Star Formation in UV-Bright Interacting Galaxies

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Abstract

The interacting pair NGC 3395 and NGC 3396 emit strongly in the ultraviolet, indicating multiple regions of active star formation. To investigate the nature of the star formation, we obtained U, B, V, and R images using the 40-inch telescope at Mt. Laguna. Our goal is to determine the sequence of star-formation episodes in these systems. Possibilities include a "chain reaction"—one burst triggering another burst and so on—or a continuity of star formation that remains approximately constant with time.

Induced Star Formation

The interaction of two or more galaxies can trigger a burst of star formation in both galaxies. Shock waves due to this interaction compress the interstellar medium, triggering stellar creation. The UV-optical emission produced by the burst is dominated by short-lived O and B stars which are absent from older galaxies. Larson and Tinsley (1978) found not only that interacting galaxies appeared bluer than normal galaxies, but also that a larger range of colors is present in the interacting galaxies. The colors of normal galaxies can be explained by using a model of continuous, but exponentially declining, star formation rate. However, the color range in interacting galaxies can only be explained through a star formation history with recent bursts of activity. Evolutionary modelling of the colors and luminosities of stellar populations can be used to estimate the recent star formation history of a galaxy.

Observations and Data Reduction

Broad-band images of the target galaxies were obtained with the 40-inch telescope at Mt. Laguna, which is owned and operated by San Diego State University. The CCD camera used a detector with good blue sensitivity, ideally suited for our analysis. Typical exposure times were 30 minutes in the U (~3600 Å), B (~4400 Å), V (~5500 Å) and R (~6500 Å) filters. Photometric standard stars were also observed to flux-calibrate the images. Bias and flat-field corrections and all subsequent manipulations including sky-subtraction and flux calibration were applied to the data using IRAF (Image Reduction and Analysis Facility).

Analysis

Much of the star formation in interacting galaxies occurs in bright cluster or "knots." These knots can be isolated from the effects of the old stellar population by subtracting a smooth background from the original image. Candidate knots are identified in figure 2. Aperture photometry was performed to obtain an estimate of the knot brightnesses through circular apertures of 10, 15, 20, 25, and 30 pixels.

Color analysis is the basis of our research; by comparing the U-B and B-V colors of our knots with an age-dependent color-color plot generated by Starburst99, we can estimate the ages of the knots.

Figure 3 (left). U-B and B-V colors of the knots are plotted with the evolutionary track from Starburst99 (curving line) with young stellar populations (10 years) at the top left and older populations (100 years) at the lower right. The effect of dust is shown as the reddening vector at lower left, while the point from NGC 3396 is shown in red, those from NGC 3395 are shown in green points.

Interpretation

The distribution of points in Figure 3 demonstrates that the knots cover a range of colors. Notice that the points are separated from the model evolutionary track toward redder colors on both axes, indicating the effects of dust. By examining the reddening vector, one notices that the stars near the top of the plot can be de-reddened to fit approximately the beginning of the age progression plot, or about 10^5 years.

However, reddening cannot explain the positions of all the points in the diagram; those more towards the center of the plot can only be interpreted as being older than those near the top, and best correspond to an age of approximately 7 million years. This gives a range of ages of least 6 million years.

Since the galaxy is viewed nearly face-on, we can make the reasonable assumption that reddening is constant across the image of the galaxy. In this case, the rightmost knots (B-V=0.6) probably contain red supergiant stars which appear in bursts of star formation only after 10 million years, producing the loops in the evolutionary track.

Conclusions and Continuing Efforts

The star-forming knots in NGC3395 and NGC3396 show a range of U-B and B-V colors, indicating ongoing and recent star formation over the past 10 million years. Further research is necessary to determine more precisely the ages of the individual knots. By mapping out the ages of the knots in the original image, we will be able to trace the age progression, if it exists. Aperture correction and reddening analysis will be performed in addition to the current photometry. The uncertainty of our current data is probably of order 5 to 10%, but formal error assessment has yet to be performed. Residual underlying stellar populations can cause further reddening, though the background has been subtracted to a large degree.