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Galaxy Clustering in Far-Infrared SWIRE Fields

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Abstract. We present measurements of galaxy clustering detected in the six SWIRE fields in all MIPS channels at 24, 70, and 160 microns. The measurements include the low-order 2-point angular correlation functions, and high-order probes including probability distribution functions and Rényi information.

1. Introduction

The *Spitzer* Wide-Area Infrared Extragalactic Survey (SWIRE) is the largest of the *Spitzer* Legacy programs covering 50 square degrees (Lonsdale et al. 2003). SWIRE provides unprecedented view of the galaxies and structures in infrared universe from 3.6 to 160 microns, tracing their evolution to a redshift of 2.5 and beyond.

The *Spitzer* mapping observations at 24, 70, and 160 microns of the six SWIRE fields have a typical coverage of 44 Basic Calibrated Data (BCD) images and 160 seconds of integration time per point. The Lockman and CDFS fields contain higher coverage with once-embargoed or validation data. The ELAIS-S1 field received only half of the nominal coverage.

2. MIPS Samples

The 24 microns raw data were processed by the S10.5 version of the SSC pipelines, flat-fielded based on scan mirror position. The SWIRE processing evens out variations in the background using the median of each image. The corrected BCDs were co-added into large mosaics using MOPEX, and source extracted using SExtractor. The nominal 1-sigma noise is 45-50 microJy. For 70 and 160 microns we co-add and source extract the filtered S11 BCDs using MOPEX. PRF fitting yields more reliable results than aperture measurements

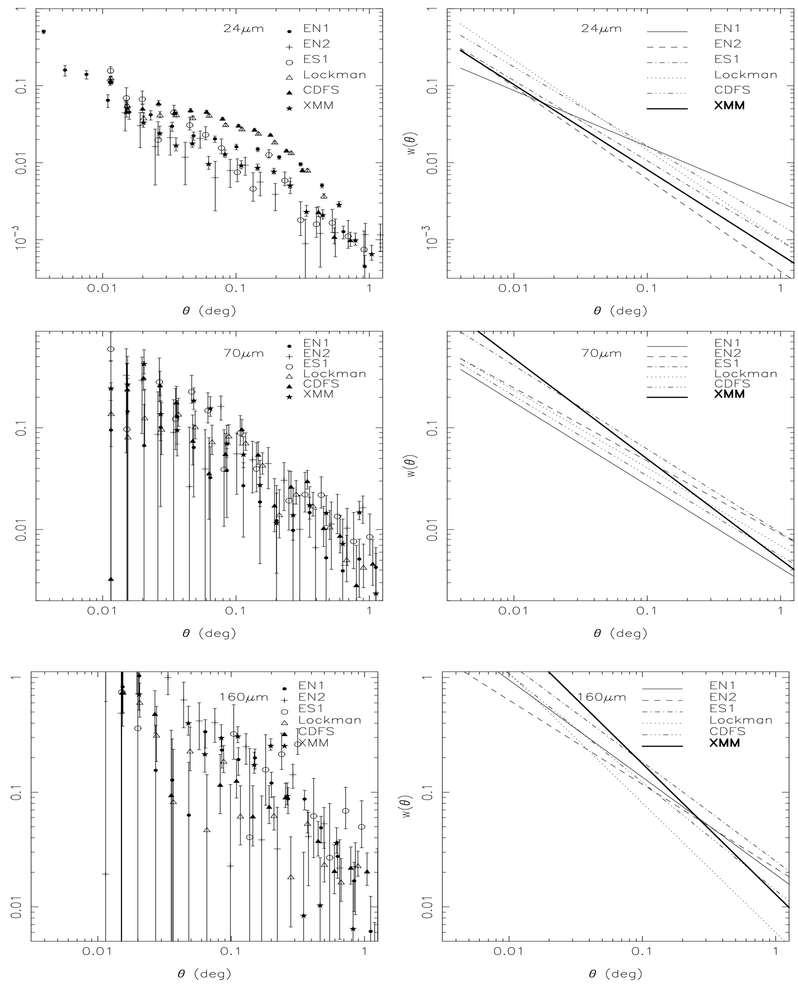

Figure 1. Angular two point correlation function at 24, 70 and 160 μm. The left panel shows the data while the right panel shows models which are simple power laws.

for faint sources in Ge data. The effective average point-source rms for the most fields is 3.5 mJy at 70 microns and 21 mJy at 160 microns.

We construct 7-sigma samples at 24 microns in the six fields. We require IRAC coverage and detection at 3.6 microns to remove stellar contamination. The number of extragalactic sources in our final samples are 6895, 7142, 5872, 18677, 19907, 22181 for ELAIS-S1, ELAIS-N2, CDFS, XMM, ELAIS-N1, and Lockman fields, respectively.

In 70 and 160 microns, we use a 5-sigma flux limit for the samples. We mask out the region around star Mira in the XMM field. The number of extragalactic sources are 671, 784, 1121, 1103, 1646, 1646 in 70 microns, 119, 294, 416, 480, 620, 608 in 160 microns in these fields, respectively.

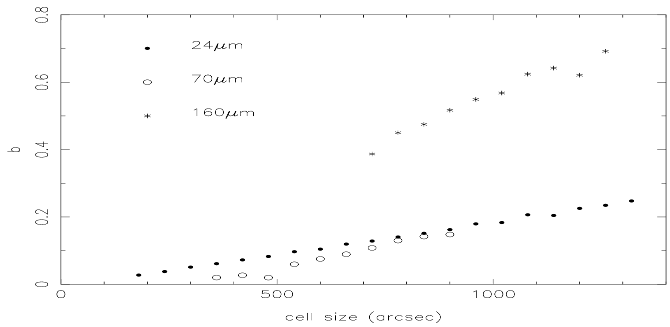

Figure 2. The probability distribution function plotted against cell size.

3. The Angular 2-point Correlations

The galaxy angular 2-point correlation function measures the excess numbers of pairs of galaxies in a single catalog as a function of angular separation compared to those in a random distribution (Fang et al. 2004). We use the Landy & Szalay estimator to calculate the 2-point angular correlation functions in the MIPS samples. We also perform linear modeling in logarithmic space, both shown in the left and right panels of Figure 1. Results from the six fields converge nicely in six fields, showing small cosmic variance. The correlation amplitude at 1 degree averaged over the fields are 0.001, 0.004, and 0.01 at 24, 70, and 160 microns, respectively. There is a noticeable "bump" in correlation from our largest Lockman, ELAIS-N1, and CDFS samples at 24 microns, however.

4. The Probability Distribution Function (PDF)

A PDF describes the probability of finding a given number of galaxies in space within a given scale of area or volume. A counts-in-cells method is used to estimate the PDF (Figure 2). The area covered by a sample is divided into cells of a given size. We use mosaic coverage file to determine the usage of each cell, and count the number of galaxies in the cells and establish the PDF.

To interpret the PDF, we use a Gravitational Quasi-Equilibrium Distribution function (Saslaw & Hamilton 1984; Saslaw & Fang 1996) to fit the distributions. The single fitting parameter b, the ratio of correlation potential energy and twice the kinetic energy, is a physical parameter, and its measured scale-dependence is shown in the above figure. Here we combined the counts in given-size cells from all six SWIRE fields before PDF fitting.

5. Rényi Information and Multi-fractality

The Rényi information (Rényi 1970) is directly related to the moments of the probability distribution (Fang 2006). The information series can be measured using a similar counts-in-cells procedure. They describe arbitrary levels of under- and over-density in a spatial structure.

In Figure 3, we plot the measured Rényi information, at orders 2, 3, 5, 10, and 20 (bottom to top), as a function of scale for the samples. The slope at a given order is also a measure of the multi-fractal dimension. The linearity of

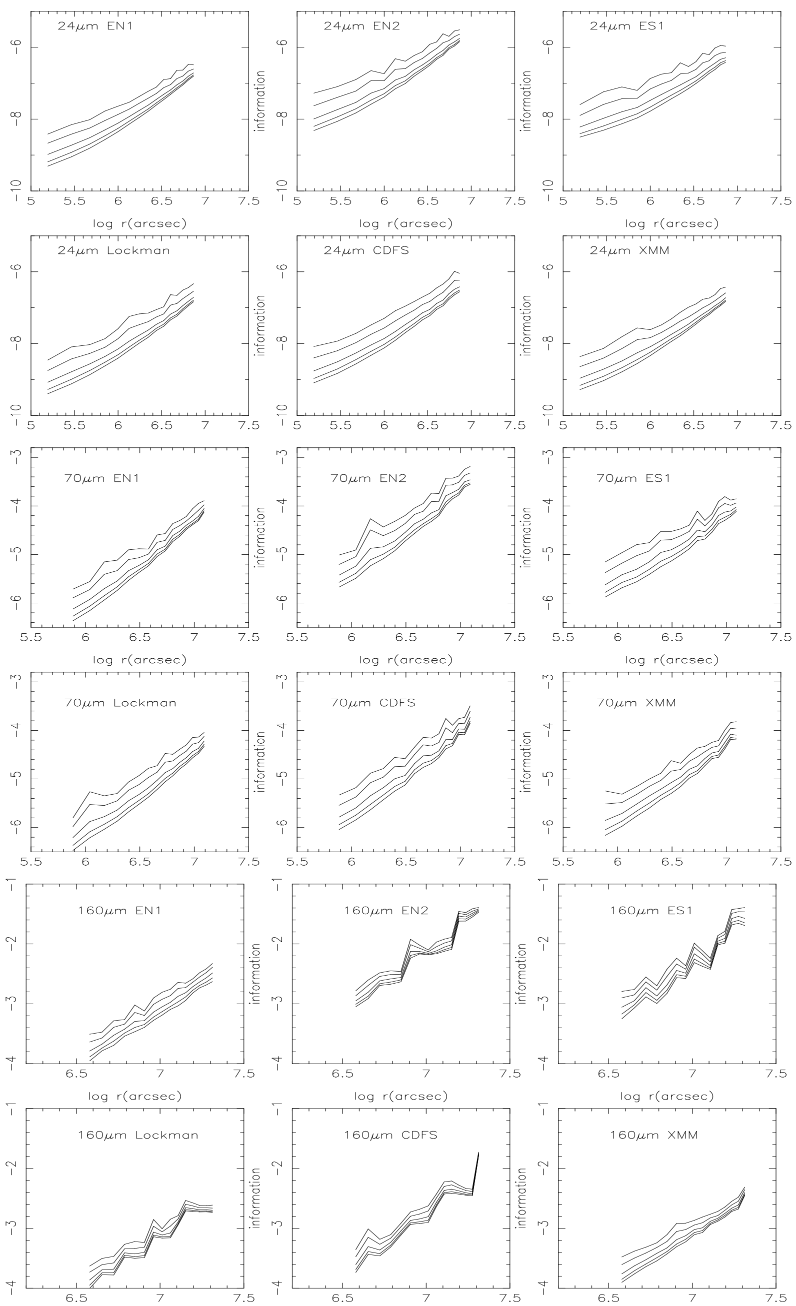

Figure 3. Rényi information for the six fields at 24, 70 and 160 μm.

the slopes implies that the galaxy distribution over the scales probed is a simple multi-fractal. This is less conclusive for sources at 160 microns, however, where the small sizes of the samples introduce significant noise in the measurement.

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