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Probing Young Stellar Populations in Local Group Galaxies with Astrosat/UVIT: M33, SMC and the Magellanic Bridge.

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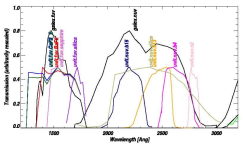
The hottest, most massive stars are the major players in the chemical and dynamical evolution of galaxies. Far-UV and near-UV measurements are indispensable to identify them and characterize them. With complementary optical data, UV measurements allow us to correctly establish their Effective Temperature and Luminosity by breaking the [Teff,extinction] degeneracy and providing better sensitivity to the hottest temperatures, resulting in a precise characterization of the youngest massive stars, and dust, that cannot be achieved with optical colors alone. HST imaging of star-forming sites in Local Group galaxies resolved the compact cores of the youngest stellar associations into their stellar constituents. GALEX wide-field FUV,NUV imaging yielded a comprehensive, unprecedented view of the young populations and dust across entire galaxies from our closest neighbors, the Magellanic Clouds, to beyond the Local Group, and changed some of the previous views on star formation.

Now filling the critical gap between HST's sub-pc (projected on the sky for Local Group galaxies) resolution over field-of-views of a few 100pc, and GALEX's 10-20pc resolution across 1.2degree fields, UVIT on Astrosat enables a more conclusive view of star-forming galaxies, sampling large portions of them (28arcmin diameter field-of-view) with spatial resolution comparable to contemporary ground-based surveys (about 1arcsec). UVIT's set of FUV (and initially NUV) filters enables a better characterization of extinction by dust than is possible with current HST filters and with GALEX broad-band filters, and therefore a robust characterization of stellar parameters.

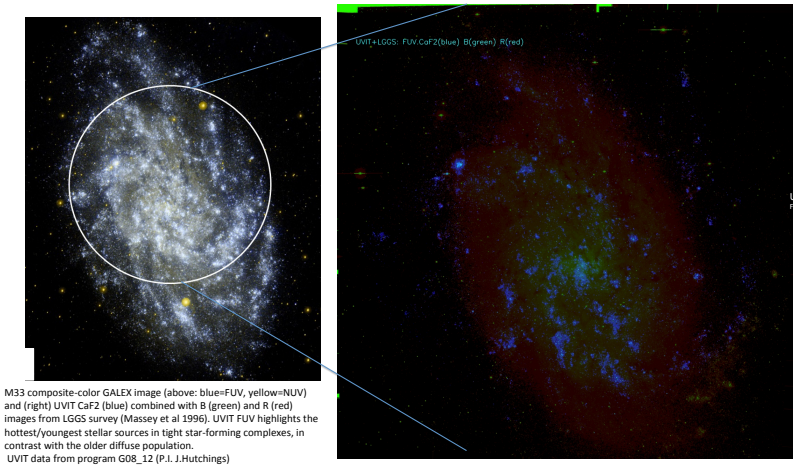
We present two projects in progress: sample fields in the very low metallicity Small Magellanic Cloud (SMC) and Magellanic Bridge (MB), that paved the way for an upcoming extensive survey described by Thilker et al. (this conference), the low-metallicity spiral M33 and dwarf NGC6822.



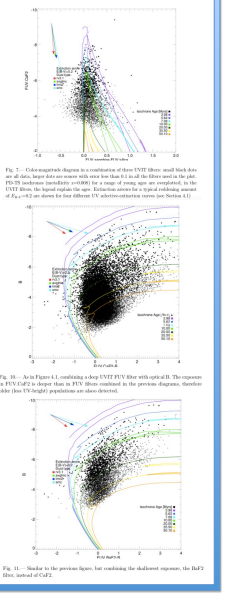
Left: transmission curves of UVIT FUV and NUV filters (arbitrarily renormalized for visibility) and of GALEX FUV and NUV filters for comparison.
All our images (from UVIT MCP photon counting detectors) were reduced with the Canadian UVIT Pipeline and FITS image processor CCDLAB (Postma & Leahy 2017 PASP 129 981). The world coordinate solutions for the images were solved automatically in CCDLAB with the trigonometric algorithm (Postma & Leahy 2020 PASP 132 054503). CCDLAB also estimates the effective exposure times. Source photometry was performed, and the flux calibration by Tandon et al. (2017, AJ 154, 128; -- 2020, AJ 159,158) was applied.

M33

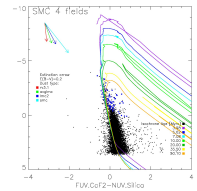
The LG spiral Triangulum galaxy, smaller but more active in star formation than M31 and the MW, was observed in four UVIT FUV filters: the broad FUV.CaF2 filter, extending to shorter wavelengths than GALEX FUV, FUV.BaF2 (similar to GALEX FUV), and two narrower filters, FUV.Sapphire and FUV.Silica, with cutoffs at progressively longer wavelengths. The 28' UVIT field covers the central part and the inner spiral arms, at a resolution about 3x better than GALEX. PSF photometry was performed in the four images, and the merged source list was matched to the optical ground-based LGGS data (Massey et al. 2006, AJ, 131, 2478). Below is a composite image and to the right some color-magnitude diagrams from Bianchi et al (in preparation) with overplotted PD-TS isochrones. All UVIT sources belong to young populations, with the hottest sources occupying the loci of few-million-years old populations.

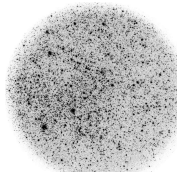


M33 composite-color GALEX image (above: blue=FUV, yellow=NUV) and (right) UVIT CaF2 (blue) combined with B (green) and R (red) images from LGGS survey (Massey et al 1996). UVIT FUV highlights the hottest/youngest stellar sources in tight star-forming complexes, in contrast with the older diffuse population.
UVIT data from program G08_12 (P.I. J.Hutchings)



Magellanic System



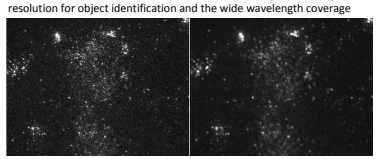


(programs: Hutchings et al G05-251, Bianchi et al A07_039, A04_066, Thilker et al. A09_038)

Four contiguous fields (two overlapping) in the SMC's periphery and 3 fields in the Magellanic Bridge were observed to identify and characterize the hot stars in these regions. All are rich in hot stars. One field is shown on the left, and a Color-Magnitude Diagram with superimposed isochrones (z=0.004, TS-PD) for the SMC region; large blue dots are sources with error <0.05mag in all four filters: FUV.CaF2, NUV.B15, NUV.Silica and NUV.N2. The photometry is plotted uncorrected for extinction, reddening arrows show the effect of E(B-V)=0.2mag reddening varying extinction types (using published extinction curves in sightlines in different galaxies, not necessarily representative of all environments in the same galaxy but covering a variety of cases). Foreground extinction is only E(B-V)=0.033mag (Schlafly & Finkbeiner 2011), the red arrow indicates E(B-V)=0.2mag Milky Way-type (Rv=3.10) reddening; for this dust type, the broad-band CaF2-Silica color is almost reddening free, similarly to GALEX FUV-NUV (Bianchi et al.2017, ApJS 230, 24; Bianchi 2014 ApSS 354, 103). We matched UVIT photometry to the STEP survey (Ripepi 2018vels.confE..45R), to derive Teff and E(B-V) of individual stellar sources. There are few massive stars younger than ~20Myrs, as expected for this peripheral location (Bianchi et al. in preparation).

NGC6822

Combining Thilker et al. program A07_118 with archival data (G07_011) we have all 9 UVIT FUV and NUV filters, with varying depth. Photometry (in progress, Thilker et al. in preparation) will be combined with several HST fields (Bianchi et al. 2012, AJ 143, 74; Bianchi & Efremova 2006, AJ 132 378; Efremova et al. 2011, AJ 730, 88) to exploit the high HST resolution for object identification and the wide wavelength coverage



Above: FUV view of the Northern part, showing UVIT (left) gain in resolution wrt GALEX (right).
Below: views at different wavelengths and resolution (figure below from Bianchi 2014 ApSS 354 103 , HST data of the bright HII region HubbleX from Bianchi et al. 2001, AJ 121, 2020)