Galaxy clashes: Making stars in the Universe's biggest collisions

Galaxies, large structures of stars, dust and gas, do not live in isolation and are known to collide with one another. During these collisions, the galaxies become disrupted as the stars, dust and gas are moved around by the tidal forces created during these events. This movement of material can cause the gas to be compacted, resulting in periods of highly enhanced star-formation rates, know as starbursts. There is a wealth of observational and simulation information that shows that starburst galaxies are typically merging galaxies. However, what the observations cannot tell us is when these starbursts occur during a merger: are they early in the merger sequence, at the very end or somewhere in between. As a merger takes well over a billion years to complete, it is not feasible to watch a merger from start to finish to answer this question. On the other hand, simulations are able to see this but may not completely and accurately reflect what goes on in the real universe.

This project will determine how the star-formation rate of a galaxy changes as a merger progresses using observations. This is something that has not been done before and we have only recently developed the techniques needed to undertake such a study.

While it is not possible to watch a single galaxy through an entire merger, it is possible to create a large sample of galaxies at different merger stages. However, identifying the merger stage is difficult, with only a simple pre-merger or post-merger classification having been done in the last year. This project will use the latest advances in artificial intelligence (AI) to identify the time before or after a merger event for a statistically large sample of galaxies. From this, an observed merger sequence will be determined and we will, for the first time, be able to see how star-formation rates in galaxies change as they merge and when these changes occur.

For this, we can use simulations of galaxy mergers. While not a perfect reproduction of the Universe, cosmological simulations are able to accurately reproduce the shapes of galaxies and how interactions distort these shapes. The simulations also provide a known time before or after a merger event. Thus, using images from simulations with known times before or after a merger event, an AI will be trained to be able to accurately determine the time before or after a merger happens. This AI will then be applied to thousands of images of real galaxies, providing accurate estimates of how long it is until a merger or how long it has been since the galaxies merged. The star-formation rates from these galaxies will then be determined and all the galaxies will be used to generate a statistical picture of how the star-formation rate of galaxies changes during a galaxy merger. From this, we will better understand why the universe looks like it does today.

The results of this work will provide a catalogue of merger times for use by other astronomers. Other physical properties of galaxies are believed to be changed as they undergo a merger and this catalogue will allow other groups to study these different phenomena, or find new properties that were not previously understood to be influenced by a galaxy merger. The AI will also be released, allowing other astronomers, and the wider public, to use and adapt it for their own needs.