National Aeronautics and Space Administration

Maximizing the Scientific Impact of the SPHEREx All-sky Spectral Survey

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Program: FY21 R&TD Topics **Strategic Focus Area: Origin, evolution, and structure of the universe**

Objectives: The main goal of this proposal is to develop methodology and implementation code to measure the 3D galaxy clustering accurately and efficiently on the largest scales. It is directly relevant to one of the SPHEREx MIDEX mission core science goal, which is to probe the origin and destiny of our Universe through the large-scale clustering of galaxies. SPHEREx will provide the first near-infrared all-sky spectral survey for the astronomical community and will create a data-set of lasting legacy. In particular, to probe the distribution of matter on the largest scales, SPHEREx will produce a galaxy redshift catalog containing 500M galaxies.

Approach and Results: We continued implementing two different methods to measure the power spectrum of galaxies on large-scales.

(1) We implemented a full sky Spherical Fourier Bessel Function (SFB), which combines spherical angular transform in the angular space with a Hankel transform in the radial direction. We handled the partial sky coverage and the induced harmonic 3D mode coupling using an approximate formalism analogous to what was developed for CMB experiments like Planck. This implementation is described in a publication (Gebhardt & Doré 2021a) and the Julia code associated has been released.

(2) We then devised a new harmonic basis that remains orthonormal on any partial sky coverage. This is achieved by solving for eigenmodes of the spherical Laplace operator on arbitrary sky area. The main advantage of this method is that it takes into account exactly the mask induced mode coupling and lead to a diagonal covariance matrix. There is no mode coupling in the associated basis, which is a great formal simplification and opens up new opportunities at higher order. This work is described in a submitted publication (Gebhardt & Doré 2021b) and the Julia code has also been released.

Significance and Benefits to JPL and NASA: This proposal aims at increasing JPL scientific leadership and science impact through the recently selected SPHEREx astrophysics medium size explorer (MIDEX). It continues to build upon the long JPL tradition of novel statistical data analysis methodology.

Publications: (1) Gebhardt & Doré, Physical Review D, 2021a, arXiv: 2102.10079 **(2)** Gebhardt & Doré, submitted to JCAP, 2021

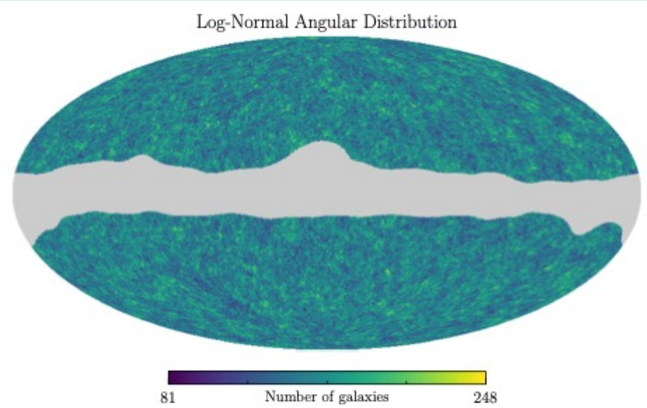

Fig. 1: Example of SPHEREx angular mask populated with log-normal galaxy distribution.

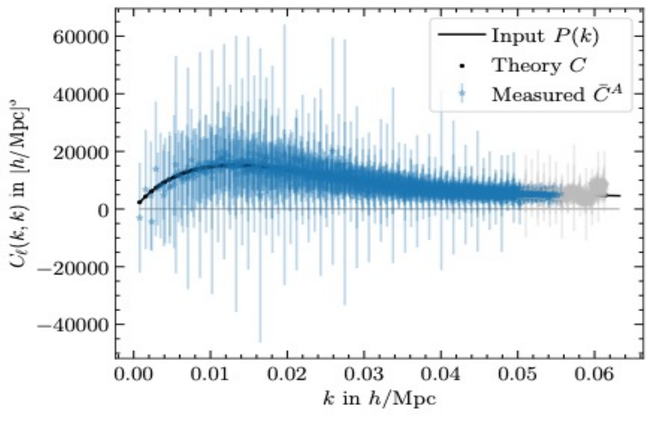

Fig. 2: Theory and measured SFB power spectrum measured and averaged over 50 simulations (from Gebhardt & Doré 2021a)

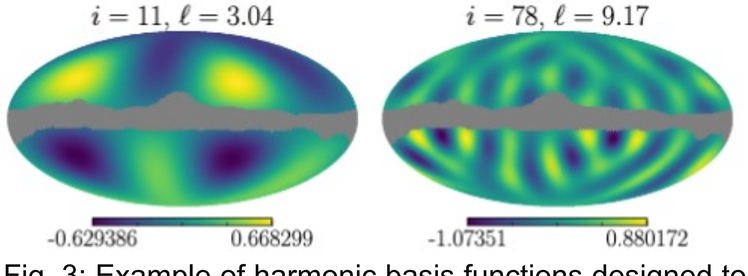

Fig. 3: Example of harmonic basis functions designed to be orthonormal on SPHEREx angular mask (from Gebhardt & Doré 2021b)

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