Deep and Wide Mid-Infrared Source Counts from the SWIRE Survey

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Background

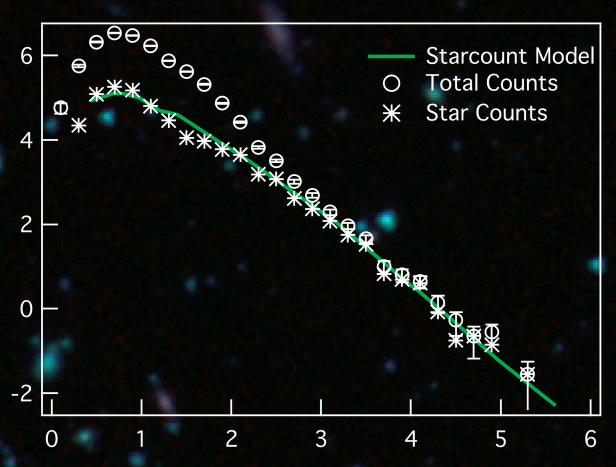
The Spitzer Wide-field Infrared Extragalactic (SWIRE) Survey is mapping 50 square degrees of the sky, split over 6 different regions (P.I. C.J. Lonsdale, see Lonsdale et al. 2003). These are the Lockman Hole, the Chanda Deep-Field South, the ELAIS N1, N2 and S1 survey regions, and the XMM-LSS region. Each of these have been specially chosen to have the lowest possible backgrounds at mid and far-infrared wavelengths (where the zodiacal background and galactic cirrus emission are the dominant contributors), and are the best contiguous large regions for study. Imaging data are collected with Spitzer at 3.6, 4.5, 5.8, 8.0, 24, 70, and 160μm. The SWIRE group (consisting of several dozen astronomers split over a dozen U.S. and European institutions) is additionally collecting ground-based imaging over most of the survey regions; both ourselves and outside groups are additionally collecting other datasets over subregions of the survey, including radio and X-ray data. The Spitzer Legacy data is publicly available from the Spitzer Science Center. In addition, the SWIRE project has made available more advanced, processed data products including catalogs and mosaiced images. Currently this includes Spitzer mid and far-IR data and UgriZ imaging for the ELAIS-N1 region. For more information, including access to these data products, please see *http://swire.ipac.caltech.edu.*

The origin of the present-day galaxy distribution is of particular interest in modern astronomy. Different models for galaxy evolution predict different distributions of galaxy populations as a function of redshift. Infrared observations are ideal; the shorter mid-IR wavelengths correspond to the redshifted peak of the rest-frame galaxy spectral energy distribution that arises from stars. Furthermore, the strong bursts of star formation expected to occur during galaxy formation manifest themselves directly as emission at longer infrared wavelengths; such bursts may otherwise be too obscured to be detected at the optical wavelengths more commonly used by surveys. It is impractical (or impossible) to acquire spectroscopic data for the millions of optically faint objects in a survey such as this. However, theoretical models of galaxy populations can be used to directly generate the observed flux distribution of sources. The observed distribution can therefore be used to constrain existing models. Shallower source counts have been derived in the mid-IR bands based on ISO. Several deep surveys exist in the near-IR, specifically at K-band. Most recently, source counts of a similar nature were presented by Fazio et al. (2004), as derived from the multi-tiered IRAC GTO survey regions.

This Project

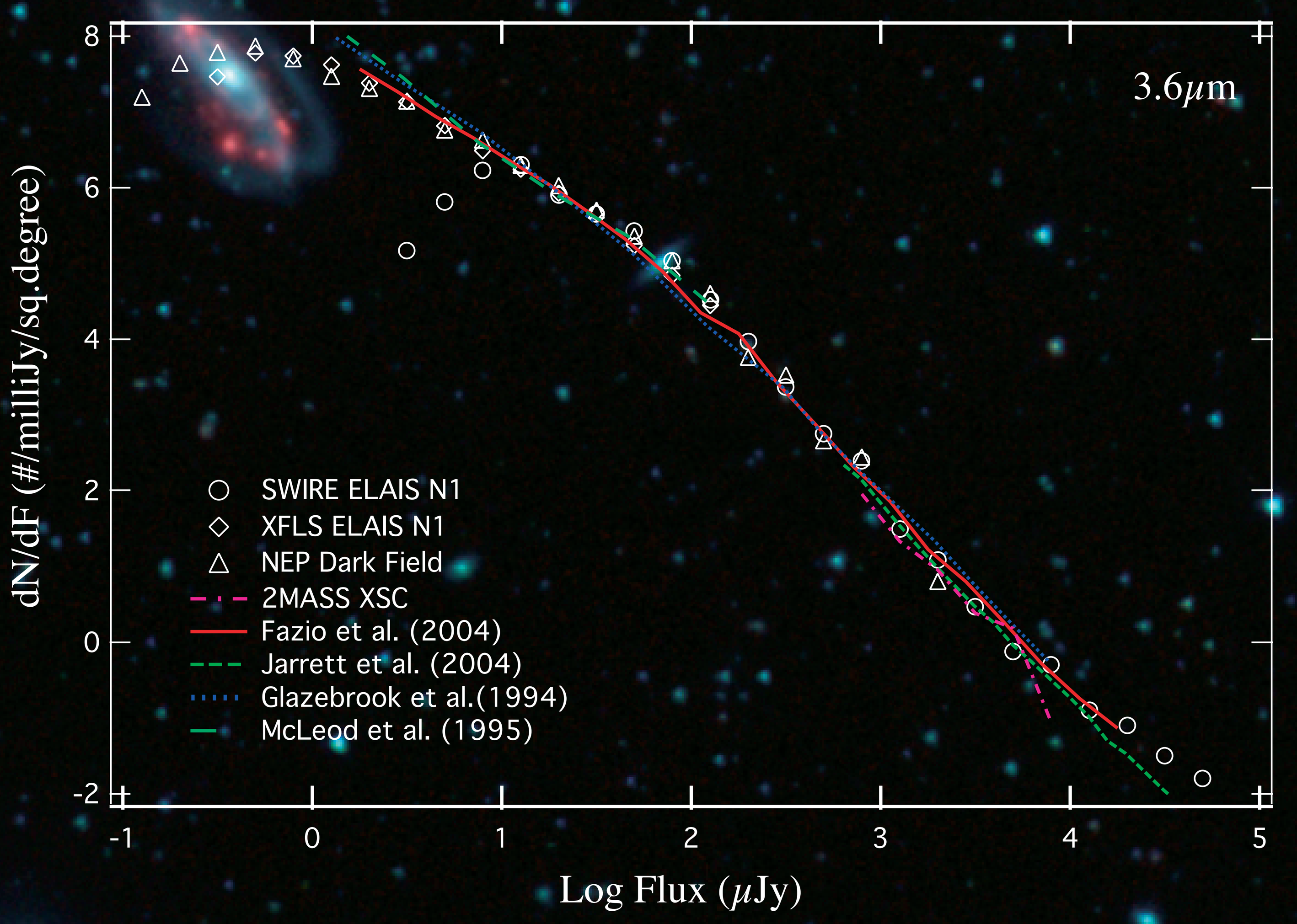
In this project we have used several available datasets to evaluate the number counts over both wide, shallow areas and small, deep areas, at wavelengths from 3.6-8μm. From the SWIRE project these were the 9 square degree ELAIS-N1 field and our 0.4 square degree validation observation of the Lockman Hole. The SWIRE data by itself is relatively shallow, and at 3.6μm the differential galaxy number counts are significantly contaminated by uncertainties in star identification. We have therefore used two other deeper datasets. The first is a deeper pointing in the ELAIS N1 region taken as part of the extragalactic First Look Survey, and which forms the backbone of the SWIRE validation plan. Finally, we have used the first six months of available dark data used for calibrating the IRAC camera, taken near the north ecliptic pole. These data reach a depth of roughly 12 hours per point on the sky (300 times that of SWIRE), but over an area of only 0.03 square degrees.

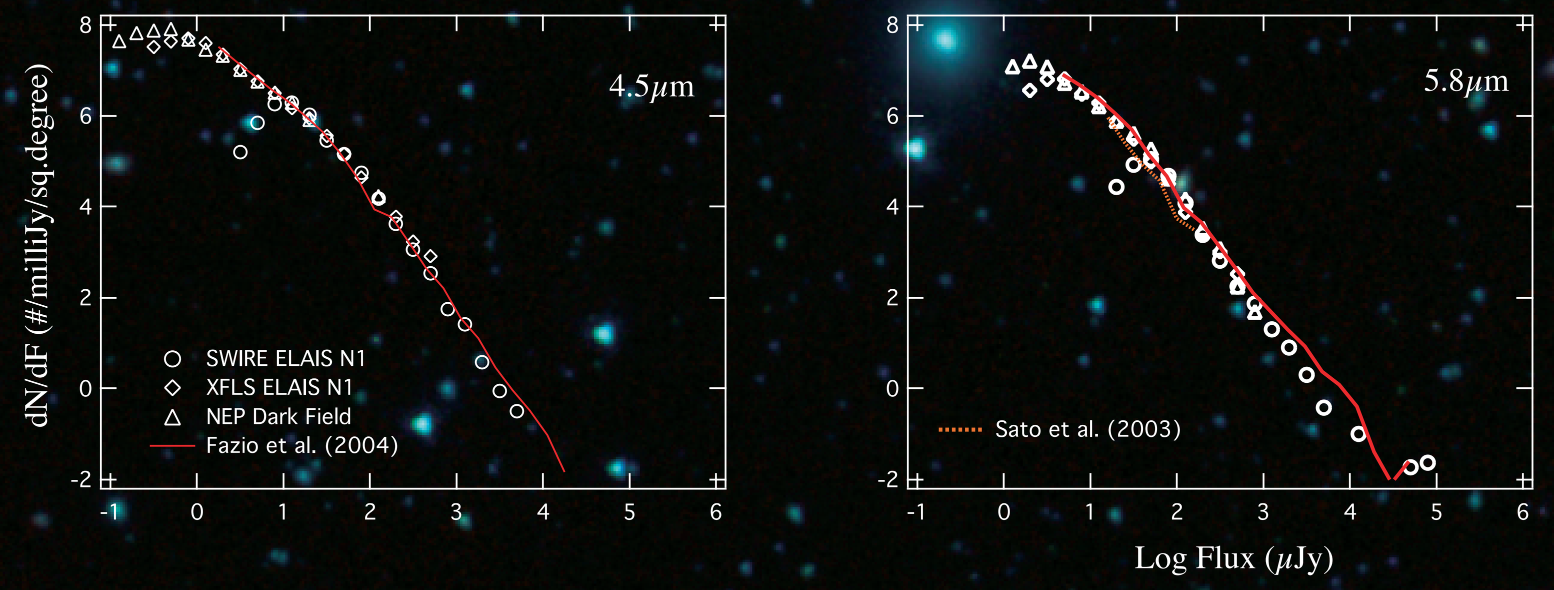
The data were reduced using the SWIRE automated pipeline. Flux extraction was performed using SExtractor. Aperture corrections were derived from the actual data. Sources were bandmerged with the other IRAC channels to create an IRAC catalog, and then cross-ID'd to our multiband optical catalog. Star-galaxy separation was performed using both spatial information (i.e. semblance of a source to the known PSF) and color information. The star-galaxy separation was confirmed by hand for bright sources and by comparison to detailed models of the three-dimensional galaxy stellar distribution (see graph at right). Reliability of sources was enforced through a multi-band detection scheme and validated by hand confirmation over a subset of the data and exceeds 99%. Photometric accuracy was checked through a variety of means, including comparison to modeled SEDs of know objects. For more details on the properties of the SWIRE data products and their validation, see Surace et al. 2004.



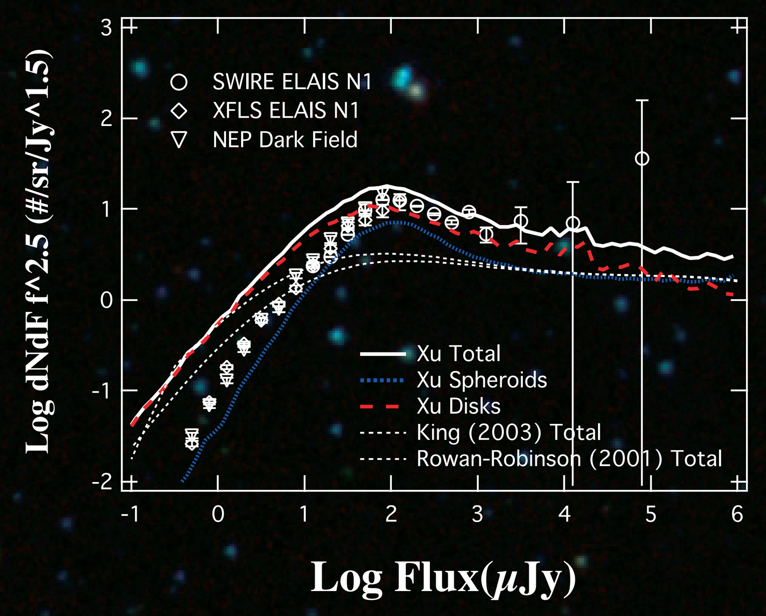
Differential Source Counts

Shown below and at right are the observed differential galaxy counts at 3.6-8μm. Also shown are the source counts in the same four bands as derived by Fazio (2004); our results in these new fields confirm those previous findings. Extrapolations to 3.6μm assuming appropriate k-corrections are shown based on several near-IR K-band surveys, including the shallow 2MASS catalog and much deeper surveys by Glazebrook and McLeod. At 5.8μm we show the ISO results of Sato (2003). For clarity, we show points below the completeness limit in order to illustrate the depth of the IRAC survey data. The change in slope of the K-band counts is also observed near 50μJy in the 3.6μm counts.

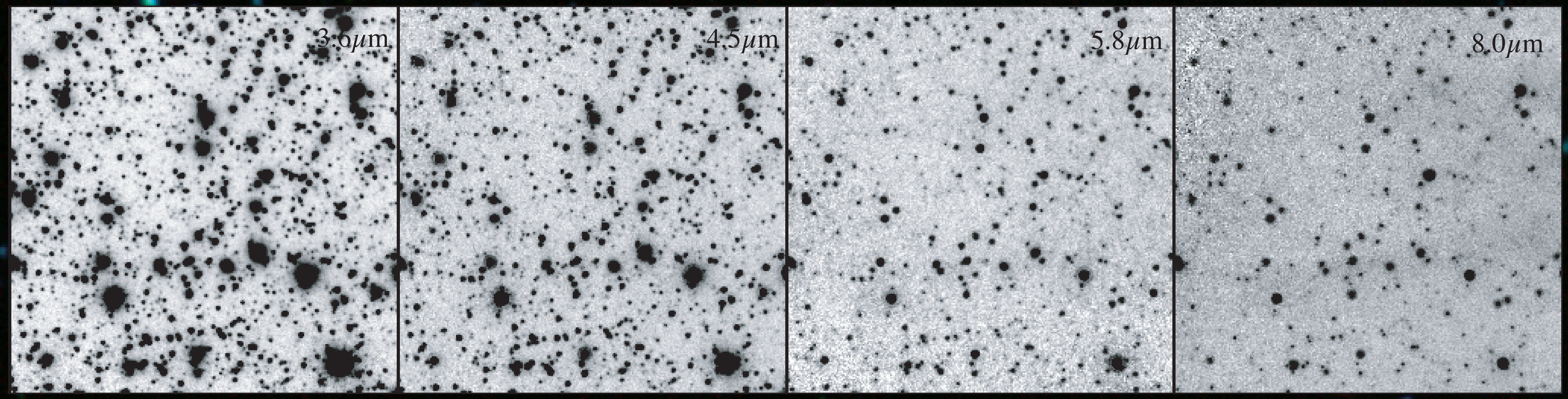




Shown at right are Euclidean-normalized differential source counts at 3.6μm. Also plotted are the model predictions for total counts, spheroids and disks of Xu et al. (2001), as well as total counts from Rowan-Robinson (2001) and King (2003). All of the models have difficulties simultaneously fitting both the bright and faint counts. In this form the change in slope of the counts is immediately apparent. One solution being explored to reconcile the models is to consider changes to the spectral energy distributions of the galaxies used in the model, as well as allowing evolution of the SED.



Confusion Limit



Spitzer suffers from a relatively large beam, which at IRAC wavelengths is (in practice) typically 2-2.5" FWHM. At right are shown 3.6-8μm images from the 12-hour IRAC dark field, where the degree of crowding is apparent even in images only 5' across, such as these. The 40 beam/src confusion limit has been reached at 3.6 and 4.5μm at 1.5 and 2μJy. Deeper surveys of 20-40 hours will reach 40 beams/src in all bands. Extrapolating from the current counts, this will be at 2 and 4μJy at 5.8 and 8μm.

The **Background** on this poster is a pseudo-color composite, where the blue, green, and red components of the image are mapped from the 3.6, 4.5, and 8μm IRAC channels. The image is 0.36 degrees across, and is roughly 0.25% of the total survey area.