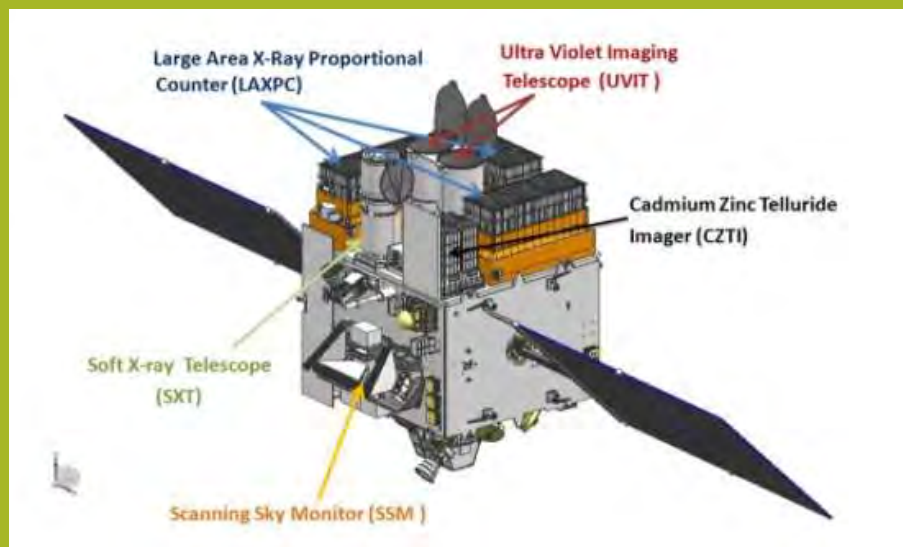
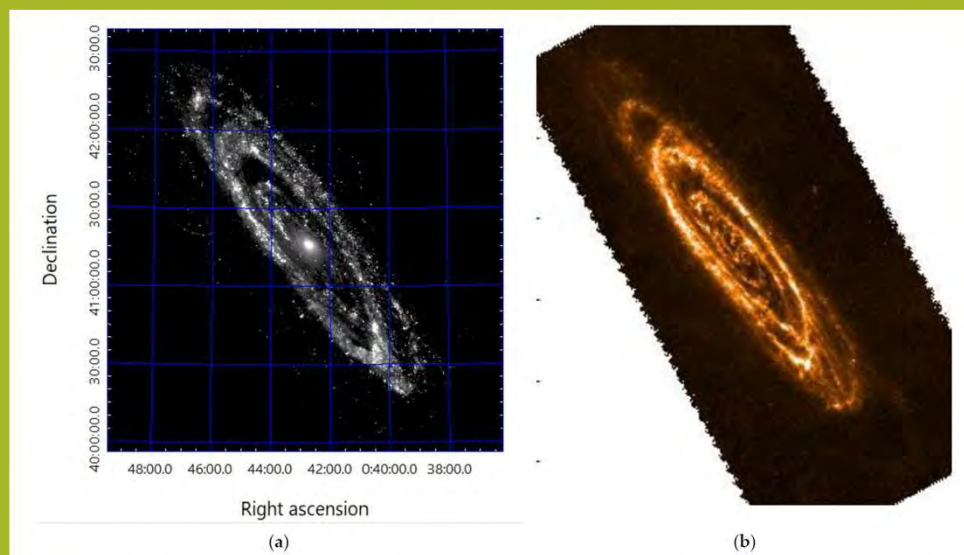


UV TO NEAR IR SPECTROPHOTOMETRY OF UV-BRIGHT STARS IN M₃₁ WITH UVIT AND HST

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The AstroSat Satellite

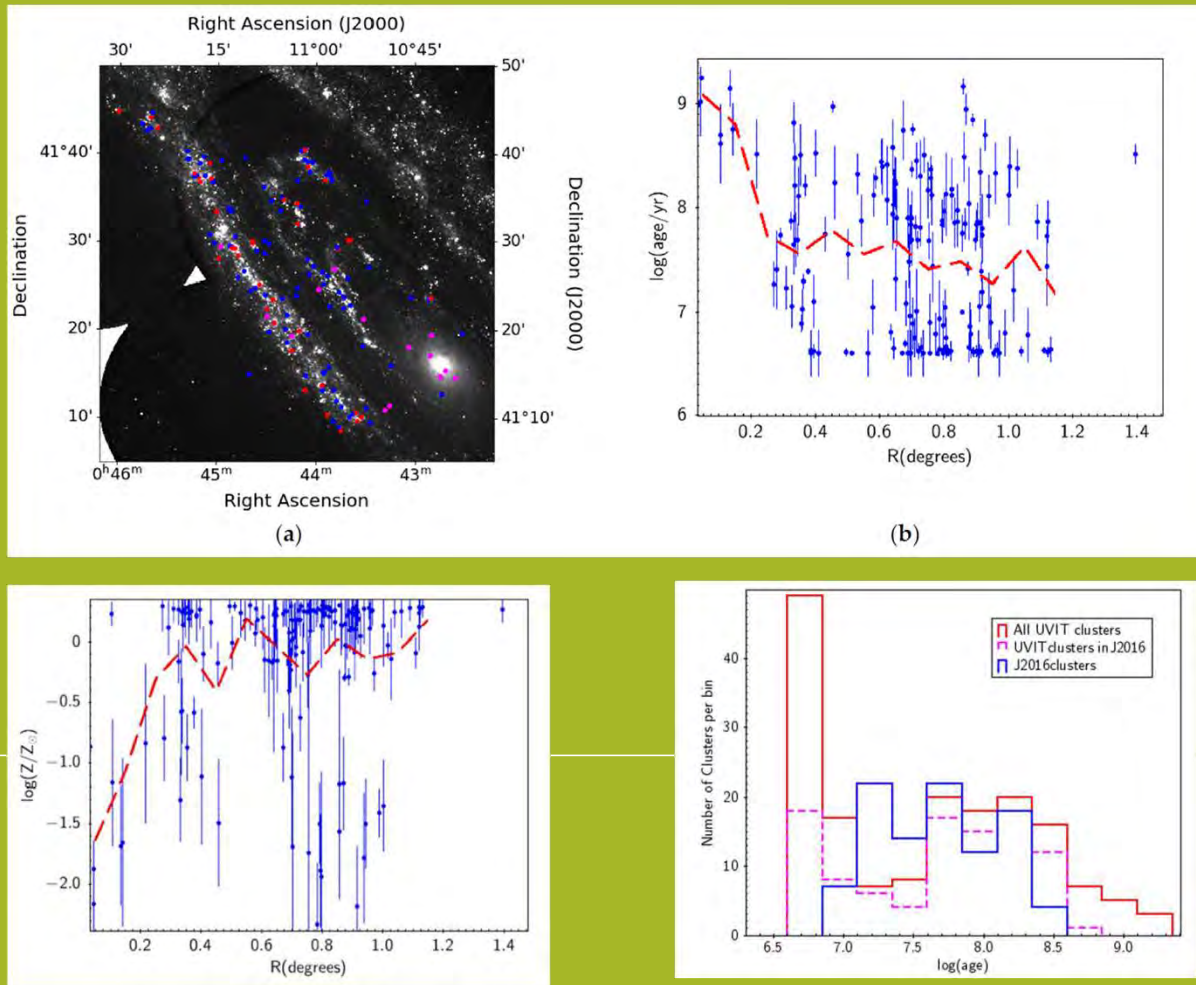
AstroSat includes 4 X-ray instruments and an ultraviolet telescope (Singh et al, 2014).

It was developed by Indian Space Research Organization in collaboration with several other institutes including the Canadian Space Agency, which supplied the detector and electronics for the UV telescope, with calibration done at the University of Calgary.

In 2025 a failure in the pointing system reduced the observing efficiency to a low level; currently slowly completing programs from 2024-2025 AO.

M₃₁, the Andromeda Galaxy

- Nearby giant spiral galaxy (785 kpc), larger in size than the Milky Way.
- Since 2017 we have been observing M₃₁ with the UVIT (ultraviolet imaging telescope) on the Astrosat satellite.
- M₃₁ survey is that 23 of 25 proposed fields have been observed, with the remaining 2 fields not observed because of FUV bright foreground stars (unsafe for UVIT).
- Above left is shown the mosaic created in the F148W filter (150 nm) band (data has 1 arcsecond resolution). The UV light is primarily from hot stars in M₃₁.
- Above right is shown the archival Herschel 250 micron image, which is from star-light heated dust in M₃₁.



Analysis of Stellar Clusters

Leahy, Buick, Leahy 2022: We selected the young clusters (ages <300 Myr) from the Johnson et al (2016) HST/PHAT cluster catalog.

Stellar cluster models were applied to UVIT plus HST photometry: derive ages, masses and metallicities of the clusters.

Top left shows the positions of the clusters,

Top right shows age vs. deprojected distance from the centre of M31 showing 2 main age groups.

Metallicity vs. radius is shown in the bottom left.

Age distributions in lower right: UVIT detects many more young clusters than Johnson et al (2016).

Multi-band bulk light analysis

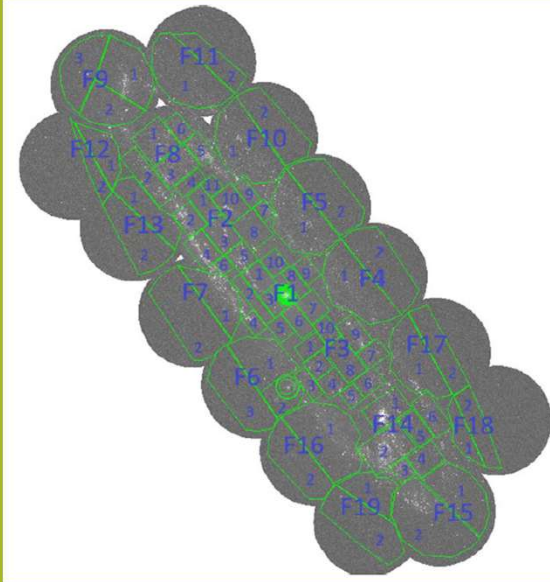
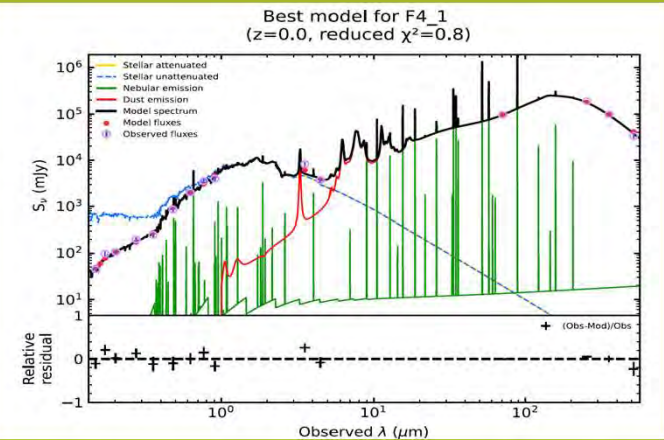
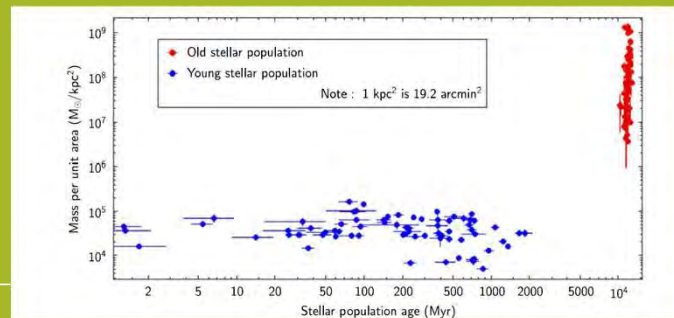
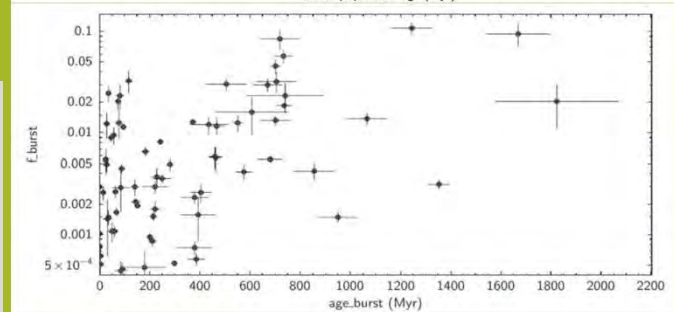
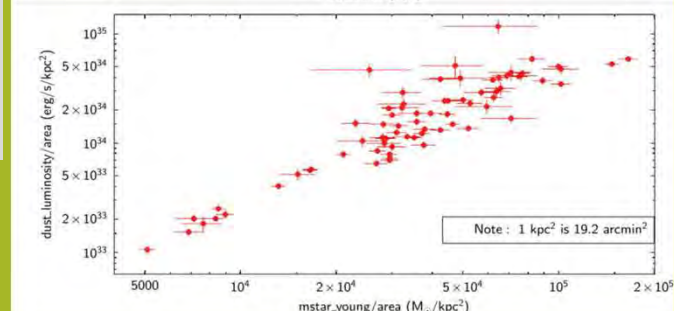
Leahy, Hansen, Hopkins 2024: To get a large scale view of M31's star formation history.

Combine the UVIT data with archival optical, near IR and far IR data (16 bands).¹

The young cluster study was restricted to the HST/PHAT area (northern disk of M31).

Cover the whole galaxy with 76 regions. The multiband photometry is fit with Cigale models: include stellar emission, nebular line emission, dust emission and dust absorption.

2 star formation bursts fits all regions. Results: metallicity, stellar masses, starts and durations of old and young stellar bursts for each region, dust properties.



Results

Above-right shows the masses per area of old and young populations vs. age. The old population has a uniform age of 11 Gyr; the young population has a wide range of ages and small masses.

Middle-right show fburst (the ratio of young to old star masses) vs. age of the young population: the more recent star formation has smaller mass bursts than the "older" young populations.

Bottom-right panel shows dust luminosity in M31 is primarily driven the young stars.

NGC 205

Leahy, Hansen, Hopkins 2025:

UVIT plus archival observations (total 18 bands) of NGC 205, (NW companion galaxy to M31).

28 regions were selected for analysis.

Background subtraction carried out (sky background plus residual light from M31 and the Milky Way).

Modelling with Cigale

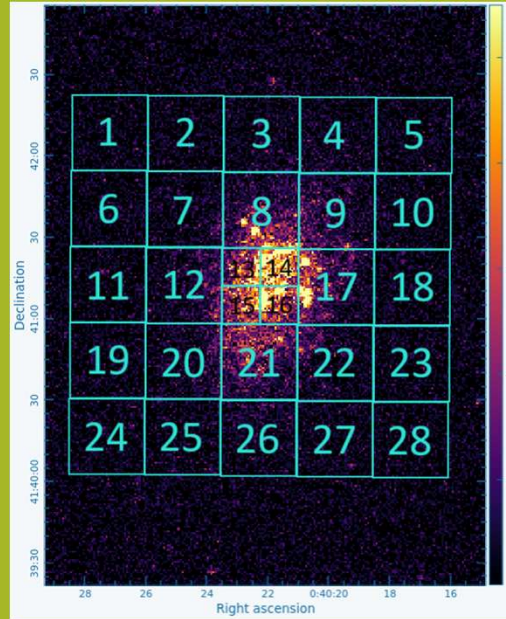


Table 2. Means and standard deviations of parameters^a for the 28 regions

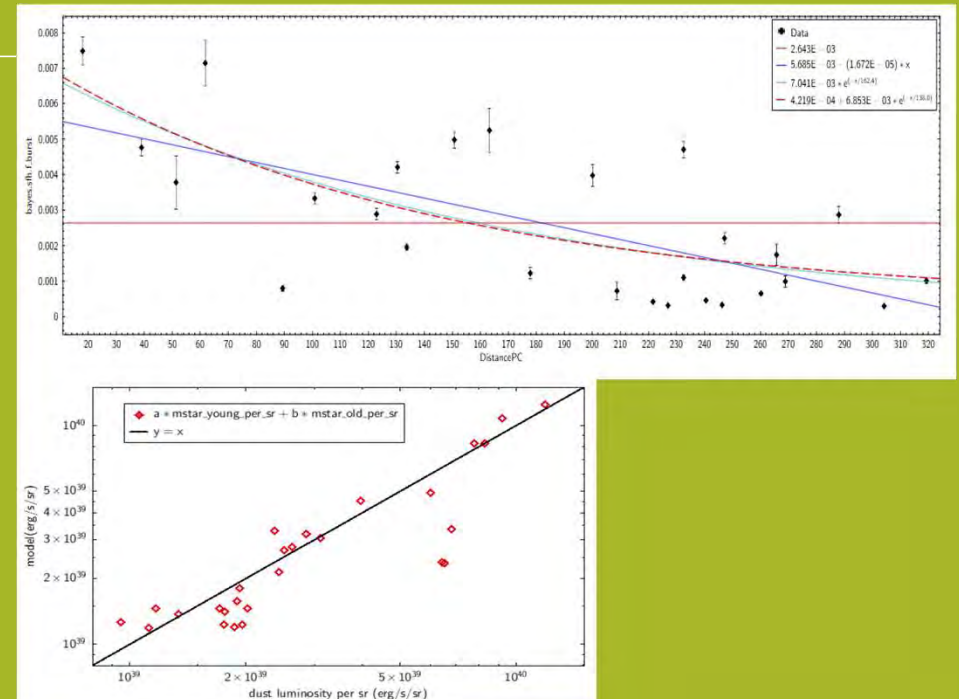
Parameter	Mean	Standard deviation
Without distance trend		
attenuation.E_BV_factor	0.372	0.150
attenuation.E_BV_lines	0.151	0.0951
attenuation.powerlaw_slope	-1.32	0.620
nebular.f_dust	0.300	0.0373
nebular.zgas	0.0203	6.25E-4
dust.qpah	5.51	1.64
dust.umin	1.36	0.803
dust.alpha	2.76	0.123
dust.gamma	0.356	0.121
sfh.age_main (Myr)	9480	259
sfh.age_burst (Myr)	906	136
sfh.tau_burst (Myr)	778	67.7
stellar_metallicity	0.0498	2.09E-4
With distance trend		
sfh.f_burst	0.0258	0.0210
sfh.tau_main (Myr)	662	219
Derived quantities		
dust.luminosity/area (erg/s/sr)	3.79E39	2.89E39
mstar_old/area (M _⊙ /sr)	2.93E14	1.50E14
mstar_young/area (M _⊙ /sr)	1.23E10	1.76E10
Other quantities		
best_reduced_chi_square	0.578	0.155
area (arcmin ²)	1.60E-8	4.81E-9

Results

The statistics of the Cigale parameters for NGC 205 are shown in Table 2.

Top-left: the fburst parameter vs distance from the centre of NGC 205. There is a young stellar population throughout NGC 205, but the young star formation is strongest near the centre (for M31 it was in the spiral arms).

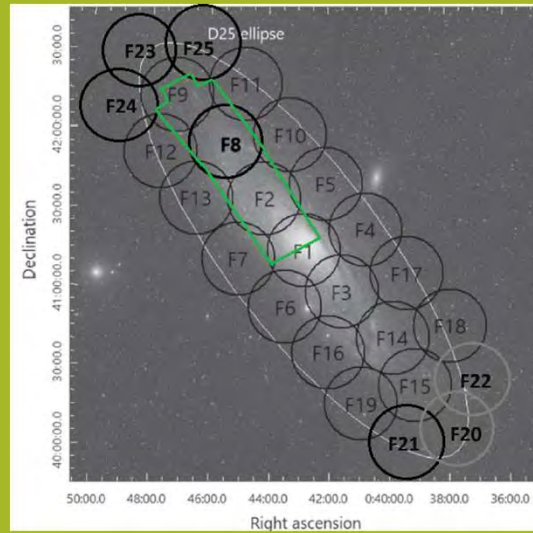
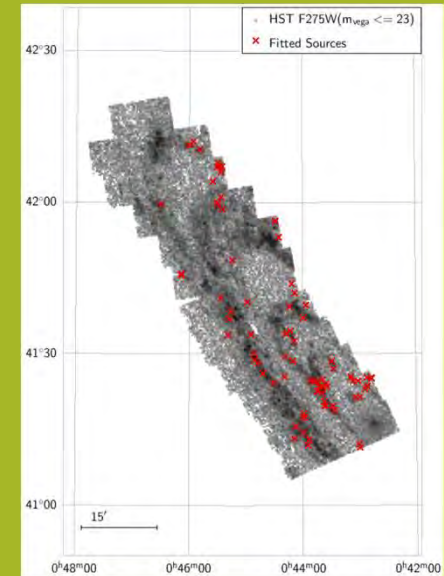
Bottom-left: dust luminosity per unit area compared to a model consisting of young star and old star driven components. We find the dust luminosity coefficients per solar mass of young stars is 1.2×10^{29} erg/s and per solar mass of old stars is 6.5×10^{24} erg/s.



Multiband (UVIT + HST/PHAT) photometry of resolved stars in M31

UVIT data from the most recent data reduction of the M31 observations: Photometry published in the M31 compact source catalog (Leahy, Ranasinghe, Mitra, Rawal 2025).

Select all UVIT sources that match a unique HST/PHAT sources with F275W measurements ($m_{\text{Vega}} < 23$) to avoid multiple hot stars within a single UVIT resolution element. Usually find cool stars along the same line-of-sight (1" is 3.8 pc at M31).

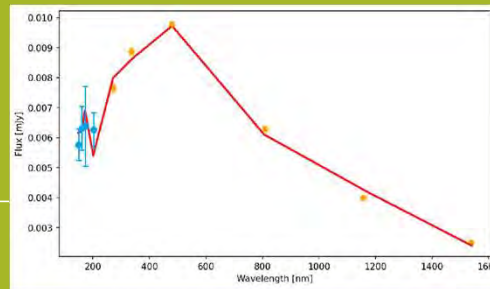
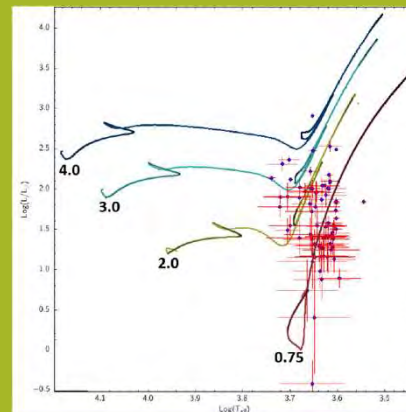
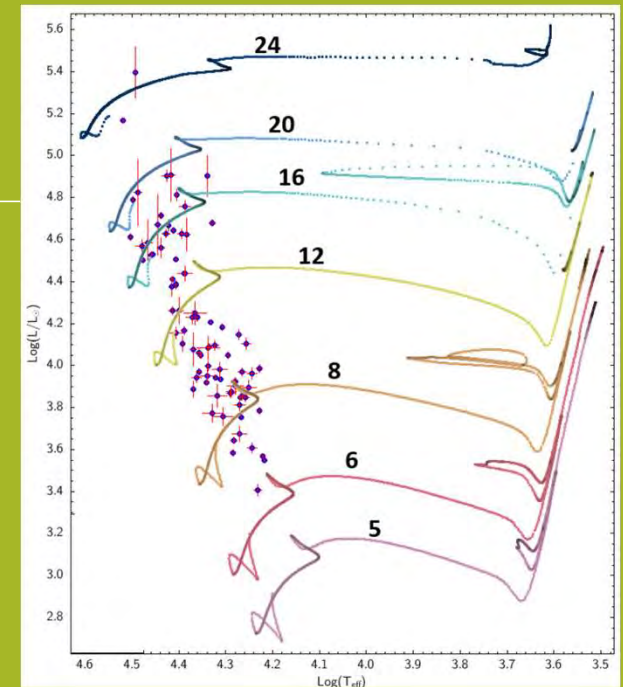


Analyzed 85 stars with Castelli & Kurucz atmospheres: 2-star (hot plus cool star) model parameters R_1 , $T_{\text{eff}1}$, $[M/H]_1$, $\log(g)_1$, $E(B-V)_1$, R_2 , $T_{\text{eff}2}$, $E(B-V)_2$

Top left: sample model fit.

Right: HR diagram with CMD evolutionary tracks for hot star components.

Lower left: HR diagram with CMD evolutionary tracks for cool star components.



SUMMARY

We study stellar populations in nearby galaxies with Astrosat/UVIT, combined with archival optical, near IR and far IR data.

We usually find younger star clusters or younger stellar populations than previous work. Also usually constrain the dust properties better than previous work because of the inclusion of UV data.

Acknowledgement: This work carried out with funding from the Canadian Space Agency.