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Inpainting of Galaxy Redshift Surveys

Elisa Antolini[1], Ilaria Caiazzo[2], Jeremy S. Heyl[⋆2]
[1] *Dipartimento di Fisica e Geologia, Università degli Studi di Perugia, I-06123 Perugia, Italia*
[2] *Department of Physics and Astronomy, University of British Columbia, 6224 Agricultural Road, Vancouver, BC V6T 1Z1, Canada*

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ABSTRACT

1 THE TECNHIQUE

The technique is straightforward to describe and to implement, and we will outline it below. Let the map be given by $a(\Omega)$ and the mask by $m(\Omega)$ where $m(\Omega) = 1$ where the underlying galaxies are visible.

(i) Set an initial guess for the underlying map.

$$y_1(\Omega) = \frac{\langle m(\Omega)a(\Omega)\rangle}{\langle m(\Omega)\rangle} \tag{1}$$

(ii) Calculate the residual of the current guess

$$r_t(\Omega) = m(\Omega)a(\Omega) - y_t(\Omega) \tag{2}$$

(iii) Expand the sum of the residuals in the unmasked region and the current guess in spherical harmonics.

$$A_{lm,t} = \int d\Omega Y^*_{lm} \left[m(\Omega)r_t(\Omega) + y_t(\Omega)\right] \tag{3}$$

(iv) Keep only the components with the largest amplitudes and set the amplitudes smaller than the threshold (λ_t) to zero.

(v) Calculate the new guess from the largest components

$$y_{t+1}(\Omega) = \sum_{|A_{lm,t}|>\lambda_t} A_{lm,t}Y_{lm}(\Omega). \tag{4}$$

(vi) Decrease the threshold λ_t and repeat from step (ii) until the stopping criterion is reached.

There is of course some art in choosing the size of the underlying basis, the thresholds and the stopping criterion. Here we expand the galaxy map to $l_{\rm max} = m_{\rm max} = 64$, so there are a total of 2,145 components. The threshold is set to keep a given fraction of the components at each step. The fraction increases from $10^{-3.5}$ to $10^{-0.5}$ over 200 iterations, so the initial representations use just a few components and the number of components increases to about 680 at the final iteration, so over two thirds of the spherical harmonic components are set to zero in the final map.

From the iterative procedure above it is apparent that the value of the guess within the masked region (where $m(\Omega) = 0$) does not contribute to the residual and does not influence the solution. However, the spherical harmonics that contribute to the data near the edge of the mask do influence the guess within the masked region.

fake test gives R=0.70

2 TESTS

To understand the effectiveness of these techniques we simulate galaxy sky maps with the Galactic plane hidden and cross-correlate the restructed galaxy maps with the original simulated map. For make the simulation as realistic as possible we use the angular power spectrum of the observed galaxy map from 2MASS to construct the test maps. These simulated maps by design have the same angular power spectrum as the real 2MASS data including the zone of avoidance but different phases, so they don't exhibit a zone of avoidance and they lack the potential higher order correlations that the data may exhibit.

2.1 Simulated Maps

2.2 Observed Maps

3 RESULTS

4 DISCUSSION

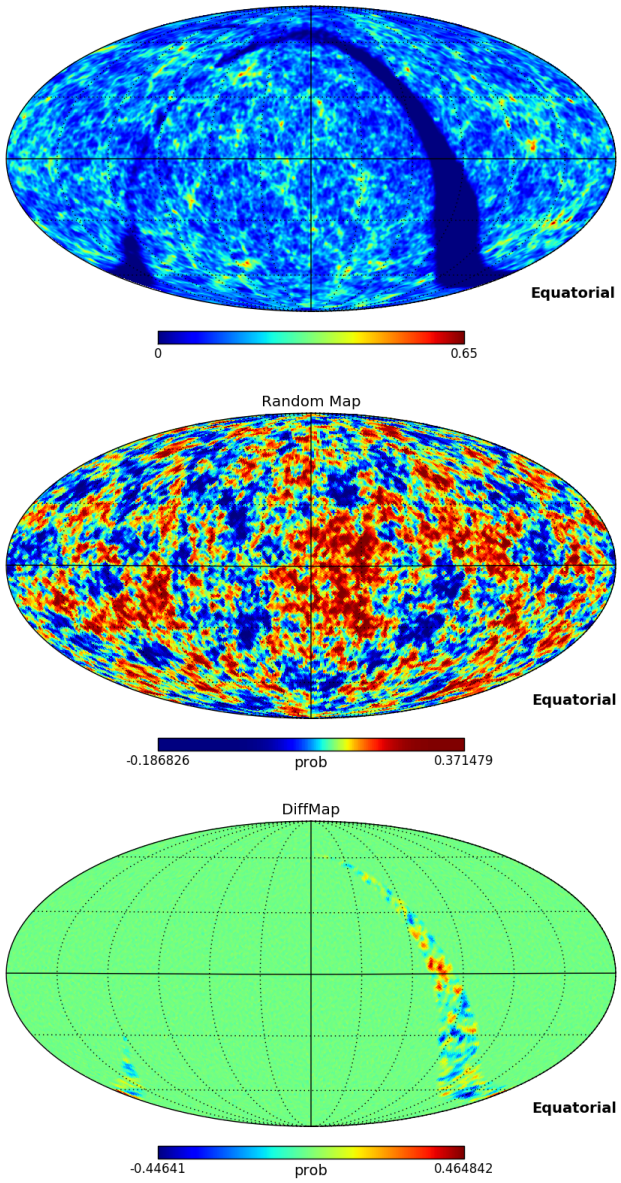

Figure 1. Upper: the relative surface density of galaxies in the 2-MASS Photometric Redshift Survey with photometric redshifts between 0.01 and 0.1, smoothed with a Gaussian of 0.6 degrees (0.01 radian), the input map. Middle: the test map constructed using the angular power spectrum of the map in the upper panel. Lower: we masked the Galactic plane of the middle panel and reconstructed the image using the techinque in § **??**. The difference between the middle panel and the reconstructed map is depicted.