Bull. Astr. Soc. India (1986) **14**, 8–10

Galaxy mergers and globular clusters*

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Received 1985 December 27

Abstract. Recent observations show that the specific globular cluster frequency in elliptical galaxies is an order of magnitude higher than that in spirals. This shows that typical elliptical galaxies cannot have formed from merging spirals.

Key words: galaxy mergers—globular clusters

1. Introduction

Inspection of the Palomar sky survey shows quite a few cases of obviously interacting galaxies. Simple dynamical arguments suggest that a significant fraction of these interacting galaxies will eventually merge. This raises the question : What can globular clusters tell us about the importance of mergers in determining a galaxy's morphology? Since globular clusters are the oldest recognizable subunits of galaxies they should contain information about the earliest phases of galaxy evolution. Furthermore globular clusters are tightly bound objects which would have no trouble surviving galaxy collisions, mergers, and similar disasters.

2. Spirals

Van den Bergh & Morbey (1984a) have shown that clusters of all ages in the Magellanic clouds are significantly more flattened than their galactic counterparts. This shows that our own Milky Way system did not form by the merger of ancestral Magellanic-type irregulars. Furthermore the rarity of carbon stars in the galactic halo indicates that no Magellanic-type irregular has merged with the Milky Way during the last few billion years (van den Bergh 1982). An additional argument against the idea that mergers were a major factor in galaxy building is provided by the radial metallicity gradient of galactic globular clusters and the

*Based on an invited review given at the IAU general assembly New Delhi 1985 November 25.

even stronger correlation between cluster diameter and galactocentric distance that is observed in the Galaxy (van den Bergh & Morbey 1984b), M31 (Crampton *et al.* 1985), and the peculiar elliptical NGC 5128 (Hesser *et al.* 1984). Not unexpectedly the specific globular cluster frequency, *i.e.* the number of globulars per $M_V = -15$ of galaxy luminosity, depends strongly on Hubble type and ranges from $S = 3$ in the Sa galaxy NGC 4594 to 0.3 in the Sb galaxy NGC 4565.

3. Ellipticals

Toomre (1977) has suggested that elliptical galaxies formed by the merger of spirals. However Ostriker (1980) notes that ellipticals occur predominantly in clusters where the velocity dispersion is high whereas the merger probability should be largest in regions of low-velocity dispersion. Additional arguments for and against the merger picture have been given by Veeraraghavan & White (1985) and by Tremaine (1981) respectively.

Perhaps the strongest argument against the notion that most ellipticals form from merging spirals is provided by the fact that elliptical galaxies typically have specific globular cluster frequencies $S \sim 3$ in the field and $S \sim 6$ in Virgo (Harris & van den Bergh 1981). These values are an order of magnitude higher than those which are observed in spirals of type Sb. This discrepancy is reduced by only a factor of two by taking into account the fact that spiral galaxies will fade in brightness as star formation dies out following the removal of gas during mergers. (Note that the removal of dust compensates for part of this effect). It is therefore concluded that field ellipticals contain $\sim$5 times and Virgo ellipticals $\sim$10 times as many globular clusters as would be expected if they had been formed by merger of typical spirals. An exception may be the fast rotating elliptical NGC 3557 for which Morbey & McClure (1985) find an unusually low specific globular cluster frequency $S = 0.8 \pm 0.6$. The low specific globular cluster frequency and the high rotational velocity of this object suggest that it might, in fact, have formed from merging spirals.

The only way to save the merger model appears to be to invoke the *ad hoc* hypothesis that the globular clusters in elliptical galaxies were formed as a direct consequence of the merger process itself. If globulars were, in fact, formed during mergers then their composition should be similar to that of the (processed) gas in spirals, *i.e.* globulars should be as metal-rich as typical stars. This appears to conflict with observations by Forte, Strom & Strom (1981) who find that the globular clusters surrounding three Vigro E galaxies are bluer (and hence presumably metal-poorer) than the background light of the galaxies on which they are superimposed. It would clearly be very important to try to confirm the photographic observations by Forte Strom & Strom (1981). Unfortunately an attempt to do this with the RCA CCD at the prime focus of the Canada-France-Hawaii telescope two years ago was frustrated by instrumental problems This is an important problem that should be attacked again with CCD detectors which are now widely available.

In summary it is concluded that the specific globular cluster frequency in average ellipticals is much higher than would be expected if these obiects had formed from the merger of typical spirals.

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