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THE AGN-STARBURST CONNECTION IN INFRARED MERGING GALAXIES

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RESUMEN

Se presentan nuevos resultados del estudio de la conexión entre brotes de formación estelar y AGNs en el kiloparsec central de 230 galaxias infrarrojas. Hemos desarrollado mallas teóricas en el visible para determinar la contribución relativa AGN vs. brote estelar a la emisión en galaxias compuestas. Las mallas se basan en síntesis de población estelar, modelos de fotoionización y choques. Comparamos la contribución de un AGN con indicadores de evolución por fusión en nuestra muestra. Nuestros resultados apoyan un escenario evolutivo en el cual la actividad de los brotes estelares se desencadena inicialmente por interacciones de marea. A medida que el gas se concentra hacia el núcleo formado por fusión, se activa el AGN. En etapas posteriores de la fusión, los brotes estelares alrededor del núcleo galáctico se convierten en el principal mecanismo de excitación.

ABSTRACT

I present new results in our study of the starburst-AGN connection in the central kpc of 230 infrared galaxies. We developed theoretical optical grids for determining the relative contribution of AGN vs. starburst emission in composite galaxies. The grids are based on stellar population synthesis, photoionization and shock models. We compared the contribution from an AGN with indicators of merger evolution for our sample. Our results support an evolutionary scenario in which starburst activity is initially triggered by tidal interactions. As gas is funnelled towards the merger nucleus, an AGN is activated. Towards later stages of the merger, circumnuclear starburst activity becomes the dominant excitation mechanism.

Key Words: **GALAXIES: INTERACTIONS — GALAXIES: ACTIVE — GALAXIES: STARBURST — GALAXIES: EVOLUTION**

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1. INTRODUCTION

The most widely supported merger scenario (described in Sanders et al. 1988) for infrared merging galaxies is based on the Toomre (1977) sequence in which two galaxies lose their mutual orbital energy and angular momentum to tidal features and/or an extended dark halo, and eventually coalesce into a single galaxy. Tidal interactions and associated shocks are throught to trigger star formation which produces soft X-rays and heats the surrounding dust, resulting in strong FIR radiation. In this sequence, activity evolves from starburst to AGN in nature.

However, AGN studies in merging galaxies produce conflicting results. Some studies find that AGN are more common in merging than isolated galaxies (eg. Wu et al. 1998). Others find no correlation (eg. Lutz et al. 1999). Some studies even find a deficiency of AGN in advanced mergers and strongly interacting systems (eg. Bushouse et al. 1986). Whether the merger evolution sequence described above occurs remains a controversial topic which we are addressing with our sample of infrared galaxies.

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2. AGN CONTRIBUTION AND MERGER PROGRESS

We obtained high resolution (40 km/s) optical spectra (presented in Kewley et al. 2001a) for 230 warm *IRAS* galaxies using the Mount Stromlo and Siding Springs 2.3m telescope. The spectra were used in combination with our shock and photoionization models (Sutherland & Dopita 1993, Kewley et al. 2001b) to determine the AGN contribution to the optical emission in each merger. Figure 1 shows an example of our model grids, which are described in Kewley et al. (2002).

The evolutionary progress of a merger is traced by a morphological interaction scheme, and projected separation.

The morphological scheme is defined as: (1) isolated; (2) paired, non-interacting; (3) mildly interacting (separate nuclei, weak tidal features); (4) strongly interacting (separate nuclei, strong tidal features); (5) merger or merger remnant (one nucleus, distorted morphology). Problems with morphological schemes include subjectivity, limited resolution, redshift effects, and favoring retrograde encounters

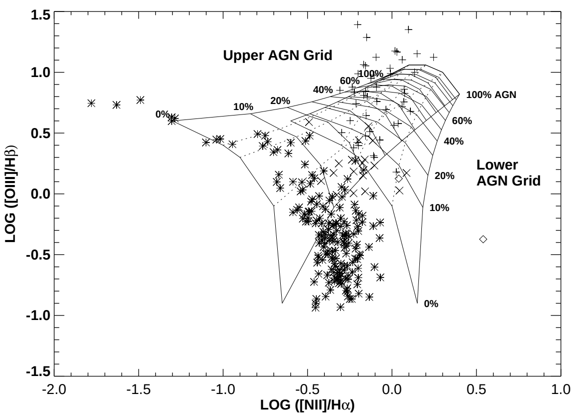

Fig. 1. An example of the upper limit (left) and lower limit (right) grids to determine the AGN contribution to the optical emission-line ratios. The 100% line is given by our shock+photoionizing precursor models. The 0% AGN (100% starburst) line for each grid is based on our photoionization models with a range of metallicities and ionization parameters. Galaxies were classified using a new scheme described in Kewley et al. (2001a).

Projected separation between the merging galaxies was found using the literature, 2MASS images, or DSS images. Due to the problems inherent to each scheme, neither can be used to compare individual galaxies, but should be used as statistical tools for large samples. In Kewley et al. (2002), we show that projected separation correlates strongly with interaction class supporting the use of these indicators of merger progress for large samples.

We compare the evolutionary progress with the optical contribution from an AGN in Figs 2 and 3. Rather than finding that AGN activity increases as the merger progresses, as suggested by the popular merger scenario, we find an anti-correlation of AGN activity with merger progress.

We speculate that if an AGN exists in the system, it will be visible in the early stages of the merger. During later stages of the merger, star formation is the dominant excitation mechanism, and the AGN is obscured by circumnuclear star formation and dust. At the final merger stage (one nucleus), it is possible that the AGN may become visible again due to stellar winds and SNR. Such a scenario and selection effects could explain the discrepancy between previous studies of AGN in merging galaxies.

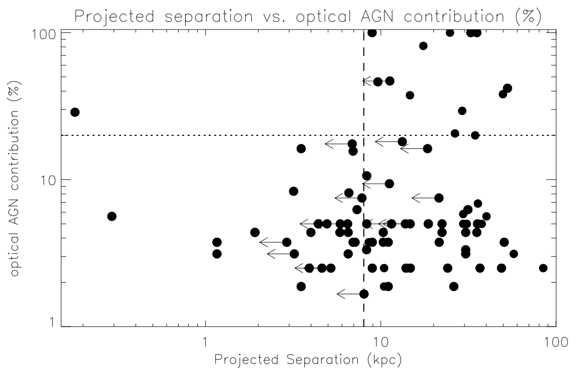

Fig. 2. AGN contribution to the optical emission vs. projected nuclear separation s. Errors in AGN contribution are typically $\pm 7\%$. 30% of objects with $s > 8$ kpc contain an AGN compared with 4% of objects with $s < 8$ kpc.

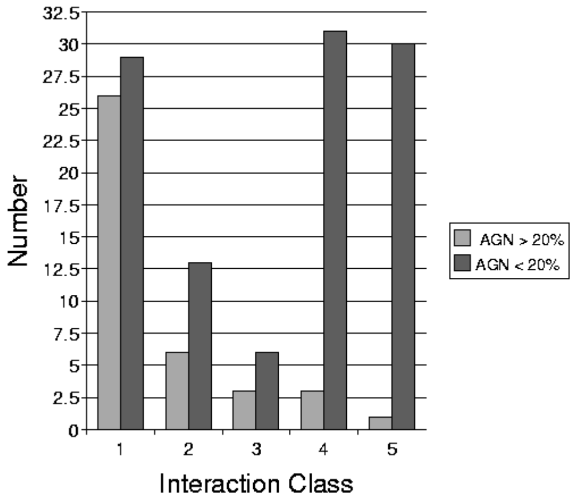

Fig. 3. The number of objects which have AGN contributions greater and less than 20% for each interaction class. Objects with AGN contribution $> 20\%$ are generally classed as AGN with standard optical diagnostics.

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