Science Justification

An increase in star formation in a galaxy is a consequence of multiple factors. One particular driver of star formation in galaxies is interactions between galaxies[5]. In fact, recent simulations show that on average a two galaxy merger results in a 30% increase in star formation rate(SFR)[8]. A smaller portion of mergers, about 17%, can even experience a 10-fold or more increase in SFR, although the overall duration of enhanced SFR for such mergers is much shorter[2]. Of course it is not necessary that the galaxies be in direct contact with each other in order to interact. It has been shown that galaxies as far apart as 150kpc are capable of enhancing star formation through tidal interactions[9]. However, as the galaxies come into close contact, the SFR increases further as the ISM's of the different galaxies interact, which causes gas to flow inwards towards the nucleus, driving a nuclear starburst[2]. The interaction of the different ISM's also sometimes lead to a more extended starburst, a process that is not as well understood[2]. At least one of the objects I intend to observe, the Antennae Galaxy, is known to display this feature.[2]

However, on average this period of higher SFR lasts only 200-400MYR, whereas merge events usually last at least twice as long as the starburst phase[4][3]. This implies an evolution in the SFR of the merging galaxies as the interaction progresses over time. This evolution is one item that I hope to observe. By looking at three interacting systems at various stages of their merging and identifying their star forming regions I hope to get a better picture of when the peak SFR occurs, as well as demonstrate the differences in SFR between the nucleus and other parts of the merging galaxy. This can be compared against the star-forming regions of non-merging galaxies to demonstrate the differences in distribution of areas of elevated SFR. The three systems in question are Arp 302, which has just recently begun its collision, UGC 8335, which is already experiencing strong tidal interactions, and the Antennae Galaxy, which has already merged to some extent[6][10][1]. I expect to see that for UGC 8335 and the Antennae Galaxy, SFR has already been enhanced. However, for ARP 302, I expect it to be too early in it's interaction to begin forming significant starburst regions[6]. I also expect to see the presence of enhanced SFR outside the nucleus in the Antennae galaxy, and will search for any similar structure in UGC 8335.

Figures & Tables

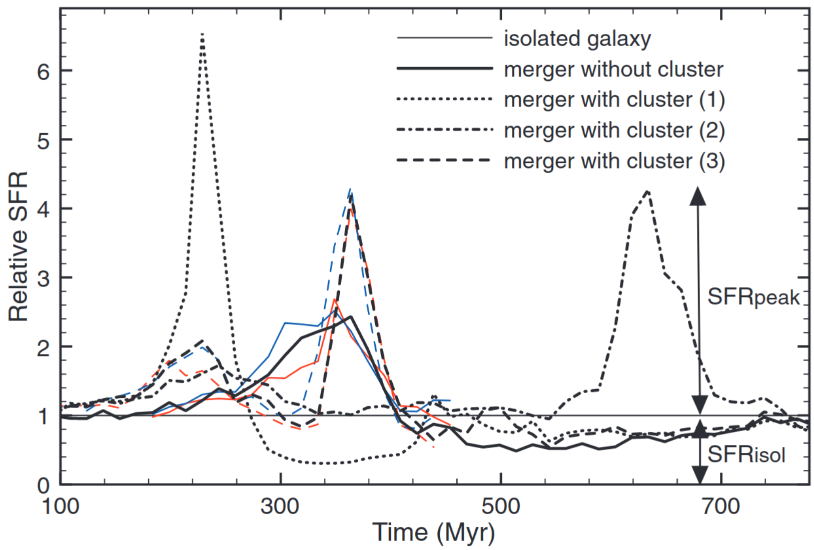

Figure 1: A comparison of SFR with and without a cluster in a variety of different configurations explained in [7]. The different configurations lead to different peaks for the SFR, but all lead to an increase in SFR over some period of time in comparison to the isolated galaxy

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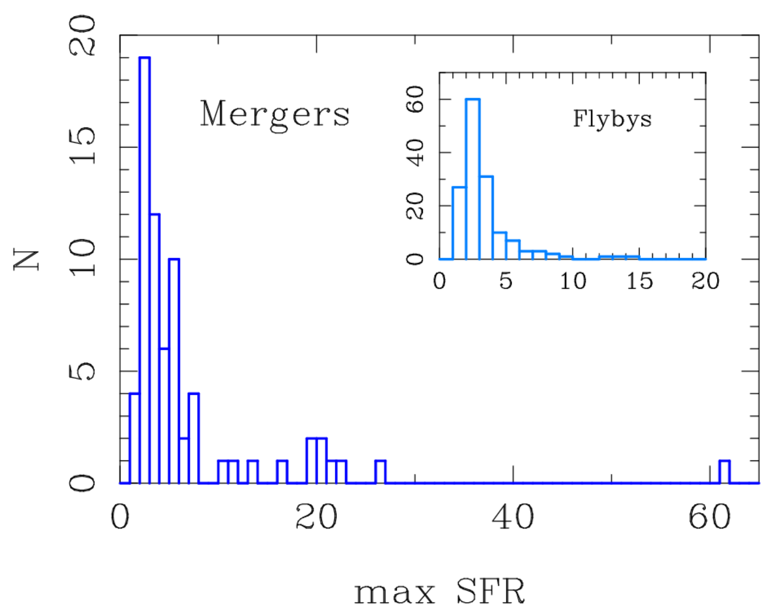

Figure 2: Count of maximum SFR for mergers. For comparison flybys are shown in the insert. This figure serves to demonstrate that most mergers do not cause a dramatic increase in SFR[4].

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Description of Observations & Justification of Exposure Times

The observation plan resembles the one used in project 3 since essentially the same regions are being found. G and R band will provide a wider picture of the galaxy in which to contextualize the presence of HII star-forming regions that will be found by the Hα filter. The McDonald telescope 30" telescope offers these filters and thus meets this requirement. The galaxies NGC 4038/NGC 4039, UGC 8335, and Arp 302 were chosen to reflect different stages of merging. They are all of sufficient angular size to have some of their structure resolved on the instrument. Their angular sizes are as follows. NGC 4038/NGC 4039: 5'.2 x 3'.1 / 3'.1 x 1'.6. UGC 8335: 1.70' x 0.70'. Arp 302: 1'.6 (0'.6 x 0'.6 / 0'.9 x 0'.3). They are also bright enough, with V magnitudes of 11.1, 14, and 11.3, to be detected by the telescope. Exposure times needed as calculated by the McDonald Observatory provided exposure calculator to reach a SNR of 100, using a conservative seeing of 4, are as follows. In Hα, for NGC 4038/NGC 4039 and Arp 302, about 4 seconds. For UGC 8335, about 54 seconds. In G and R, for NGC 4038/NGC 4039 and Arp 302, a time of under a second. For UGC 8335, about 5 seconds. Intuitively these seem like underestimates, so I am likely to follow the recommendations from Project 3 regarding exposure time, with 3 minutes in G and R and 10 minutes in Hα for NGC 4038/NGC 4039 and Arp 302. For UGC 8335 time will be increased to 9 minutes in G and R and 30 minutes in Hα. This can all be achieved in one night.

The distance to all of these galaxies is fairly well known. Therefore an Hα luminosity function describing the HII regions for each galaxy can be created. Image processing can also be done in SAO DS9 to show where in each galaxy the HII regions are. This can then be compared to the repository of data created for project 3 to show the difference in the location and strength of the star forming regions of merging galaxies in comparison to isolated galaxies. If necessary, models from literature can be included as well to better illustrated the differences. The differences in HII regions between the three different mergers can then also be compared to show how HII regions evolve as the galaxies come into closer contact with each other.

References and Target Table

Table 1: Target Table

Object	RA	DEC
NGC 4038/NGC 4039	12h 01m 53.0s	-18° 52' 10"
Arp 302	14h 56m 54s	+24° 36' 00"
UGC 8335	13h 15m 32.8s	+62° 07' 37"

References

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[10] *UGC 8335*. URL: `https://www.spacetelescope.org/images/heic0810al/`.