Characterizing the Outskirts of M82 and NGC 3077: A Timeline of the M81 Group

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Motivation:

- Mergers and interactions between galaxies dramatically change their structure and composition
- Galactic outskirts act as a fossil record of these events, allowing us to understand the merger history of galaxies.
- The M81 group is an ideal candidate for studying how galaxies change during a massive merger: The group is nearby, easily observable, and the three main galaxies at the center of this group are actively interacting and will merge in the next 2 Gyr (Smercina et al. 2020).
- Past work have characterized aspects of M81's stellar halo and pieces of the two galaxies analyzed here; we measure the end of star formation (t_{90}) and metallicity to understand how the interactions and mergers of these three galaxies have shaped the past, present, and future of this group

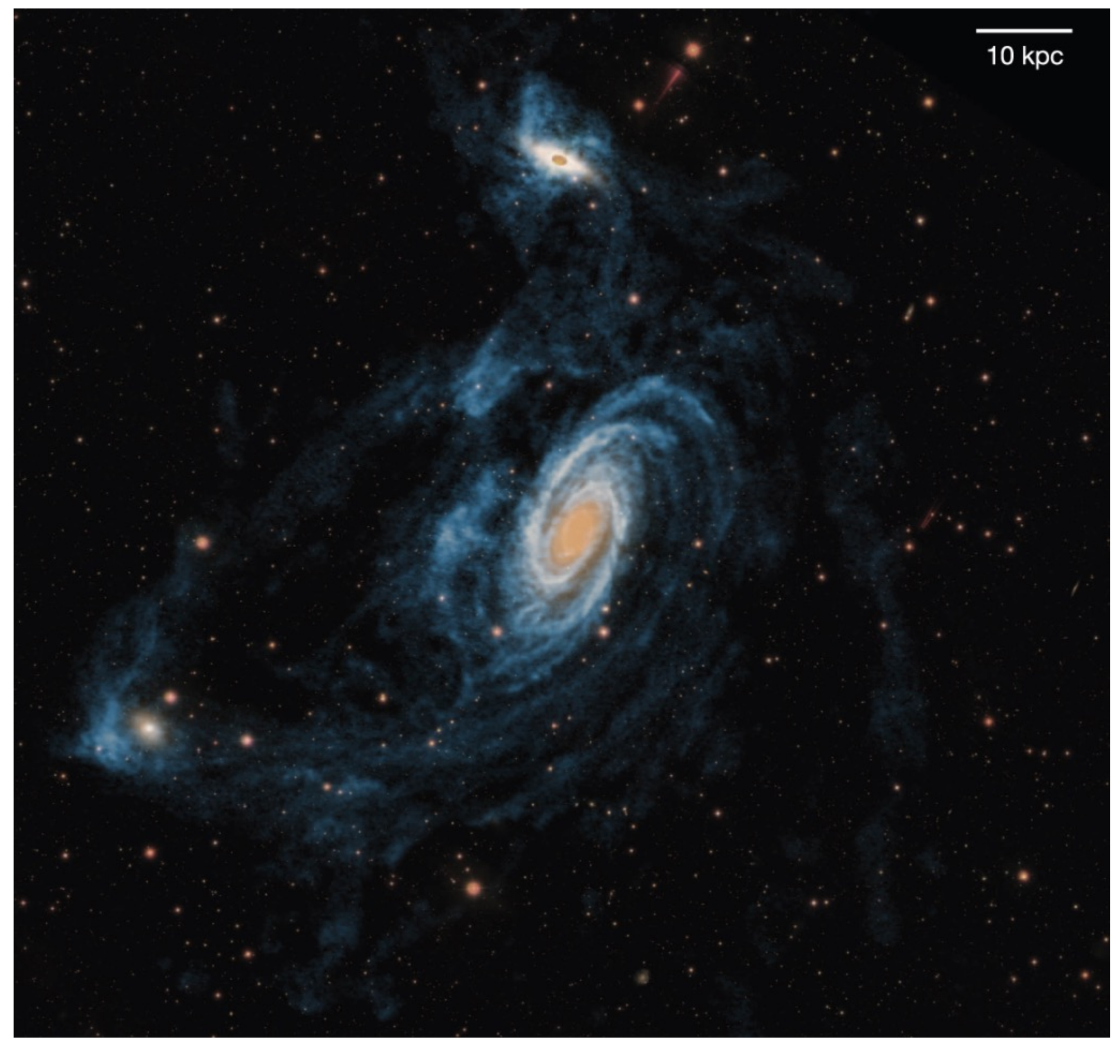

Figure 1: An image of the M81 group, taken from de Block et. al. 2018. Streams of gas connecting these galaxies are clearly visible, evidence of their recent interactions.

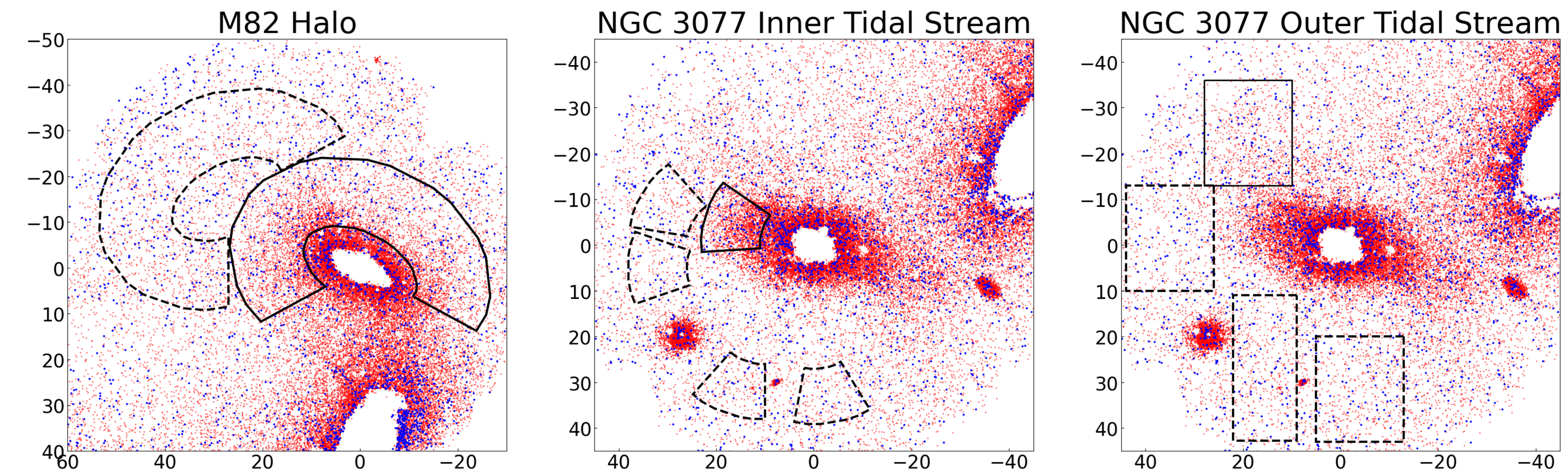

Figure 2: Wide field images from the Subaru telescope, with RGB stars in red and AGB stars in blue. The spatial selections of M82's stellar halo and NGC 3077's tidal arm analyzed in this work are shown with solid lines, and selections used for background subtraction are shown with dashed lines.

Methodology:

- Using the methods outline in Harmsen et. al. (2023), t_{90} was calculating using the ratio of AGB to RGB stars contained in the selections shown in Figure 3
- Metallicity was found by interpolating over a set of 10 Gyr RGB isochrones with finely spaced [M/H]. Each point in color-magnitude space identified as a RGB star contributed to the metallicity of the selection; mean values and the standard deviation of each selection are reported in this work.

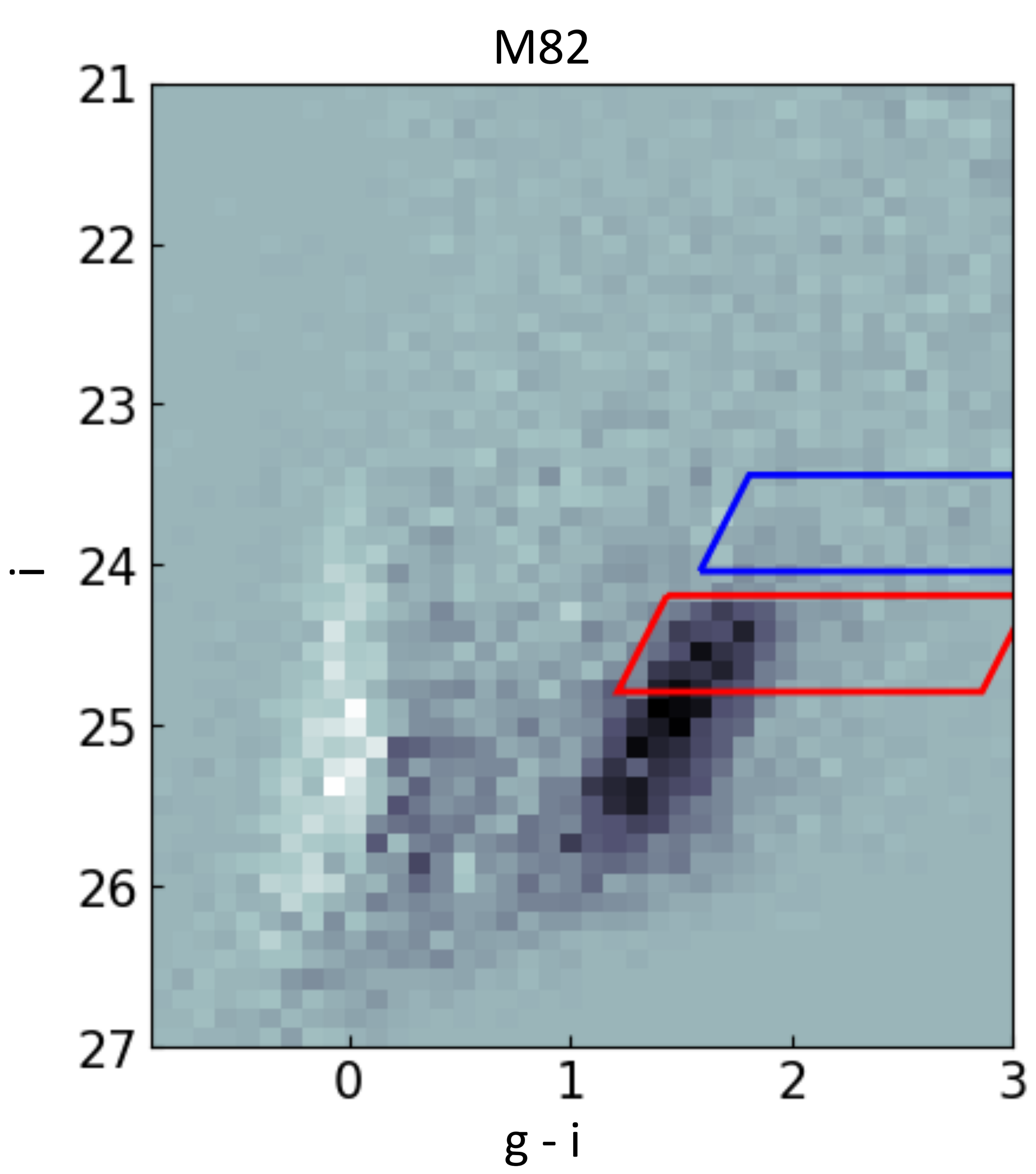

Figure 3: The background subtracted CMD of M82's stellar halo. The blue box shows the AGB selection, and the red shows the RGB. CMDs like these were made of the two selections of NGC 3077 to measure the quantities shown in Table 1.

	$N_{*,AGB}$	$N_{*,TRGB}$	$\log_{10}(N_{*,AGB}/N_{*,TRGB})$	t_{90} (Gyr)	[M/H]
M82	126 ± 21	1990 ± 50	-1.19 ± 0.07	6.6 ± 2.6	-1.56 ± 0.40
NGC 3077 (inner tidal stream)	70 ± 9	908 ± 42	-1.11 ± 0.06	5.7 ± 2.4	-1.39 ± 0.37
NGC 3077 (outer tidal stream)	16 ± 6	140 ± 54	-0.93 ± 0.23	3.6 ± 3.3	-1.54 ± 0.37

Table 1: The measurements made in this work. The counts in the two left columns correspond to the number of point sources identified as stars in the CMD selections in Figure 3. These were used to calculate t_{90}. Metallicity measurements are outlined in the methodology section.

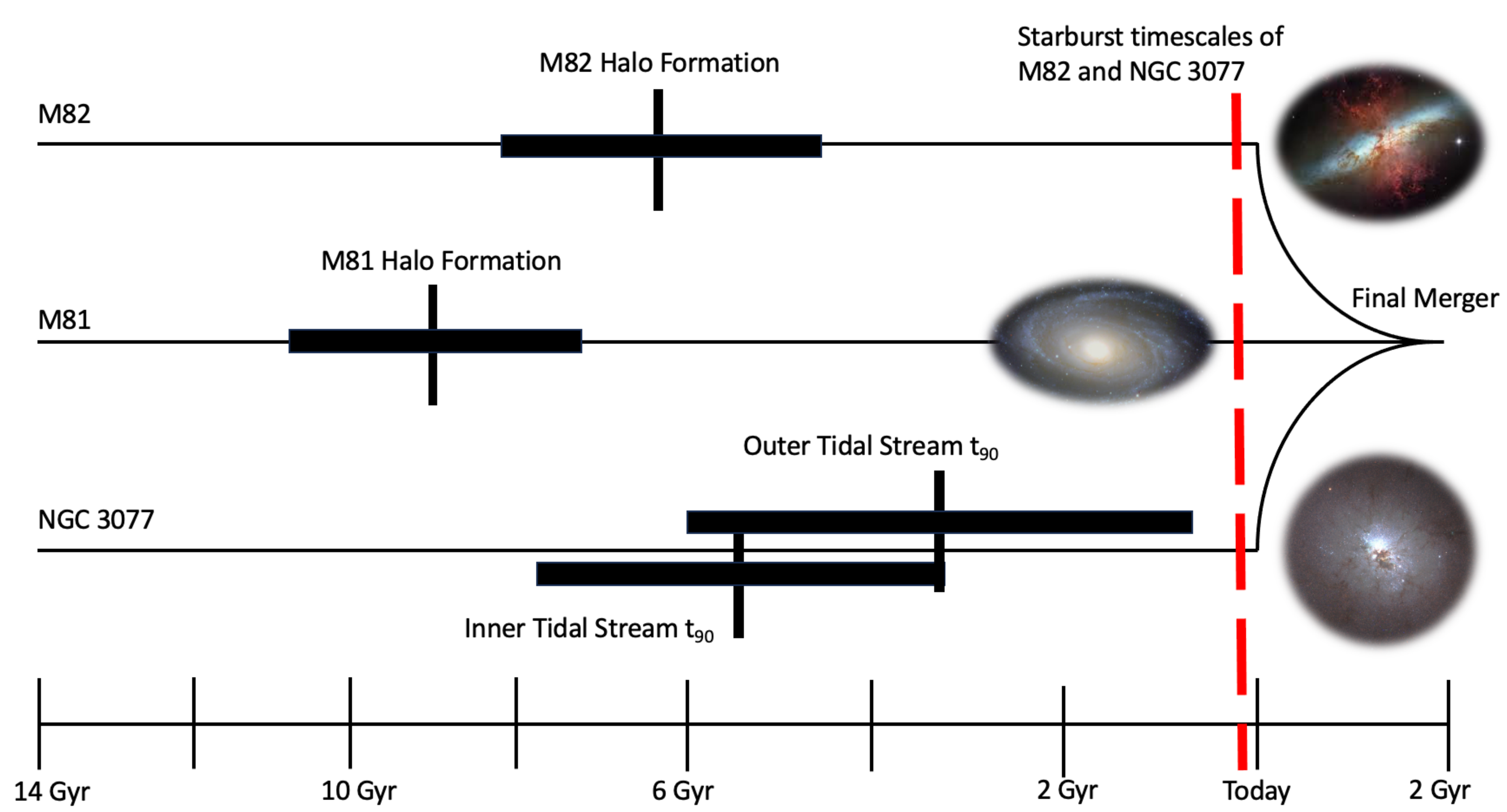

Figure 4: A timeline of the M81 group, constructed with our measurements of M82 and NGC 3077, the measurement of M81's halo from Durrell et. Al. 2010, and the starburst timescales taken from (citations).

Results:

- M82 possesses a metal poor, intermediate aged halo, composed of roughly 6 * 10^8 solar masses of stars (estimated based on the unbound mass measurement made by Smercina et. al. 2020).
- NGC 3077's tails contain a mild, old to young age gradient; the metallicity we find matches that reported in Okomoto et. al. (2023).

Interpretations:

- Based on comparisons with simulations and past works analyzing similar halos, M82's stellar halo was most likely formed by the accretion of a SMC sized satellite.
- The ages of the stars we find in NGC 3077's tail imply that they were not formed from the recent interaction between it and M81. A pre-existing intermediate aged population was present before tidal disruption for the t_{90} we measure to be present.
- While unexpected, intermediate aged tails around galaxies are present in TNG50 simulations.
- With these measurements and interpretations in hand, we construct a full timeline of this galaxy group (Figure 4).

References:
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