Wide-field Infrared Survey Explorer

WISE High Resolution Galaxy Atlas

T. Jarrett (IPAC), F. Masci (IPAC), C.W. Tsai (IPAC), S. Petty (UCLA), D. Benford (GSFC), K. Sheth (NRAO)

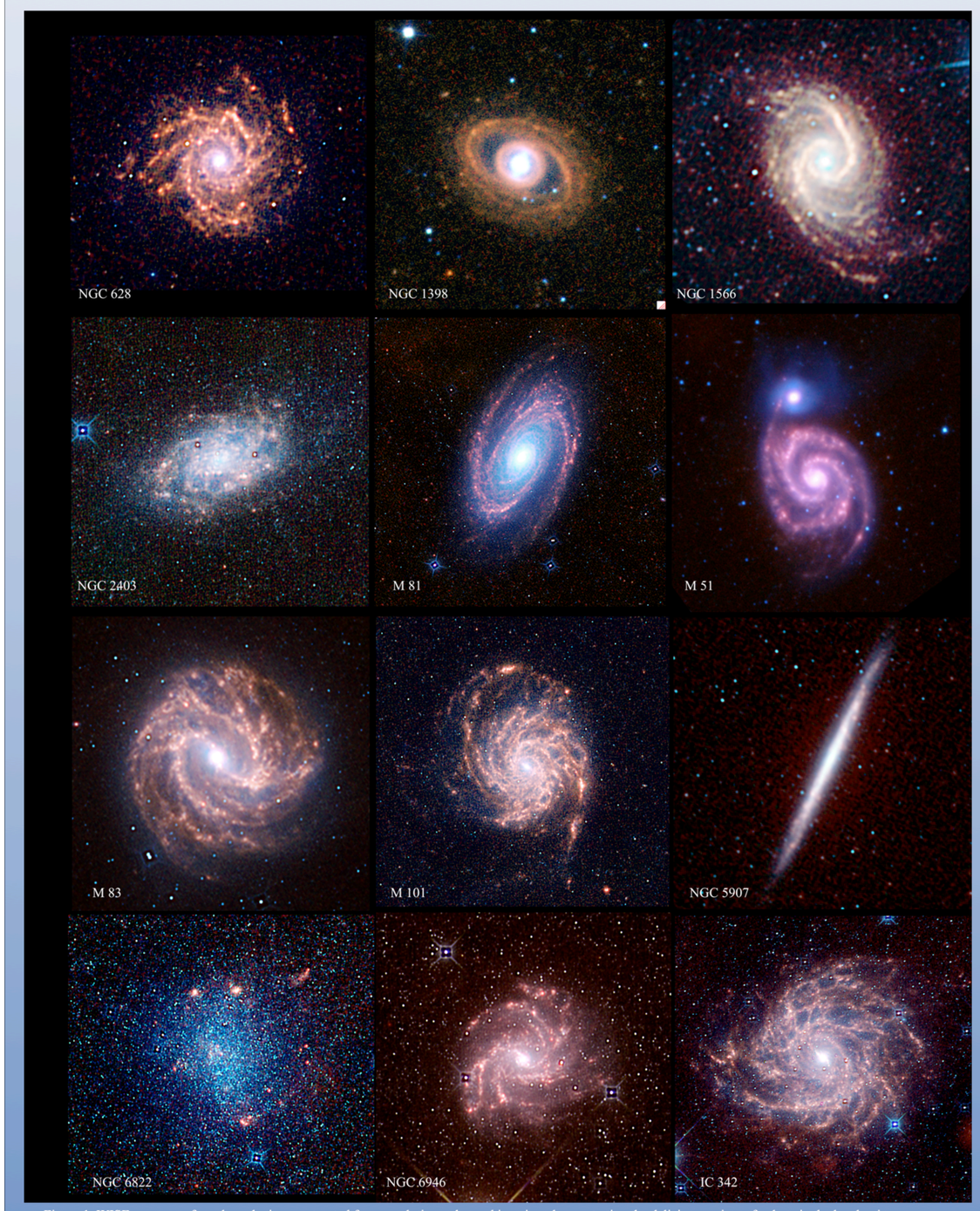


Figure 1. WISE montage of nearby galaxies constructed from resolution-enhanced imaging, demonstrating the delicious variety of galaxy in the local universe.. The colors correspond to WISE bands: 3.4 μm (blue), 4.6 μm (green), 12.0 μm (orange), 22 μm (red).

After eight months of continuous observations from a sun-synchronous polar orbit, WISE mapped the entire sky at 3.4 μm, 4.6 μm, 12 μm and 22 μm, producing a coadded Image Atlas and a Source Catalogue, available through the Infrared Science Archive. The data reduction pipeline was optimized to detect and measure the fluxes of point sources. Sources that are larger than one arc minute in diameter, however, will not have been characterized in the released data products. Accordingly, we have begun a dedicated project to fully characterize large, nearby galaxies and produce a legacy image atlas and catalogue that will serve the community for decades to come. Here we demonstrate the early results of the WISE High Resolution Galaxy Atlas (WHRGA) project for a sample of 17 galaxies, chosen to be of large angular size, diverse morphology, and covering a range in color, stellar mass and star formation. It includes many familiar galaxies, including M51, M81, M87, M83, M101, IC 342. Photometry and surface brightness decomposition is carried out with special super-resolution processing of WISE imaging, achieving spatial resolutions similar to that of Spitzer-IRAC. In this work we present basic photometric and characterization measurements for the sample galaxies, comparing the WISE results with those of Spitzer and IRAS. We derive star formation rates using the PAH-sensitive 12 μm (W3) and warm dust sensitive 22 μm (W4) measurements, and stellar masses using the 3.4 μm (W1) and 4.6 μm (W2) measurements that trace the baryon-dominant evolved population of stars. We highlight and showcase the detailed results of M 83, comparing the WISE/Spitzer results with the radio Hi gas distribution and GALEX UV emission, tracing the evolution from gas to stars. In addition to the super-resolution images, WISE's all-sky coverage provides a tremendous advantage over Spitzer for building a complete nearby galxy catalog, tracing both stellar mass and star-formation histories. We discuss the construction of a complete mid-infrared catalog of galaxies in D < 40 Mpc.

Resolution-Enhanced Mosaic Images

The WISE Data Science Center has developed a generic co-addition and resolution enhancement (HiRes) tool specifically designed to operate on WISE single-exposure image frames. This tool produces science-quality mosaic products with statistically-validated uncertainty estimates on fluxes. The HiRes algorithm is based on the Maximum Correlation Method (MCM) of Masci & Fowler (2009) and is an extension of the classic Richardson-Lucy deconvolution algorithm.

WISE Atlas Mosaics

WISE High-Resolution Atlas Mosaics

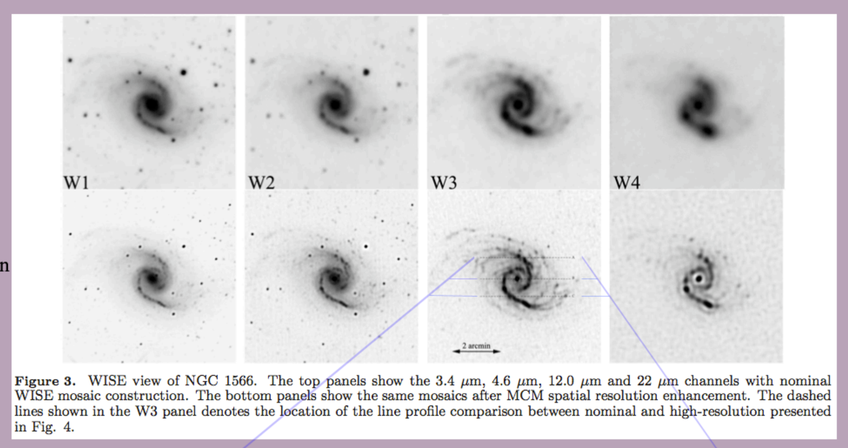


Figure 3. WISE view of NGC 1566. The top panels show the 3.4 μm, 4.6 μm, 12.0 μm and 22 μm channels with nominal WISE mosaic construction. The bottom panels show the same mosaics after MCM spatial resolution enhancement. The dashed lines shown in the W3 panel denotes the location of the line profile comparison between nominal and high-resolution presented in Fig. 4.

Slicing through NGC 1566

Spatial resoltuion is improved by a factor of 3 to 4, matching the nominal resolution of Spitzer-IRAC and nearly matcing that of Spitzer-MIPS.

A dramatic example of the improvment is seen with the comparison between WISE and Spitzer for the barrred galaxy M83 (see left).

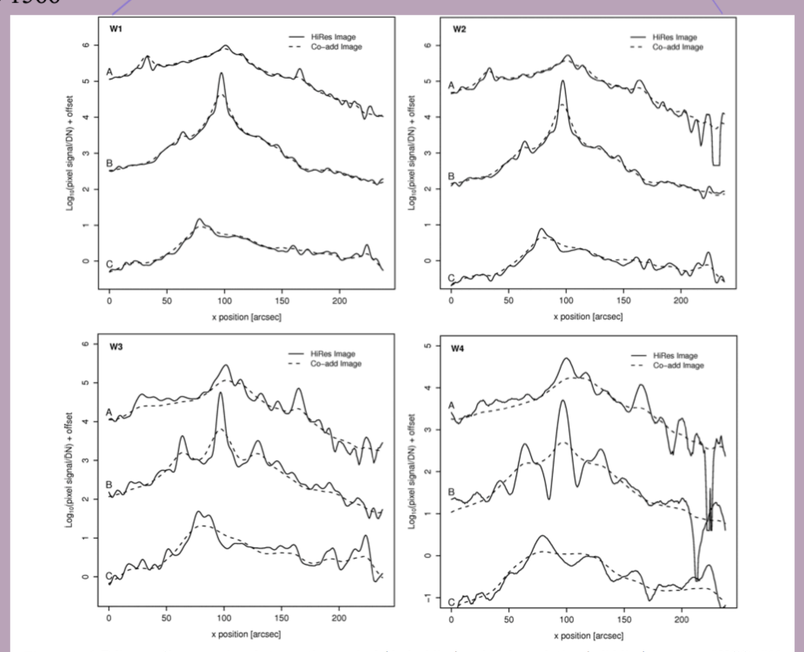


Figure 4. 1-D line profile comparison between the nominal (dashed line) and high-resolution (solid line) imaging of NGC 1566. Three profiles or line-cuts are shown (labeled A, B, C; Fig. 3 specifies the regions), with the center profile (B) slicing across the nucleus and spiral arms.

M83

WISE vs. Spitzer

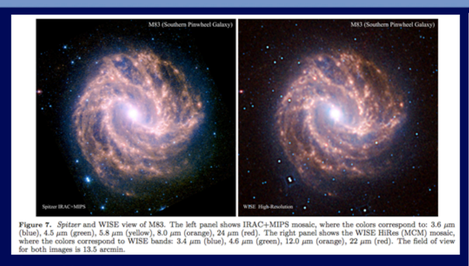


Figure 7. *Spitzer* and WISE view of M83. The left panel shows IRAC+MIPS mosaic, where the colors correspond to: 3.6 μm (blue), 4.5 μm (green), 5.8 μm (yellow), 8.0 μm (orange), 24 μm (red). The right panel shows the WISE HiRes (MCM) mosaic, where the colors correspond to WISE bands: 3.4 μm (blue), 4.6 μm (green), 12.0 μm (orange), 22 μm (red). The field of view for both images is 13.5 arcmin.

A key feature of the WISE High-Resolution Galaxy Atlas (WHRGA) is construction of resolution-enhanced images with a factor of ~3 to 4 improvement in resolution compared to native WISE mosaics. The achieved resolutions are comparable to those of Spitzer-IRAC and MIPS-24. The reconstructed images do not suffer from any loss of integrity or science quality (see radial profiles, right). HiRes imaging enables detailed study of the internal anatomy of galaxies: delineating the nuclear, spiral arm, bar, halo and disk structures, as well as shells, tidal arms and debris that arise from dynamical interactions with other galaxies.

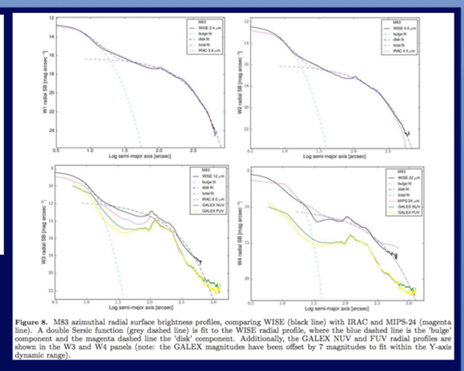


Figure 8. M83 azimuthal radial surface brightness profiles, comparing WISE (black line) with IRAC and MIPS-24 (magenta line). A double Sersic function (grey dashed line) is fit to the WISE radial profile, where the blue dashed line is the 'bulge' component and the magenta dashed line the 'disk' component. Additionally, the GALEX NUV and FUV radial profiles are shown in the W3 and W4 panels (note: the GALEX magnitudes have been offset by 7 magnitudes to fit within the Y-axis dynamic range).

Multi-Wavelength Synergy

The four (relatively extinction-free) WISE spectral bands have the dual capability of sensitively (a) tracing the stellar mass (old, evolved stellar population) and (b) providing a window to the current star formation activity as traced by the polycyclic aromatic hydrocarbons (PAHs) and warm dust emission associated with massive star formation. Direct comparison of star formation rates, using the WISE long-wavelength bands, with stellar mass estimates from the short-wavelength bands, quantitatively enumerates the present-to-past star formation history, a critical metric of morphological evolution.

Figure 10. GALEX and WISE color-composite view of M83. The color assignment for the WISE high-resolution imaging (3.4 μm + 4.6 μm, 12.0 μm and 22 μm) and GALEX imaging (0.227 μm and 0.152 μm) is shown with the small panels to the left.

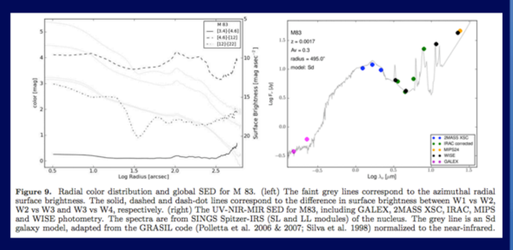
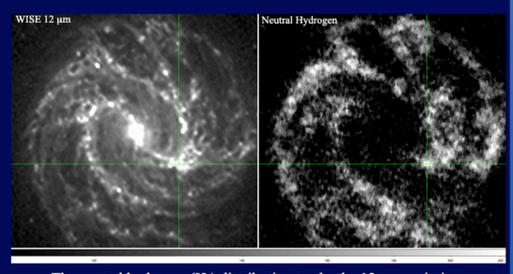


Figure 9. Radial color distribution and global SED for M 83. (left) The faint grey lines correspond to the azimuthal radial surface brightness. The solid, dashed and dash-dot lines correspond to the difference in surface brightness between W1 vs W2, W2 vs W3 and W3 vs W4, respectively. (right) The UV-NIR-MIR SED for M83, including GALEX, 2MASS XSC, IRAC, MIPS and WISE photometry. The spectra are from SINGS Spitzer-IRS (SL and LL modules) of the nucleus. The grey line is an Sd galaxy model, adapted from the GRASIL code (Poletta et al. 2006 & 2007; Silva et al. 1998) normalized to the near-infrared.



The neutral hydrogen (HI) distribution tracks the 12 μm emission, tracing the PAH-emission arising from photodissociation regions and star-forming sites in the spiral arms and bar ends. The radio maps are courtesy of Baerbel Koribalski, obtained with the ATNF-ATCA.

Since WISE is an all-sky survey, covering every pixel of the heavens, the WISE High-Resolution Galaxy Atlas (WHRGA) will provide resolution-enhanced versions for the largest galaxies in the local universe, including those of the immense Andromeda System and the Local Group. This provides a data continuity between WISE and Spitzer, where WISE completes the area of the sky without Spitzer coverage or regions that were mapped coarsely.

The WHRGA will represent a complete, unbiased mid-infrared census of the local extragalactic universe, a vital legacy that will serve the community for decades to come. The images and source catalog of the WHRGA will be made freely available through NASA/IPAC Extragalactic database (NED) and the Infrared Science Archive (IRSA).

Figure 7: The Andromeda Galaxy (M31) as captured in all four bands of WISE. The angular width is nearly 3 degrees across.