Simulating and Analyzing Wide Field High Resolution Images of Nearby Galaxies

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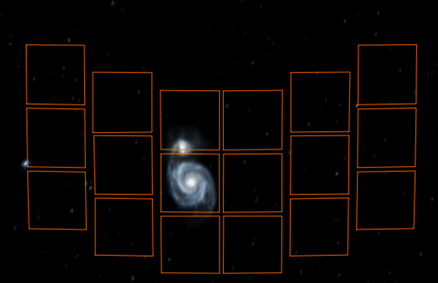


WINGS: WFIRST Infrared Nearby Galaxies Survey

The large field of view, high sensitivity and high spatial resolution of WFIRST at 0.5~2.0μm will enable the study of the stellar contents and halo substructures of galaxies at 1~10 Mpc in unprecedented detail. We are producing realistic simulated multi-band WFI imaging data by combining synthetic stellar population and observed background galaxy catalogs. We use these catalogs as input to the Space Telescope Image Product Simulator (STIPS) to produce images with the detector and optics characteristics expected for the Wide Field Imager. Furthermore, we are developing software to measure the photometric properties of the simulated objects in the STIPS images using DOLPHOT. This suite of tools is beginning to provide end-to-end simulations of WFIRST nearby galaxy observations and analysis. Here we demonstrate the advantages of simultaneously developing image simulation and data analysis capabilities as instrumental designs are finalized.

Fig 1

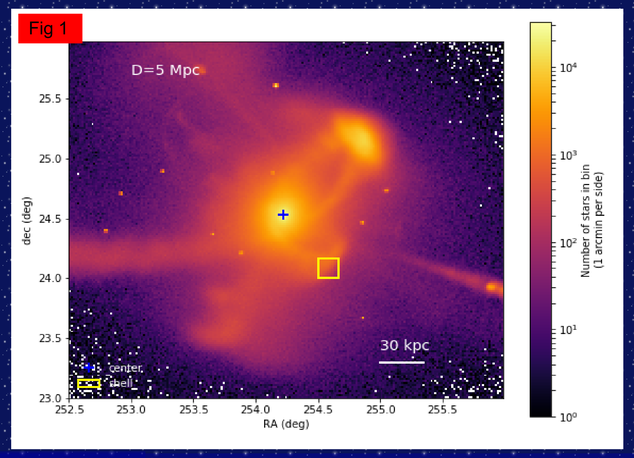
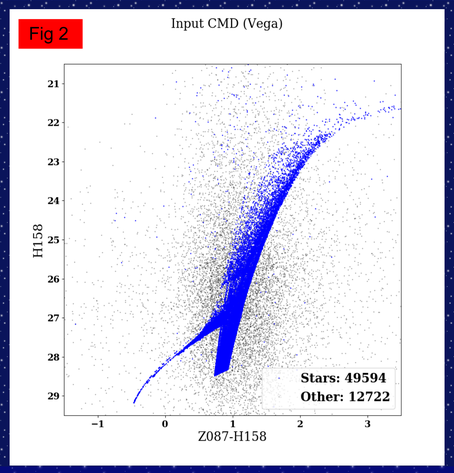


Fig 2



Please see posters 362.02 and 344.03 for details on input stellar catalogs generation

Fig 3

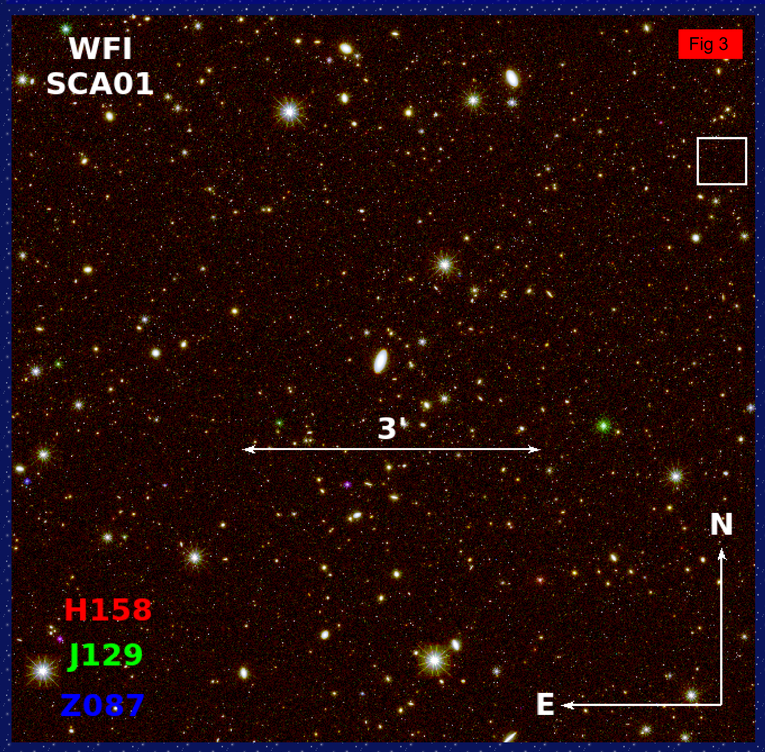


Fig 4

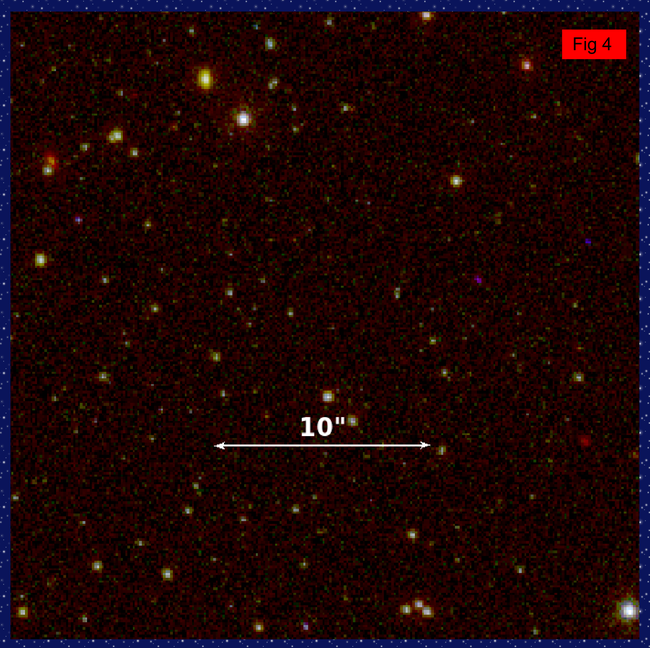


Image Simulations

First we produce catalogs of stellar populations consisting of sky coordinates and multi-band near-IR photometry by combining *FIRE* ("Feedback In Realistic Environments") galaxy formation simulations (Fig-1) with PARSEC stellar isochrones (Bressan et. al. 2012) in the WFI filters. Next, the stellar catalog is contaminated with background galaxies sampled from the CANDELS GOODS South field (Guo et al. 2013), their Sersic profile best fit parameters determined in HST F105W/F125W/F160W bands and source densities scaled to the Hubble Ultra Deep Field. Finally, we use parts of this catalog (stars+galaxies, blue/black on Fig-2) as the input for the WFIRST implementation of the Space Telescope Image Product Simulator (STIPS) to generate multi-band WFI images accounting for the point spread functions, instrumental noise, cosmic rays and average sky levels. Fig-3 shows a RGB color image produced from WFI ZJH band simulations generated with STIPS for the yellow-box region of Fig-1 (CMD: Fig-2) covering the FOV of one WFI chip (7.5' x 7.5'). Fig-4 shows a zoom-in of the white-box region of Fig-3.

Survey and Analysis Optimization

An integrated pipeline to simulate realistic astronomical images and produce clean photometric catalogs lets us simultaneously test mutual suitability of observatory design specifications and science program objectives. This in turn informs survey design (target selection, dither pattern, cadence), optimal resource allocation (filter combinations, integration time distribution) and data analysis strategy (photometry algorithm, software development, parameters choice). As the observatory design is finalized and image simulations software development progresses in tandem, we will architect a scalable data analysis pipeline for image simulations, photometric analysis and unsupervised resource allocation optimization to run on the cloud and HPC facilities.

Acknowledgements: WFIRST and the WINGS SIT are supported by NASA contracts NNH15ZDA001N-WFIRST and NNG16PJ28C. STIPS is developed at the STScI by Brian York with guidance and contributions from Klaus Pontoppidan, Jason Kalirai, Pey Lian Lim and Stefano Casertano, making use of open software developed by Justin Bird, Ahmed Fasih and Adam Ginsburg. The FIRE project is led by Phil Hopkins, Claude-André Faucher-Giguère, Dusan Keres and Eliot Quataert, with grant support from the NSF and NASA.

Fig 5

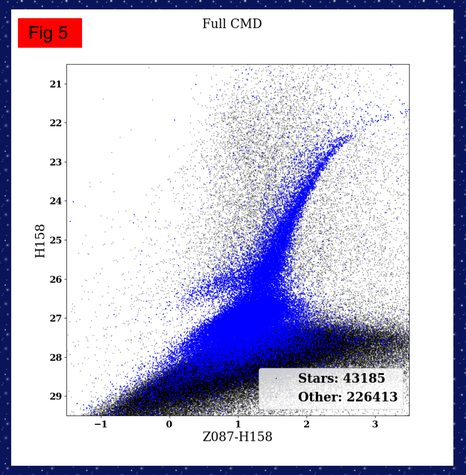
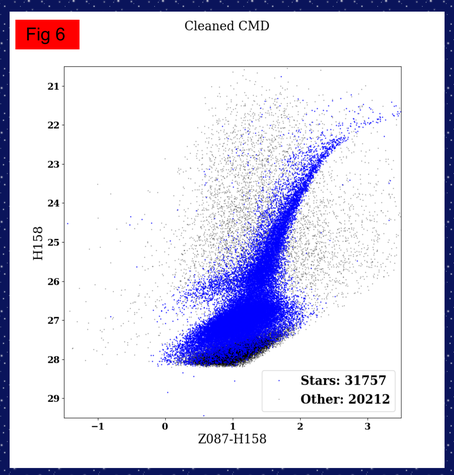


Fig 6



Photometric Catalogs

We align the simulated images, extract point sources and measure their fluxes using the WFIRST module of DOLPHOT (Dolphin 2000) and a spatial grid of WFIRST PSFs in each filter generated using WebbPSF. Fig-5 shows the color magnitude diagram of all sources identified on Fig-3 by DOLPHOT, with the blue points representing closest matches to input stellar sources detected within 1-pixel (0.11"). Next we execute an iterative, multivariate culling of the extracted source catalog based on their photometry quality parameters such as (Figs 7,8,9) aggregate photometric uncertainty, contamination due to crowding, roundness and sharpness of the detected source, SNR etc. until a predefined stopping criteria is met. The input and extracted catalogs are mapped anew at each iteration so that the "True-True training set" (detected sources that are closest matches of input stars) used to determine quality parameter cuts continuously evolves. Fig-6 shows the iteratively cleaned CMD corresponding to Fig-5 where the stopping criteria was defined as <=40% False Rate, that is, at least 60% of the sources in the cleaned catalog should be closest matches to stars in the input catalog at <=1-pixel.

Fig 7

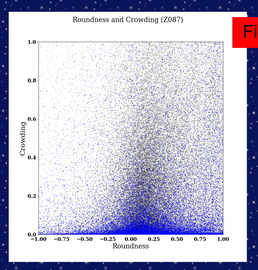


Fig 8

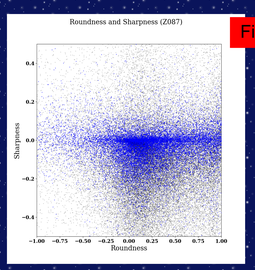


Fig 9