The GALEX Nearby Galaxies Survey (NGS)

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Abstract GALEX (The Galaxy Evolution Explorer), a NASA Small Explorer (SMEX) mission, was launched on April 28, 2003, to perform spectroscopic and imaging surveys in the space ultraviolet (1300-3000Å). The GALEX mission will produce an unprecedented all-sky map in two UV bands (comparable to the deepest existing surveys at other wavelengths) and an unbiased catalog of UV sources. A dedicated survey of nearby galaxies will be performed, deeper than the all-sky map. The GALEX field of view (1.2°) and sensitivity will provide complete coverage for large Local Group (LG) objects, in far-UV and near-UV simultaneously. These data will provide a snapshot of recent high-mass star formation across entire galaxies, allowing for the study of rest-frame UV morphology, spatial variations of the local SFR, and UV extinction. The GALEX NGS will complement other new datasets on the stellar populations and gas content of LG galaxies being acquired at other wavelengths by independent on-going projects, and the detailed information that HST is providing on small selected regions within these objects.

1 The GALEX mission

GALEX (The Galaxy Evolution Explorer) is a NASA Small Explorer (SMEX) mission (see Bianchi et al 1998, 1999a, 2000a,b, Martin et al 1999), performing a series of spectroscopic and imaging surveys in the space ultraviolet (1300-3000Å), that will map the history and probe the causes of star formation over the $0 < z < 2$ range, 80% of the life of the Universe. GALEX will provide a direct measurement of redshift, extinction, and star formation rate (UV luminosity) in 100,000 galaxies, with efficient slitless grism spectroscopy. It will determine whether rapid evolution has occured in the star formation rate, or in the extinction or initial mass function. The GALEX database will provide a framework for the interpretation of the deepest HST images and those that may be obtained by the JWST. The GALEX mission will produce an unprecedented all-sky map in two UV bands and an unbiased catalog of UV sources, filling in the crucial missing piece of the spectrum so that our knowledge of the sky from 100 μm to 10 Å is complete.

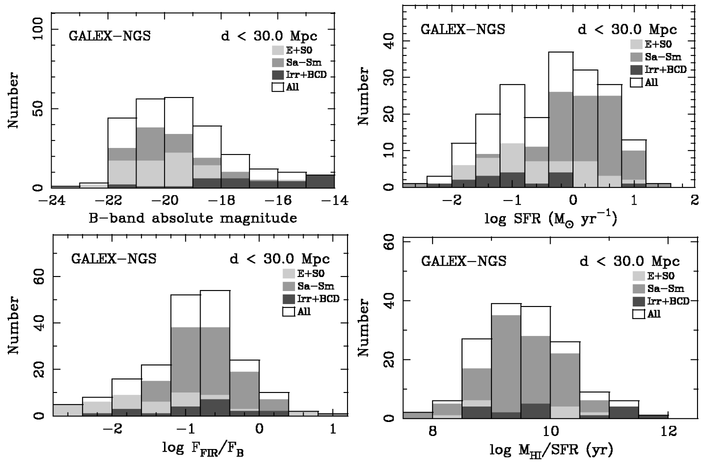

Figure 1. Key properties of the GALEX NGS sample.

GALEX will produce a unique, statistically powerful database of UV images and spectra of nearby and distant galaxies, linked to a multiwavelength archive (Bianchi et al. 1999b, Volpicelli et al. 2003). Using UV properties, supplemented by measurements at other wavelengths, GALEX will derive global parameters for each galaxy: star formation rate (from UV luminosity), extinction (from UV slope), initial mass function (IMF), starburst parameters *versus* redshift, and characterize their relationship to galaxy properties (luminosity, type, metallicity, neighborhood, gas supply) and their evolution by comparing statistical distribution of these parameters to cosmological models of the history of galaxies and QSOs. GALEX will address these goals with surveys summarized on the last page.

2 The Nearby Galaxies Survey

A working group within the GALEX Science Team, led by B. Madore and L. Bianchi, has planned to cover a selected sample of ~ 200 nearby galaxies with deeper exposures than the all sky survey (AIS). We currently anticipate spending two eclipses on each target, making these observations a factor of $6\times$ more sensitive than the AIS.

The entire GALEX Nearby Galaxy Survey (NGS) sample comprises galaxies selected both for specific science goals and for complementarity with other planned or on-going surveys at diverse wavelengths, including SIRTF's Legacy and GTO observations, multiple ground-based surveys at Hα (PO/LCO, STARFORM), and at radio wavelengths (WSRT SINGS, BIMA SONG). Our goals include studies of multi-wavelength morphology, scrutiny of young clusters and stellar populations in the nearest galaxies, and analysis of UV extinction as measured on small scales.

For Local Group galaxies in particular, GALEX offers the unique advantage of a large field of view, thus affording complete coverage with uniform and sufficient sensitivity to provide a complete census of UV fluxes for e.g. post-AGB objects in the Magellanic Clouds (MC), and clusters younger than a few times 10^8 yrs in M33, M31. All regions of active star formation in M31, M33, and the MCs will be surveyed, with the possible exception of areas near especially bright field stars. Even at larger distances (D $\sim$ 10 Mpc), we can achieve S/N $>$ 10 in NUV and FUV for clusters brighter than a fiducial source having mass $\sim 10^5$ $M_\odot$ and age 50 Myr.

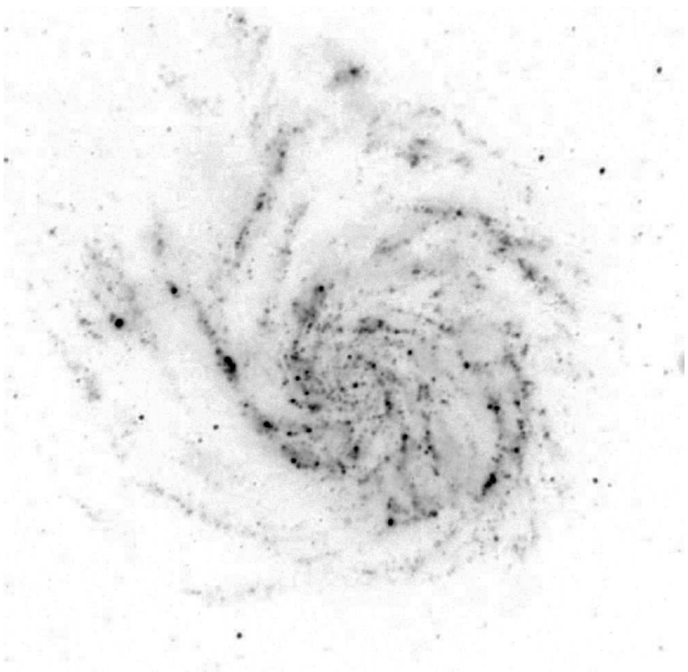

Figure 2. Early GALEX observation of M101. This image is a band-merged NUV+FUV composite.

A subsample of the NGS is scheduled for observation in the early part of the mission (see the table at the end). This subsample is already somewhat representative of a number of properties and types. The high-priority NGS subsample contains 5 Seyfert, 8 LINER, 5 Starburst, and 5 HII galaxies.

The complete NGS sample was chosen to fairly represent the local Universe. The accuracy to which this goal is achieved is vital, as the NGS will serve as a benchmark for interpretation of high z surveys. Figure 1 shows the distribution of target properties for several key observables for NGS targets within 30 Mpc.

Photometry of the NGS sample will be performed using a new method based on HIIphot (Thilker et al. 2000), but generalized to produce coherent photometry spanning a suite of linear scales and optionally several wavelengths. The algorithm first computes the multi-scale "à trous" wavelet decomposition of all available imagery, followed with independent reconstruction of each scale and λ. "Structures" are then associated with each significant peak in these "filtered" reconstructions. The extent and shape of each structure is determined using an iterative growth algorithm. Finally, hierarchically-defined objects are assembled by repeatedly grouping substructures of smaller scale or different wavelength if they are contained by a parent structure already assigned to the object.

Adopting a multi-scale, multi-wavelength approach to the issue of photometry has several advantages. First, by performing the measurements at a standardized set of linear resolutions we facilitate intercomparison of observed quantities, such as the UV and Hα luminosity functions (LFs) of young star-forming regions, in galaxies of varied distance. Secondly, the availability of measurements obtained at standard scales allows direct comparison with synthetic models of the LF which have been tuned to a given resolution. Finally, the multi-wavelength focus allows for identification of interesting objects based upon their spectral energy distribution and morphology.

To determine the properties of individual HII regions and young stellar clusters, plus ensemble characteristics of galaxy-wide cluster populations, we will employ population synthesis models. The clusters in each Monte Carlo realization of a galaxy-wide population are selected according to an initial cluster membership function, CMF, and star-formation history, SFH, while the stars comprising these clusters are drawn from an assumed IMF. Our method allows for accurate treatment of stochasticity in clusters having only a modest number of stars (see Cervino & Valls-Gabaud 2003), because we generate the synthetic predictions by adding spectral contributions to each cluster on a star-by-star basis. This attention to detail leads to a break in the slope of the LF at moderate luminosities, reflecting the greater dispersion in predicted luminosity for clusters that poorly sample the IMF. Our modeling technique produces viable LFs in the absence of source blending due to limited spatial resolution.

To address the issue of blending we have started an investigation of the small-scale clustering properties of HII regions as viewed with HST at resolution $<< 50$ pc. The eventual goal is a parameterization of the clustering behaviour, which can eventually be folded into the synthetic LF predictions. Thus, we will generate UV LFs spanning a multivariate parameter space, with spatial resolution, SFH, cluster membership function, and IMF as the principal variables. These predictions will be directly fit to the observed GALEX measurements. Multiwavelength observations will be used to break degeneracies within the family of best fit solutions.

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3 References

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GALEX MISSION SUMMARY

Parameter	Far UV	Near UV
Band	1350-1800 Å	1800-3000 Å
Field of View	1.25 degrees	1.25 degrees
Angular Resolution (80% EE)	$\approx$ 4 arcsec	$\approx$ 5 arcsec
Detector Pixels	4096^2 (1.1" X 1.1")	4096^2 (1.1" X 1.1")
Spectral Resolution $\lambda/\Delta\lambda$	$\approx$ 100	$\approx$200
Redshift Range	0<z<1	1<z<2
Redshift Accuracy	<$\pm$0.005	<$\pm$0.005

GALEX SURVEY SUMMARY

Survey ($\star$)	Area [deg^2]	Duration [months]	Mag.Limit [m_{AB}]	No.Galaxies	N. QSOs	Cosmic Volume
AIS	41,000	4	$21^{a,b}$	10^7	700,000	6e9
MIS	1000	1	$24^{a,b}$	10^3		
NGS	450	0.5	$24\text{-}25^{a,b}$	400		
DIS	160	4	$26^{a,b}$	10^6	300,000	1e9
WSS	160	4	$20.3/22.5^{a,c}$	60K/200K	5K/10K	3e7
MSS	16	4	$22.0/24.0^{a,c}$	50K/100K	1K/2K	2e7
DSS	2	4	$23.3/25.2^{a,c}$	30K/80K	1K/2K	1e7
AIP	–	4	–			

($\star$) AIS = All Sky Imaging Survey, MIS = Mid Imaging Survey, NGS = Nearby Galaxies Survey, DIS = Deep Imaging Survey, WSS = Wide-field Spectroscopic Survey, MSS = Medium Spectroscopic Survey, DSS = Deep Spectroscopic Survey, AIP = Associate Investigator Program
(a) AB mag @ 2000Å = -2.5 log f_{nu} -48.6
(b) S/N = 5 (c) S/N = 10, Full resolution / Reduced resolution

Type	Early Observation NGS Target
E	NGC1399, M84, M87
S0	NGC1316
Sa-Sb	M81, M31, M51, NGC3521, NGC3190
Sc-Sd	M83, NGC0628, M101, NGC0253, NGC0247, M33, NGC0925, NGC2403
Sm	NGC4395, NGC0055
Im	IC1613, NGC6822, Holmberg II
BCD	NGC2537, NGC4344, IZw18
Others	NGC4039/NGC4039 (Antennae), HCG092 (SQ), NGC5128 (Centaurus A)