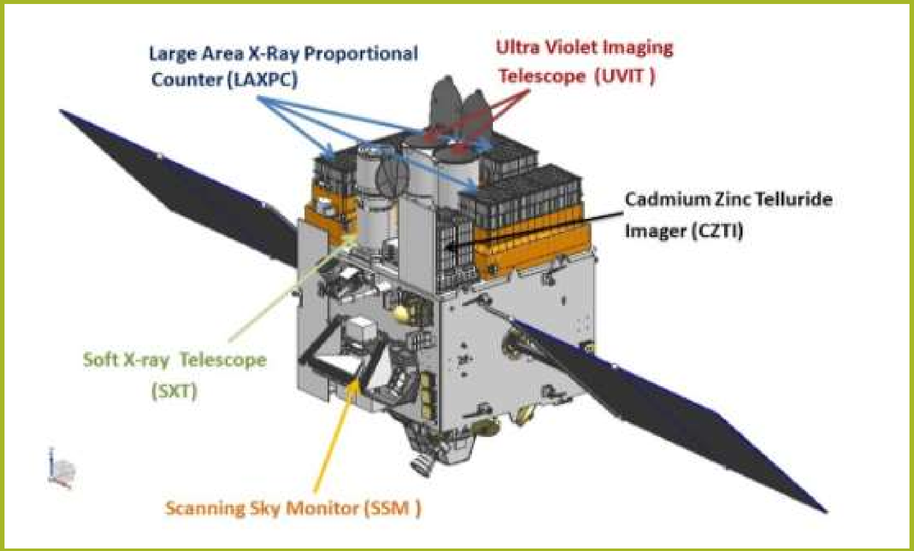
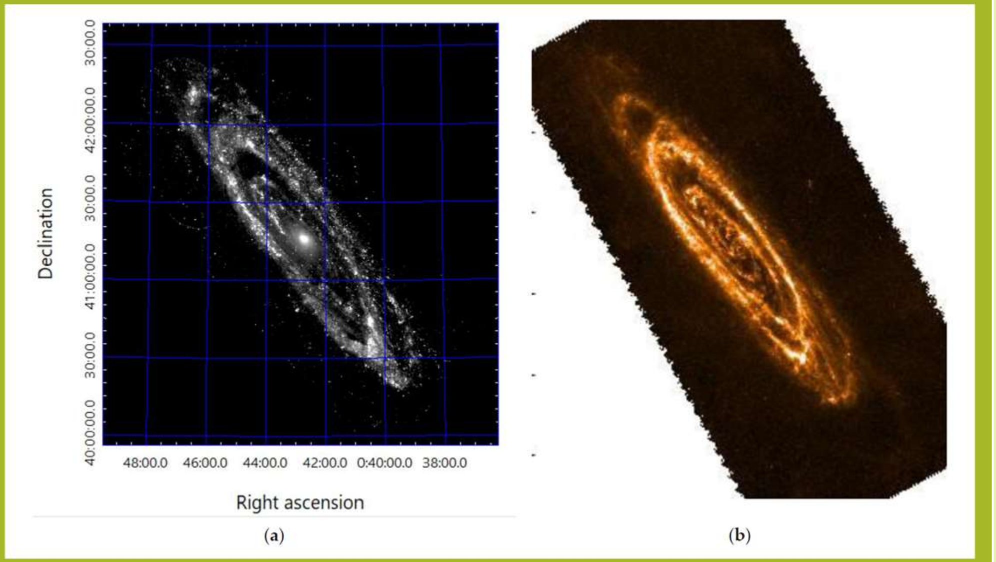
USING NEAR UV AND FAR UV OBSERVATIONS TO CONSTRAIN THE STAR FORMATION HISTORY OF NEARBY GALAXIES

DENIS LEAHY, JAKE HANSEN (DEPT. PHYSICS AND ASTRONOMY, UNIVERSITY OF CALGARY



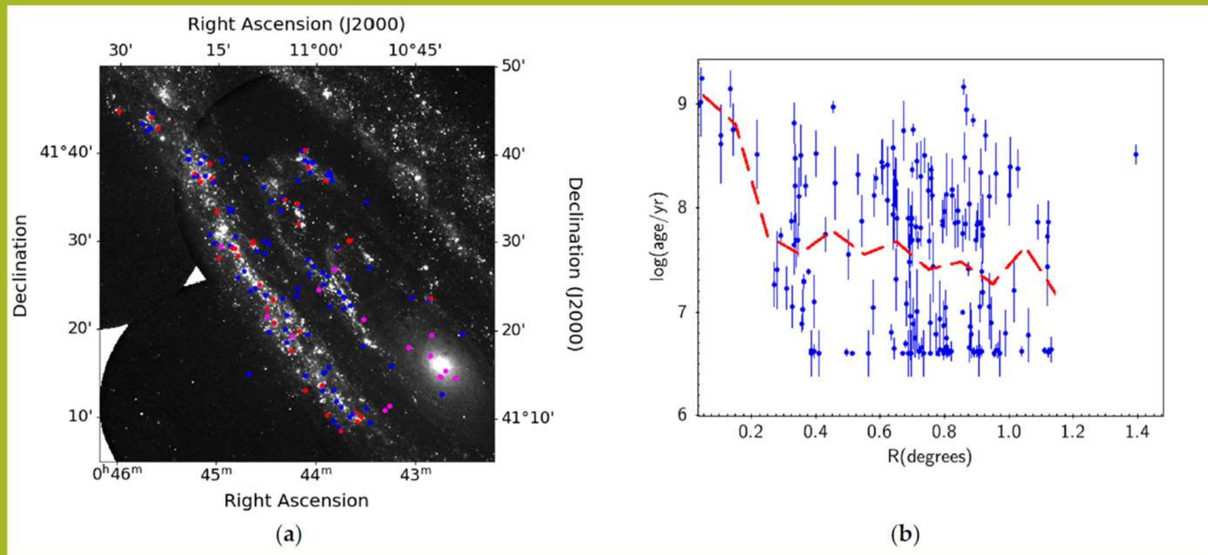


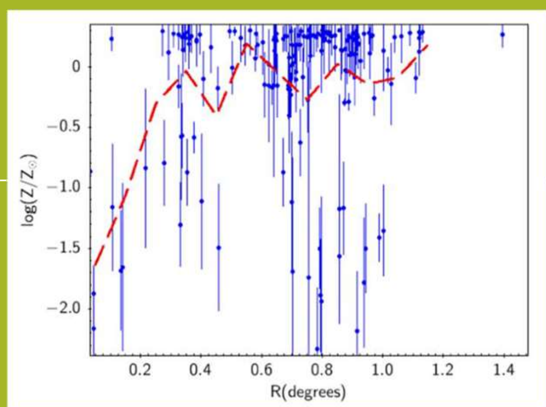
The AstroSat Satellite

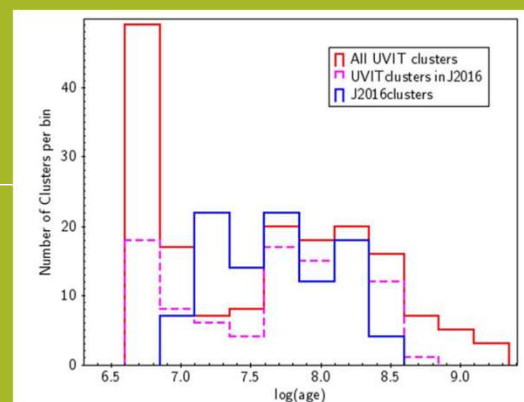
ASTROSAT includes 4 X-ray instruments and an ultraviolet telescope (Singh et al, 2014). It was developed by Indian Space Research Organization in collaboration with several other institutes including the Canadian Space Agency

M31, the Andromeda Galaxy

- M31 is a nearby giant spiral galaxy, similar in size to the Milky Way. Since 2017 we have been observing M31 with the UVIT (ultraviolet imaging telescope) on the Astrosat satellite. The current status of the M31 survey is that 23 of 25 fields have been observed, with the remaining 2 fields not observed because f UV bright foreground stars (unsafe for UVIT). Above left is shown the mosaic created in the F148W filter (150 nm) band, with 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.





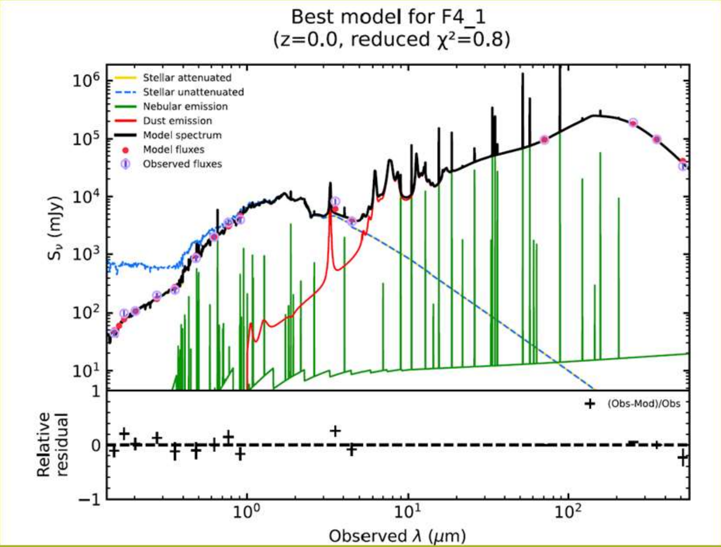


Analysis of stellar clusters

We selected the young clusters (ages <300 Myr) from the Johnson et al (2016) catalog, which was based on HST observations. The UVIT photometry was added to the HST photometry, and stellar cluster models applied to 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 and age distributions in lower right. UVIT detects many more young clusters than Johnson et al (2016).

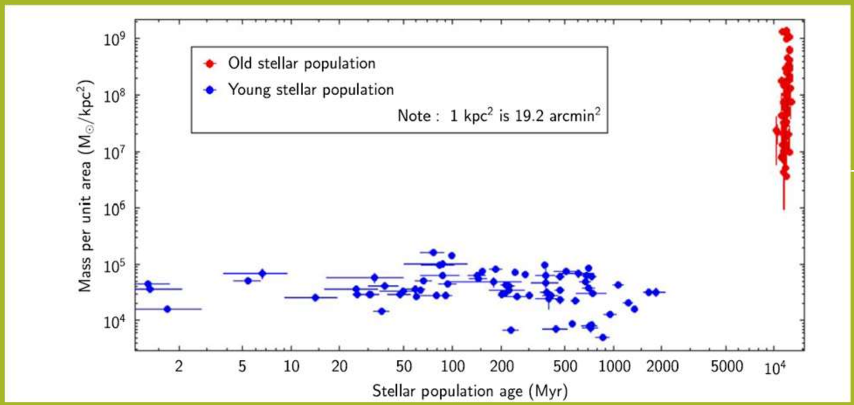
Cigale models for bulk light

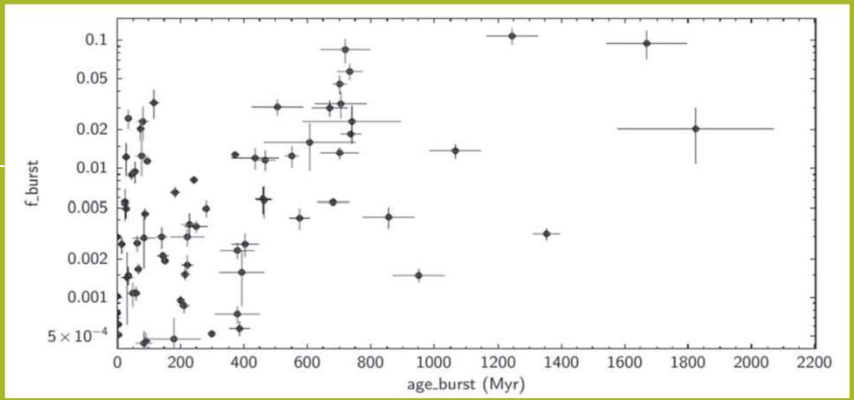
To get a larger scale view of the star formation history, we combine the UVIT data with archival optical, near IR and far IR data (see Table 1). In contrast to the young clusters, which was restricted to the HST area (northern disk of M31) , we cover the whole galaxy (using 76 regions). The multiband photometry is fit with the Cigale code, which includes stellar emission, nebular line emission, dust emission and dust absorption.



Model outputs

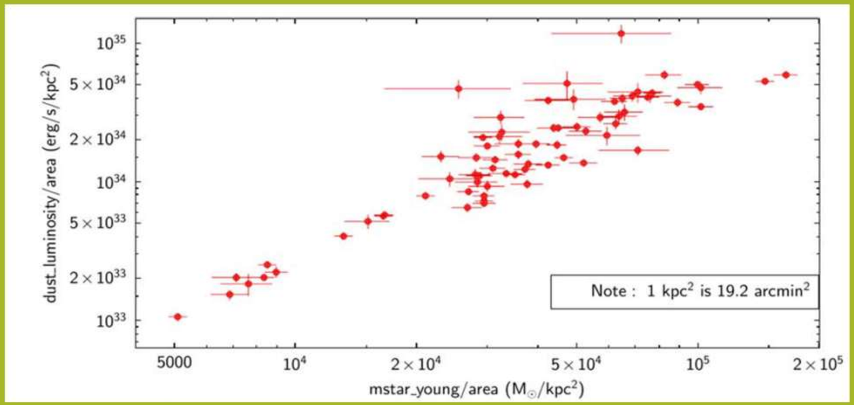
The plot shows the Cigale fit to one of the 76 regions. We found 2 star formation bursts fits all regions. The results from the fits are metallicity, stellar masses, start ages and durations of old and young stellar populations for each region, plus dust properties.





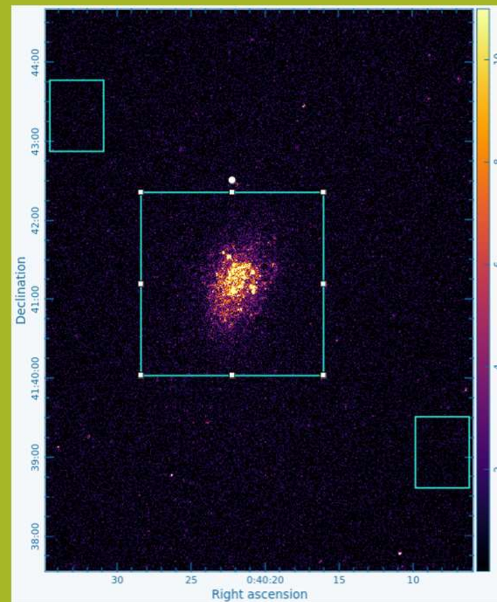
Results

The top plot above 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. The top-right panel show fburst (the ratio of young to old star masses) vs. age of the young population: the more recent star formation has smaller masses than the "older" young populations. The bottom panel shows dust luminosity in M31 is primarily driven the young stars



NGC 205

We also obtained UVIT observations of NGC 205 a companion galaxy to M31. Multiband archival data was obtained, then 28 regions were selected for analysis, as shown above, with 2 regions for background subtraction (any sky background plus residual light from M31 and the Milky Way. Modelling was carried out with Cigale



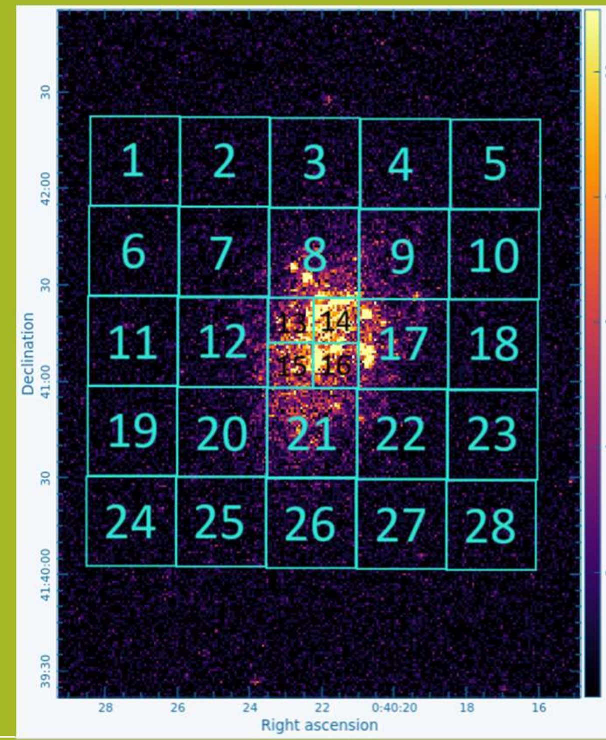


Table 1. Filter name, central wavelength, and telescope for the images used.

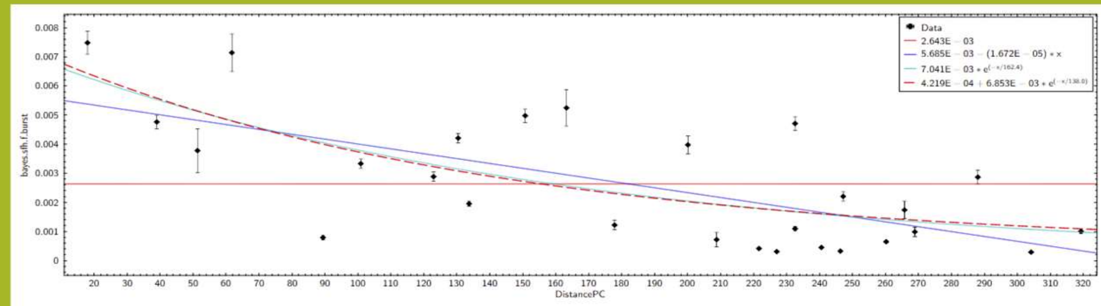
Filter Name	Central wavelength (m)	Telescope
F148W	1.48E-07	UVIT
F169M	1.61E-07	UVIT
F172M	1.72E-07	UVIT
U	3.65E-07	JKT
B	4.40E-07	JKT
V	5.50E-07	JKT
R	7.00E-07	JKT
J	1.20E-06	2MASS
H	1.60E-06	2MASS
K	2.20E-06	2MASS
SPITZER_I1	3.55E-06	Spitzer
SPITZER_I2	4.49E-06	Spitzer
MIPS24	2.40E-05	Spitzer
PACS 70	7.00E-05	Herschel
PACS 160	1.60E-04	Herschel
PSW	2.50E-04	Herschel
PMW	3.50E-04	Herschel
PLW	5.00E-04	Herschel

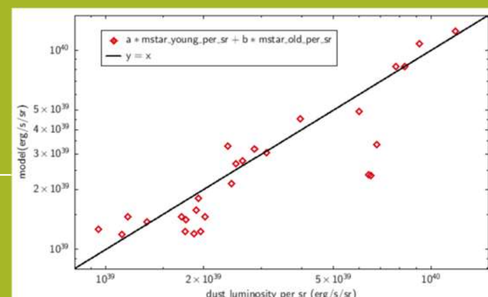
Results

The statistics of the Cigale parameters for NGC 205 are shown in Table 2. The top plot shows 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). The lower plot shows the dust luminosity per 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 x 10^{29} erg/s and per solar mass of old stars is 6.5 x 10^{24} erg/s.

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 ($M_\odot$/sr)	2.93E14	1.50E14
mstar_young/area ($M_\odot$/sr)	1.23E10	1.76E10
Other quantities		
best_reduced_chi_square	0.578	0.155
area ($arcmin^2$)	1.60E−8	4.81E−9





SUMMARY

M31 and NGC 205 have been observed with Astrosat/UVIT in multiple filter bands. We combine the UV with archival optical, near IR and far IR data to study the star formation history of both galaxies. We find younger star clusters than previous work, and constrain the spatial star formation and dust properties better than previous work because of the inclusion of UV data, which is sensitive to hot stars and to dust absorption.

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