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YOUNG STELLAR POPULATIONS IN M31

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Abstract

We present a comprehensive study of star–forming (SF) regions in the nearest large spiral galaxy M31. We use *GALEX* far–UV and near–UV imaging to detect young massive stars and trace the recent star formation across the galaxy. The far–UV and near–UV flux measurements, combined with ground–based data for estimating the reddening by interstellar dust, are used to derive ages and masses of the star–forming regions. The *GALEX* imaging, combining deep sensitivity and entire coverage of the galaxy, provides a complete picture of the recent star formation in M31 and its variation with environment throughout the galaxy.

Introduction

Young massive stars are a robust tracer of recent galaxy evolution. They emit powerful UV radiation. In particular, far–UV imaging is ideal to detect these stars, which are confused with older stellar populations in observations at other wavelengths. Most young massive stars are born in associations. The FUV - NUV colour of young associations is very sensitive to the age of the population, because massive stars evolve rapidly. We estimate the ages of young SF regions from their FUV-NUV color, and their masses from the extinction-corrected UV luminosities. These results are used to study the recent star formation in M31.

Data

We selected 7 *GALEX* fields covering the entire disk region of M31, with homogeneous exposure time. Each GALEX field (1.2deg diameter) has far–UV (134.4-178.6nm, FUV) and near–UV (177.1-283.1nm, NUV) imaging. We also used multi-band optical data from the KPNO survey by Massey et al. (2006).

No.	Field Name	Field Center		Exposure Time (s)	Threshold (c/s)
		R.A. (deg.)	Dec. (deg.)		
1	NGA_M31_MOS11	12.2049	42.9561	3340.35	0.00397
2	NGA_M31_MOS8	12.1648	42.0309	2702.75	0.00387
3	NGA_M31_MOS18	11.4031	42.3702	3244.45	0.00365
4	NGA_M31_MOS4	11.2531	41.8638	3589.70	0.00373
5	PS_M31_MOS00	10.6836	41.2777	3760.10	0.00353
6	NGA_M31_MOS0	10.1740	40.8365	6811.30	0.00324
7	PS_M31_MOS03	9.9574	40.3585	1182.20	0.00446

Detection

We used the field "NGA_M31_MOS0" (exposure 6,811s), to test and refine our procedures, which were then applied to all our selected fields. The first step was to detect young SF regions, and define their contours, using the FUV image. We tested several methods, varying the procedures for background estimate and contour definition. We defined contours of SF regions where more than 50 contiguous pixels (~1,600 pc^2, or ~40 pc size in M31) have flux at 3-sigma above the mean background flux. This results in a threshold of ~0.0032 c/s/pixel, or ~25.8 mag/arcsec^2; the corresponding limit on the detected masses (as a function of age) is shown in Fig.3.

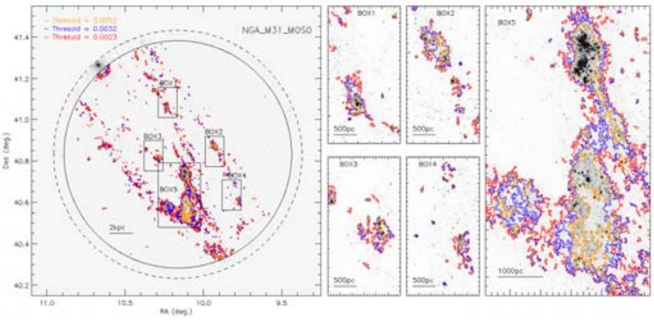


Fig.1. Detected SF regions in "NGA_M31_MOS0" field, using three different thresholds (Red/ blue/ orange contours: two / three / five sigma above the mean background). The solid circle is our selection field of view (excluding the edge). Enlargements of five sample regions (BOX 1-5) in this field are shown in the right panels.

Interstellar Extinction

We estimated the extinction by interstellar dust for each SF region from multi-band photometry (taken from Massey et al. 2006) of the OB stars within the SF contours, using stellar model colours (Bianchi et al.).

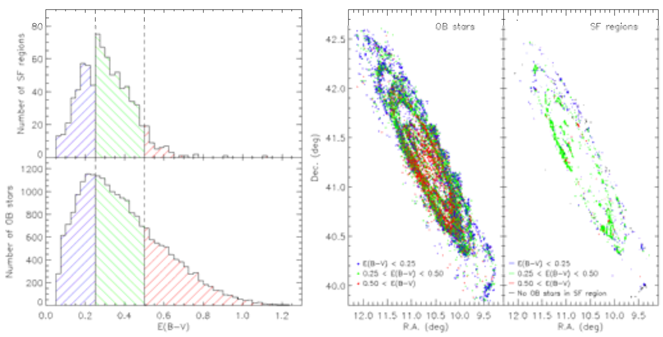


Fig.2. Left – Number distributions of reddening for OB stars and detected SF regions.
Right – Spatial distribution of selected OB stars and detected SF regions.

Ages and Masses

We estimated the ages of the SF regions by comparing the measured FUV - NUV colour with simple stellar population synthesis models, exploring effects of metallicity and dust type (e.g. Bianchi 2008). We then estimated the masses from the reddening corrected UV luminosity.

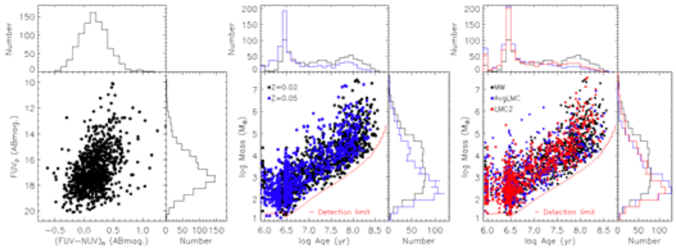


Fig.3.Left: Colour-magnitude diagram of the SF regions, Middle: Age vs. mass: two metallicities (Z=0.02 and 0.05) with MW extinction, Right: Age vs. mass: three types of interstellar dust (MW: Milky Way, AvgLMC: average LMC, LMC2: 30 Doradus) with Z=0.02

Spatial Distribution

The SF regions follow the disk structure of M31, out to outermost radii.

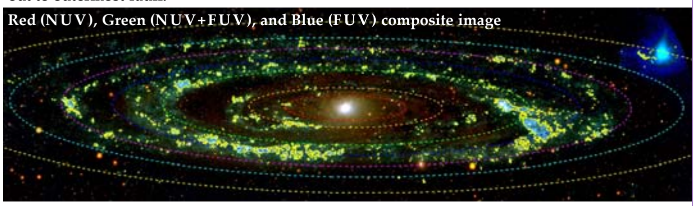


Fig.4. Yellow contours are the detected SF regions. Dashed-line ellipses are drawn at 18′(red), 28′(orange), 53′(green), 68′(blue), 83′(purple), 98′(cyan), and 120′(yellow) distance from the galaxy centre (de-projected assuming an inclination of 77.7 degrees).

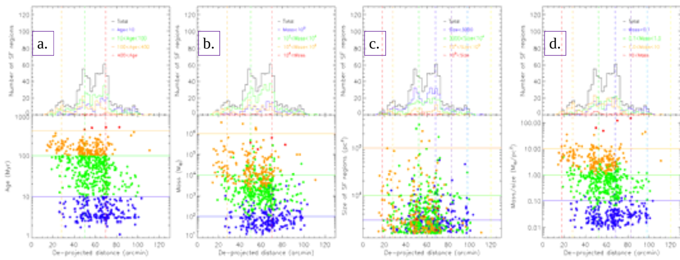
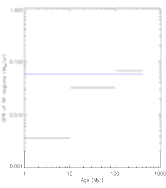


Fig.5. Distribution by de-projected distance: a. age, b. mass, c. size, d. mass-per-unit-area of the SF regions. The dashed lines mark the radius of ellipses in Fig.4 (colours as in Fig.4). Symbol colours in the plots correspond to age ranges as defined in the left panel (a).

Conclusions

We estimated ages and masses of SF regions in M31, detected from FUV imaging. Most are younger than 400 Myrs (UV is not sensitive to older ages). Interestingly, there are no massive associations at young ages (Fig.3.a), suggesting a decrease of the star-formation rate. We estimated the SFR in three time intervals adding the masses of the SF regions of corresponding ages. These are restricted by our detection limit. Fig.6 shows the recent decrease of the SFR (black bars: SFR in a time bin, blue bar: average SFR in the past 400 Myr)



Future Work

We will compare the SF regions' parameters from the integrated measurements with resolved studies of their stellar populations (from ground-based and Bianchi's HST programs data). We will estimate ages and masses from deeper GALEX images to test the limit of our current detection threshold.

References

Bianchi, L. 2008, APSS, 41B

Massey, P., & et al. 2006, AJ, 131, 247

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