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Luminosity Profiles of Merger Remnants

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Abstract. Hydrodynamical simulations of gas-rich mergers predict that huge concentrations of gas will accumulate within the central regions of the merger remnants. Should this material be converted into stars, the resulting remnant luminosity profiles will be unlike those seen in normal ellipticals (Mihos & Hernquist 1994), exhibiting a luminosity "spike" at small radii. We investigate this prediction observationally using three on-going or late-stage mergers for which high-resolution molecular and optical or near infrared surface brightness profiles are available from the literature. For each system, the observed gas column density is converted into an optical surface brightness by assuming a stellar mass-to-light ratio appropriate for an evolved population. For NGC 3921 and NGC 7252 we predict that the resulting luminosity profiles will be characterized by an $r^{1/4}$ law. In view of previous optical work on these systems, it seems likely that they will evolve into normal ellipticals as regards their optical properties. Due to a much higher central molecular column density, Arp 220 might not evolve such a "seamless" light profile. We conclude that ultraluminous infrared mergers such as Arp 220 either evolve into ellipticals with anomalous luminosity profiles, or do not produce many low-mass stars out of their central molecular gas complexes.

1. Discussion

This experiment was conducted with the late-stage mergers NGC 3921 and NGC 7252 and the ultraluminous infrared (ULIR) merger Arp 220. Observations suggest that each of these systems is the result of two gas-rich disk galaxies merging together (see Hibbard & Yun 1999 and references therein). All three systems have been observed at relatively high spatial resolution in the CO(1-0) molecular line transition and in the optical or NIR with HST. Our procedure is to assume that *all* of the molecular gas is turned into stars and to add the expected luminosity from this burst population to the observed optical surface brightness by adopting a stellar mass-to-light ratio appropriate for a 2 Gyr old population. The observed CO fluxes are converted to a molecular gas by adopting a standard CO-to-H_2 conversion factor, and the evolved mass-to-light ratio is calculated assuming an exponentially declining star formation history,

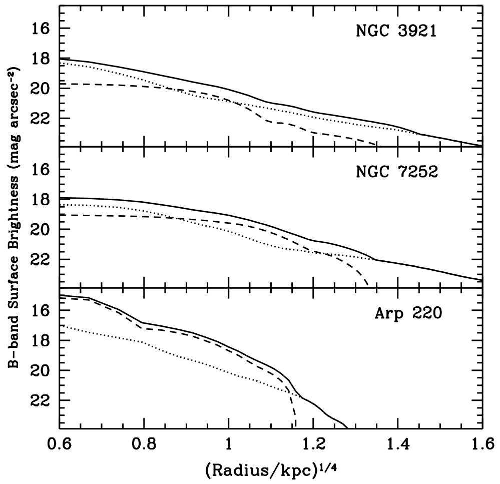

Figure 1. Predicted $B-$band luminosity profiles as a function of the fourth-root of the radius for the aged remnants of NGC 3921, NGC 7252, and Arp 220. Dotted lines: expected contribution from the existing stellar component, after aging by 2 Gyr. Dashed lines: contribution from the expected post-merger population assuming that all the molecular gas is turned into stars. Solid lines: the resulting luminosity profiles after adding in the aged stellar and post-merger populations.

a Salpeter IMF, and Solar metallicity. Full details can be found in Hibbard & Yun (1999). The adopted parameters favor the production of a luminous central burst population, since we assume that none of the molecular gas is lost to stellar winds or SNe and the adopted IMF favors the production of many long-lived low-mass stars.

The results of this exercise are plotted in Figure 1. This plot shows that the observed gas densities in NGC 3921 and NGC 7252, although high, are not high enough to significantly affect the present luminosity profiles. We therefore conclude that at least some mergers between gas-rich disks *will* evolve into elliptical-like remnants with typical luminosity profiles, even considering their present central gas supply. For ULIR galaxies like Arp 220 the case is less clear. This system does show a noticeable rise at small radii, however much less than the two orders of magnitude increase predicted by the simulations. We conclude that such systems produce remnants which exhibit an excess of light at small radii (as seen in a small number of ellipticals – see Byun et al. 1996), or require some process such as mass-loaded galactic winds or a top-heavy IMF to deplete the central gas supply without leaving too many evolved stars. If the latter possibility can be excluded, then the frequency of such profiles may be used to constrain the number of early type systems formed via ULIR mergers.

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