PROTO–GLOBULAR CLUSTER CANDIDATES IN NGC 1275

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The discovery, with *HST* imaging, of proto–globular cluster candidates in NGC 1275 (Holtzman et al. 1992) was regarded by many as a major success of the merger model for globular cluster formation (e.g. Ashman & Zepf 1992) and has been cited in support of the idea that elliptical galaxies form from the merger of two or more spiral galaxies. A prediction of the Ashman & Zepf model was that newly–formed clusters should be observable in currently or recently merging systems. The NGC 1275 clusters constitute an important test of globular cluster formation models. NGC 1275 is the peculiar cD galaxy at the center of the Perseus cluster. It shows evidence for a merger history and may indeed be undergoing a merger at present. It also has one of the largest known cooling flows.

Spectroscopy with the Keck I telescope of 5 proto–globular cluster candidates in NGC 1275 (Brodie et al. 1997) revealed that the candidates are not HII regions, are clearly dominated by early A–type stars, and are not similar to young or intermediate age Magellanic Cloud or Milky Way open clusters.

The Balmer absorption lines were found to be too strong to be consistent with any of the standard IMF (Salpeter or Scalo), solar metallicity, Bruzual & Charlot stellar evolutionary models at any age. The preliminary Bruzual & Charlot (1997) models indicate that no appreciable increase in equivalent width can be achieved by changing the metallicity. However, a 2–3 $M_\odot$ IMF, adopted to simulate a flatter IMF, reproduces the observed equivalent widths and colors and indicates an age of $\sim$ 500 Myr for these objects. Preliminary Fritze v. Alvensleben & Kurth (1997) models are better able to reproduce the observed equivalent widths, with a best fit at 350 Myr, but the model continuum is redder than the observed spectra. The sense of the discrepancy is that the model predicts too much red light, consistent with the suggestion of a flatter cluster IMF.

Another problem with the assumption of a standard IMF for these objects is the fact that, based on their luminosities, the masses of these bright

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clusters are deduced to be $\sim 10^8 M_\odot$. Such high mass clusters would be difficult to form, requiring surprisingly massive progenitor gas clouds, and would be very unlikely to loose sufficient mass during their evolution to bring them into the mass range of normal old globular clusters. On the other hand, a pure A–star population, for example, would have a mass of $\sim 10^6 M_\odot$ at these luminosities, and a flatter than normal IMF would produce a mass somewhere in between.

Other key properties of the proto–globular cluster candidates are their spatial distribution and their velocity dispersion. These objects are extremely centrally concentrated. The entire sample (some 60 objects) is within 8 kpc of the nucleus and the brightest clusters are all within 2 kpc. We find a low (compared to the stellar value) velocity dispersion, $\sim$ 200 km/s, for our sample of 5 of the brighter candidates.

The spectroscopic information allows us to set some interesting constraints on the origin of these objects. We can clearly rule out formation in a continuous cooling flow. The spatial scale of the clusters is very much less than the cooling flow radius and their age is very much greater than the cooling time of $\sim$ 10 Myr. The star formation rate in excess of 400 $M_\odot$/yr, deduced from the cooling flow (Allen & Fabian 1997), and the absence of high mass stars (Smith et al. 1992) imply a steep IMF rather than the flat IMF deduced for the clusters. It is equally clear that these clusters did not form in widespread shocks from merging galaxies. They are centrally concentrated and, if they formed far from the center and later fell in, a high rather than a low velocity dispersion would be expected.

It appears, then, that the clusters formed in a discrete event some 500 Myr ago. This may have been induced by a merger which provided the fuel for a short–lived gas inflow episode. However, their properties are such that they may not represent formation processes that had any significant effect on the global properties of globular cluster systems. The resultant clusters are not distributed like old globular clusters in central cD galaxies, which are significantly more diffuse than the galaxy light. If they do indeed have an IMF which is biased against low mass stars, they may fade very rapidly. A pure A–star population would fade away in only $\sim 10^9$ yr.

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