A complete census of massive star formation in M31 and M33: The relation between star formation and ISM properties


ABSTRACT: We utilize GALEX FUV and NUV observations (Thilker et al. 2005), Spitzer (MIPS), WSRT and VLA HI mosaics, plus published CO data of M31 and M33 to measure the spatial distribution of extinction-corrected star formation rate (SFR) and gas surface density. The powerful combination of UV and IR datasets allows us to firmly constrain the SFR over a comprehensive range of galactic environments, from relatively unobscured locales to highly extincted clusters embedded in the spiral arms. With this complete census of massive star forming regions, we have started to re-examine the relationship between the multi-phase ISM and recent star formation activity, focusing on the Schmidt Law and well-known star formation thresholds. This poster describes our initial (lowest-resolution) results, using all MIPS bands.

METHOD: Most of the energy radiated from an OB stellar population originates in the UV, however the emergent spectrum is environmentally modified by dust obscuration and reddening. The balance of UV photons lost to the circumsolar environment can be recovered by considering the thermal emission from dust grains. A first-order estimate of the original bolometric luminosity is obtained by summing the TIR (8-1000 µm) and UV luminosity without any extinction correction. In this study, we adopt the TIR+UV luminosity as our fiducial SFR metric, computing TIR flux from all three MIPS bands following Dale & Helou 2002. The resolution of MIPS (25, 70, and 160 pc for 24, 70, and 160 µm) and GALEX (25 pc) in our Local Group targets (D = 0.77, 0.84 kpc for M31, M33) provides a chance to calibrate other SFR tracers against this robust fiducial at unprecedentedly small scales.

As shown by Calzetti et al. (#60.03) for SF complexes in M51, the MIPS 24µm band correlates well with the nebular (Pα) SFR on scales >500 pc, yet any metric based on grain emission is by construction incomplete for near environments largely cleared of dust, or missing it from the start. That is, no IR SFR metric can account (except statistically) for the fraction of a young stellar population's bolometric luminosity which succeeds in escaping without being absorbed by dust. Much of our effort will focus on establishing the 24µm band as a reliable metric for UV photons which are not as lucky, so we can gain a factor 6x in spatial resolution by avoiding dependence on the MIPS 70 and 160µm bands.

RESULTS: Global UV+IR SFR analysis (at right) shows that the majority of intrinsic UV emission is typically reprocessed into the IR, and only leaves the galaxy indiscernibly. However, our MIPS/GALEX images of M31 and M33 also show that SF can occur in IR-faint locales, whether faint due to a dilute radiation field or simply a dust deficient environment. Only together can UV and IR tracers provide a complete census of SF activity.

Star formation at large radii and low \( \Sigma_{\text{gas}} \)

The incidence of (continuing?) SF in outer disks of spiral galaxies has historically been underappreciated. Only in the past decade have sensitive Hα (eg. Ferguson et al. 1998) and multi-color broadband surveys (eg. Cuillandre et al. 2006) revealed groupings of young stars at radii beyond a few times \( R_e \). The extraordinary sensitivity of GALEX has enhanced awareness of these sources, in some cases even suggesting continuous SF profiles across the “threshold radius” conspicuously evident in the distribution of HII regions. M31 is no exception, and our GALEX mosaic reveals many clusters at large radii. We do not yet have a source catalog, due to the difficulty of excluding background galaxies, but work is in progress. Although the azimuthally averaged N(HI) is low at such galactocentric distances, star clusters appear to generally trace local maxima. These SF regions are rarely apparent in the IR.

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