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Globular cluster systems in giant elliptical galaxies : a probe for the galaxy formation and evolution

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Abstract. Most of the globular clusters in the universe reside in gaint elliptical galaxies. The number of GCs present in them is about a few thousands. Due to their large distances ($\geq$ 10 Mpc), it is impossible to observe their individual members. However, their integrated light observations can be obtained and used to understand them. The observables of the globular cluster systems (GCS) such as luminosity and mass distributions, specific frequencies, metallicity distributions and kinematics can be related to the competing hypotheses for galaxy formation : in situ, mergers, or accretions. Comprehensive recent discussions can be seen in Ashman & Zepf (1998) and Harris (1999a).

GCS in external galaxies: GCS in other large spiral galaxies generally appear very much like the Milky Way GCS, but the same is not true for many elliptical galaxies, both giants and dwarfs. Observing the GCS in distant galaxies has a very large advantage over observing the field-star halo light : the globular clusters can be isolated one by one, and can be used to construct a full distribution function of metallicity, luminosity or radial velocity.

Specific frequencies: The specific frequency is the number of clusters per unit galaxy luminosity. The average value for an elliptical is 3.5, but some have values as high as 20. It is still not understood why such large variation in the specific frequency exists between galaxies that are otherwise similar in structure.

Metallicity distribution function (MDF): Large galaxy-to-galaxy difference in MDF exist even between otherwise similar ellipticals. Bimodal MDFs are commonly, but not universally, found in ellipticals. A bimodal MDF is usually interpreted as an indicator of at least two major phases of galaxy formation at early times, but the exact mechanism is still debated.

Luminosity distribution function (LDF): The LDF has a roughly gaussian-like shape with a characteristic peak point. The symmetric Gaussian-like shape has been consistently verified and the turnover luminosity is also consistent making it a standard candle for distance determination.

Radial velocity: The radial velocity measurements can be used to identify the kinematic subgroups within the galaxy. Recently it is seen that the metal-poor component and metal-rich component has different rotational velocities. This can put constraints on the formation mechanisms.

Galaxy formation models: The *in situ* models are of two kinds : the Searle & Zinn (1978) picture whereby a large galaxy is assembled over a relatively long period of time from many small, dwarf-sized gas clouds; and the monolithic collapse picture of Eggen, Lynden-Bell & Sandage(1962). The accretion picture starts with a large intial galaxy which had already formed through an i*n situ* process. Then a sequence of smaller galaxies are added to it and thus build up the metal poor halo component. The outcome depends on the amount of gas present in the accreted galaxies. The result should be an elliptical of low specific frequency if the merging objects are pre-existing disk galaxies. Here also, the presence or absence of gas in the merging galaxies play an important role in the outcome.

Which model ?: None of the above mentioned approaches can singly answer all the galaxies. Instead, we need all of them to tell the complete story. The challenge is to identify the particular set of processes which has ended up dominating the present day structure of any galaxy.

Necessity for 8-to 10-m class telescopes: The turnover magnitude of the LDF for a galaxy at ~ 10 Mpc is ~ 23 mag in V band. Also, to understand the LDF properly, one needs to go at least 3 magnitudes below the turnover. To study the central galaxies in far away galaxy clusters, we require large size telescopes. The radial velocity measurements of individual globular cluster also requires these types of telescopes. This new line of analysis is made possible by the 8- to 10m class telescopes (cf Harris 1999b). Kinematical analysis of GCS is in its infancy. Such analysis has been done recently for M 87 and NGC 4472 (~ 16 Mpc). The Coma cluster of Galaxies poses new challenge for the galaxy formation models. These galaxies have LDF turnover around 27 magnitude. To study these systems, the large telescope is necessary

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