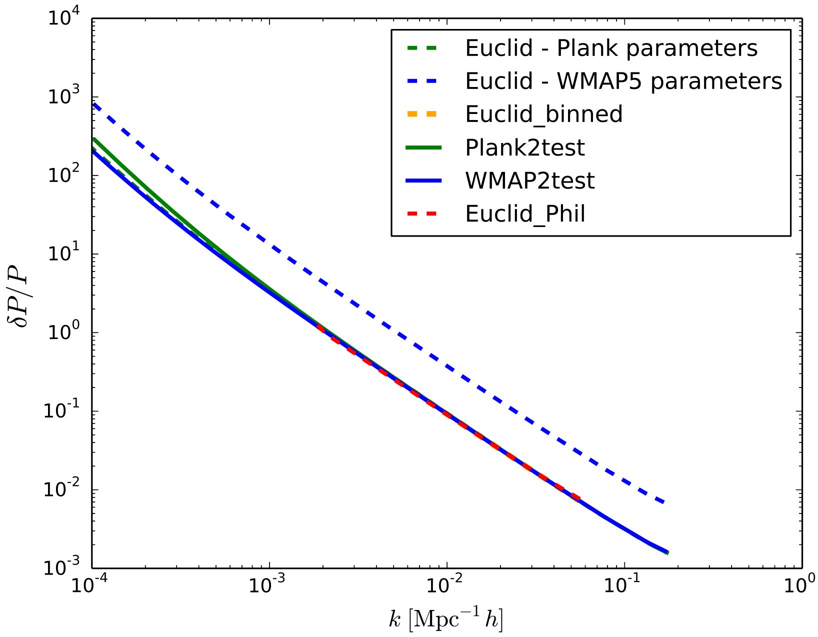


Figure 3: The Figure shows $\delta P/P$ for Euclid, for red-shift 1 and the corresponding bias=1.5. All the approached lie on top of each other except when we use the WMAP 5 parameters (blue).

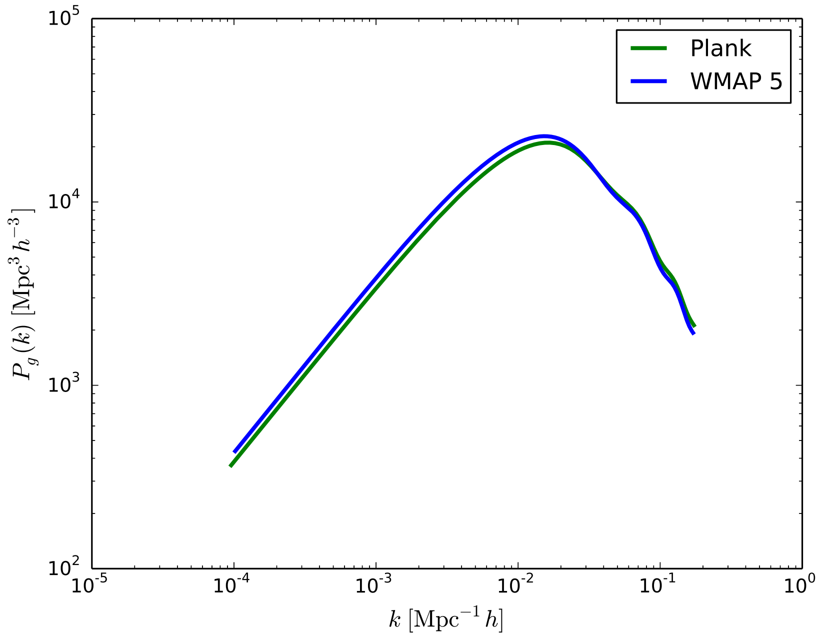
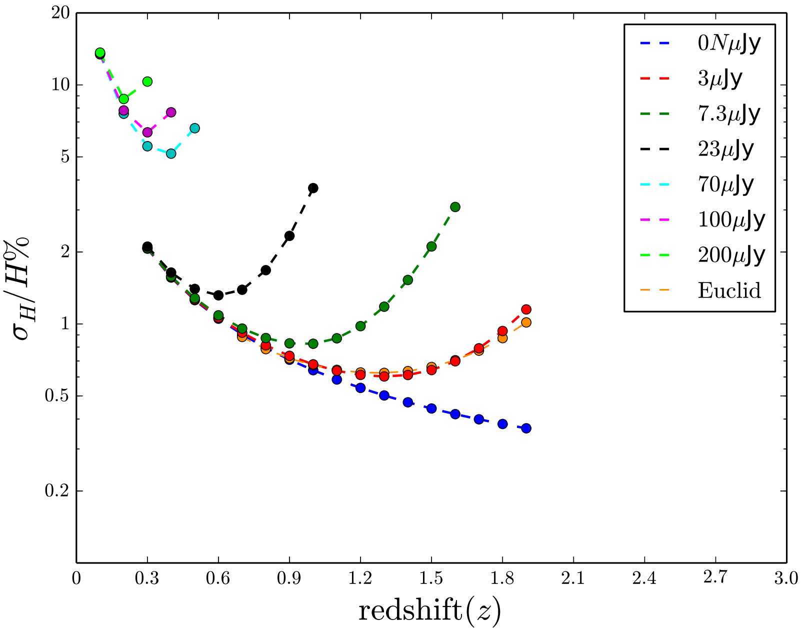


Figure 4: The power spectrum vs k Mpch^{-1}



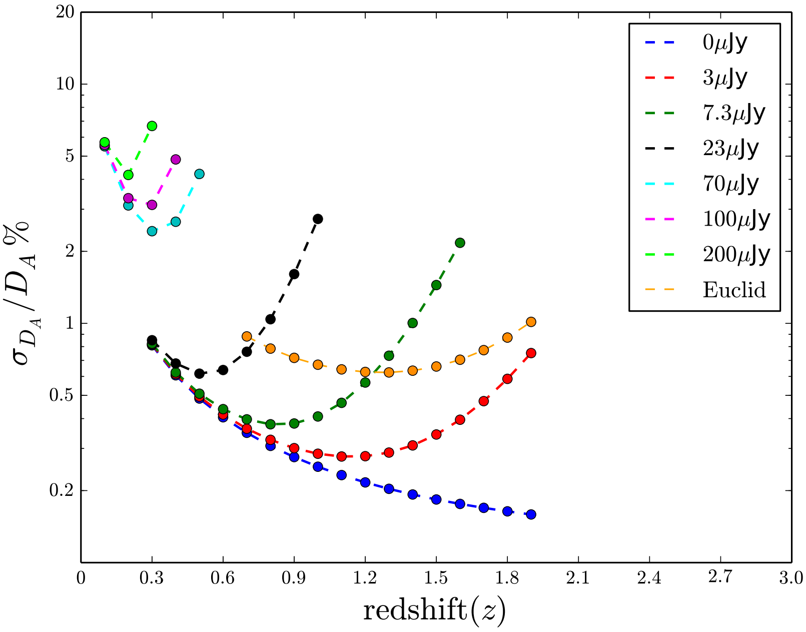


Figure 5: The Figure shows $\sigma_H/H\%$ and $\sigma_{D_A}/D_A\%$ for SKA and Euclid (orange).