Globular clusters and the challenge of blue straggler stars

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Globular clusters are some of the most spectacular astronomical objects observed through the telescope. Like a glittering jewel in the optical field of view, a globular cluster contains a myriad of stars. So far, about 160 globular clusters are known to surround the Galactic centre in a roughly spherical halo.[1]

Because the stars of a globular cluster are closely associated visually, astronomers believe they *are* closely associated in space and the same distance away from Earth. Evolutionists further assume that all the stars formed from the same collapsing cloud of gas at about the same time and have held together subsequently by mutual gravitational attraction. Thus, the stars all began with a similar chemical composition and share a common evolutionary history. Their main differences are believed to be due to their different masses. Because the stars have so many similarities, evolutionists believe that globular clusters provide a straightforward way of testing their stellar evolutionary theory, which seeks to explain the behaviour of stars over billions of years.[2]

Colour-magnitude diagram

When the brightness and colour of each star in a globular cluster are plotted on a colour-magnitude diagram, they have the characteristic pattern shown in Figure 1. The shape of this plot is assumed to support the correctness of stellar evolutionary theory.

According to theory, the energy emitted by each star is derived almost entirely from thermonuclear fusion.[2,3] The section of the graph from A to B is called the 'main sequence' and each point represents a star that has supposedly been 'burning' hydrogen steadily for millions of years, not changing much over all that time. According to theoretical calculations, the more massive the star, the faster it 'burns' its fuel. So the points near A are for the smallest and least luminous stars that burn their hydrogen the slowest. The points near B represent the largest and brightest stars that are converting their hydrogen into helium most quickly.

Calculations indicate that once a significant portion of the star's hydrogen has been converted to helium, the temperature and luminosity of the star changes drastically and it becomes larger and redder, and no longer plots on the main sequence.[2] The points from B to C are interpreted as such stars. The brightest and reddest stars, called red giants, plot at point C and the line B–C is called the red giant branch.[3] Remember that all the stars are assumed to have formed at about the same time. Thus, if stars on the red giant branch are much more evolved, they then must have been much more massive than the stars still on the main sequence.

A third sequence of stars, called the horizontal branch, extends from D to E. These stars are interpreted to be the most evolved, having passed through the red giant phase.[3] They must have been the most massive of all the stars that originally formed in the globular cluster.

In this way the colour-magnitude plot is interpreted to represent progressive stages in stellar evolution, starting with the least evolved stars at point A and moving through points B, C and D to the most evolved stars at point E. Of particular interest is point B, the turn-off point, which represents the most massive star still on the main sequence. According to evolutionary theory, this point would gradually move downwards over millions of years as stars of successively lower mass burn up their hydrogen and evolve away. In picturesque language, this point is often described as 'burning down like a candle'.[3]

Significantly, the main sequence turn-off can be used to estimate the

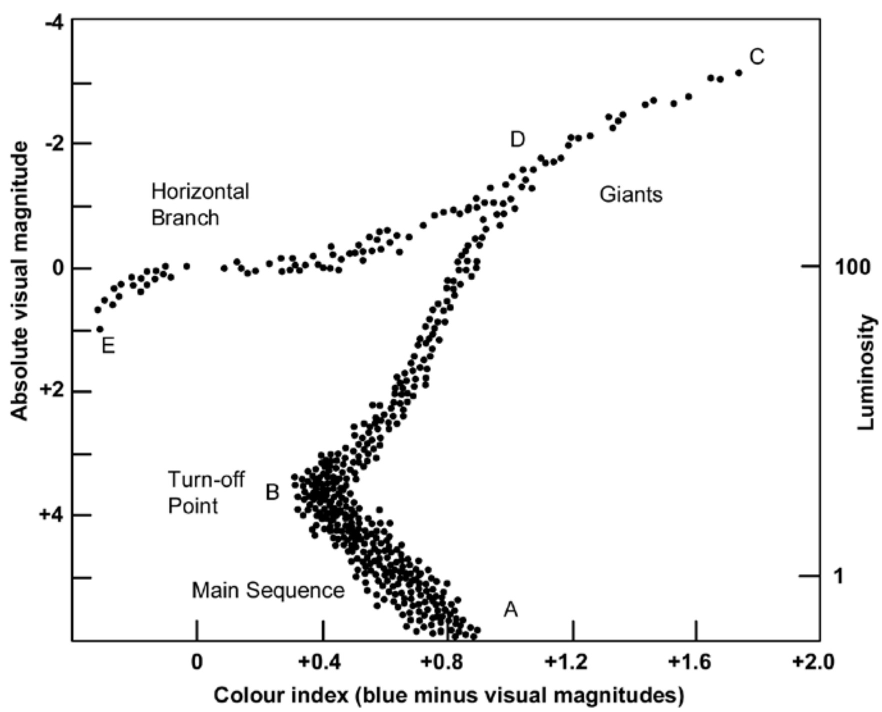

Figure 1. *Colour-magnitude (H–R, Hertzsprung–Russell) diagram for a hypothetical globular cluster (adapted from Abell* et al.*).*[13] *When the distance to the cluster is known the apparent magnitude of each star can be converted to absolute magnitude. In most globular clusters the turn-off point occurs at an absolute magnitude of about +3.5.*

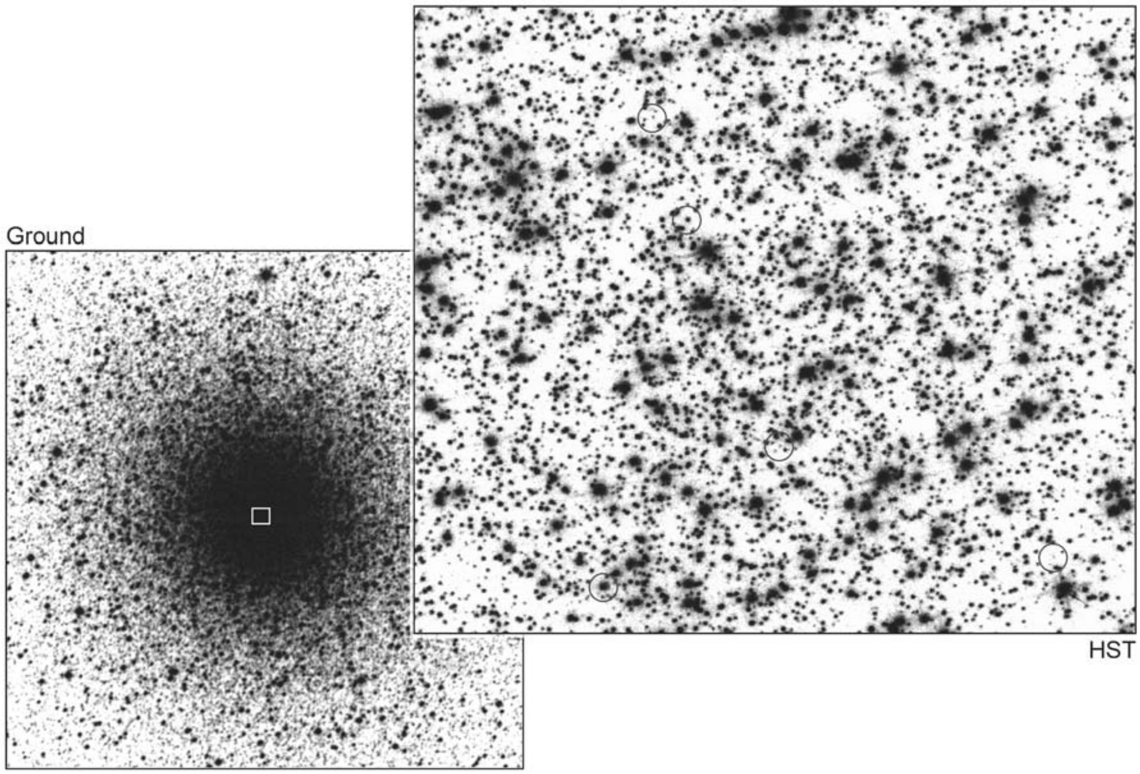

Figure 2. *Blue stragglers in globular cluster 47 Tuscanae (from NASA).*[14] *Photo at left is from ground. Photo at right is Hubble Space Telescope closeup of its dense centre with blue stragglers circled.*

age of the globular cluster from stellar evolution theory. Once the magnitude or luminosity of the star at the turn-off point has been determined, the mass of the star can be estimated from a mass-luminosity relationship using our Sun as reference. Similarly, from the mass of the star, an ‘age’ can be calculated from nuclear fusion models for main-sequence stars.[4] In this way, evolutionists have determined the ‘age’ of globular clusters surrounding our Galaxy and, surprisingly, they are all 13–15 billion years old.[5]

Blue straggler stars

This story sounds convincing until we realize that there is no way of testing it. By adding secondary explanations, the story can accommodate any astronomical observation. Indeed, the situation is not as simple as the simple theory claims.

For example, most globulars are revolving around the Galaxy in highly eccentric orbits with a period of some 100 million years.[5] In 15 billion years, each cluster would have orbited the Galaxy over one hundred times, passing though the Galaxy disk twice each time. This raises the question of how the star clusters could have remained together and compact for all that time.

Furthermore, stars toward the end of the red giant branch and in the horizontal branch have masses that are much lower than those of stars once on the main sequence from which they have supposedly evolved. Again, explanations are devised for how stars lose mass as they evolve from the main sequence.[6]

Also, the age of the globular clusters, calculated from the main sequence turn-off, has been the subject of ongoing revision. The problem is that the age of the stars in the globular clusters must be less than the age of the universe as calculated from the Hubble constant.[7,8]

And then there are blue straggler stars. According to theory, the main sequence should not be populated above the main sequence turn-off (point B, Figure 1) because all stars of greater luminosity and mass should have long ago evolved away. However, stars have been observed in this region for every globular cluster studied.[9]

> ‘Some globular clusters also have a small number of enigmatic blue stragglers, stars with an atypical blue colour and high luminosity. They look much hotter and younger than the rest of the cluster’s stars.’[10]

According to theory, they should not be there, but they are. They should have evolved away from the main sequence but for some reason, they are straggling behind, hence the term, blue straggler stars. Although blue stragglers have been known for some 50 years, their study has only blossomed in the last decade with the advent of powerful new hardware and software that can analyze individual stars in the densely packed cluster.

So, how are blue straggler stars explained? Remember that the stellar evolution theory involving billions of years is not an issue. The theory has already been accepted as correct. If the basic theory is above challenge then, clearly, the blue stragglers must have either been kept young, are intruders from a different stellar population, or have a different chemical composition that caused them to burn more slowly.

At first, it was suggested that the enigmatic blue stars were not really members of the cluster. Perhaps the cluster image was polluted with other stars that just happened to lie along the line of sight or perhaps the cluster somehow captured some younger stars. However, it was found that the blue stragglers tended to concentrate in the cores of clusters and have consistent radial velocities.[9]

Another idea was that stars in the cluster's horizontal branch coincidentally crossed the extended main sequence. However, blue stragglers are significantly different from horizontal branch stars.[9]

Perhaps the blue stragglers are not being kept young but represent stars that formed within the cluster long after the first cycle of star birth—a younger generation of stars. However, a secondary period of star formation is unlikely because of the extreme lack of star forming materials in globular clusters.[9]

By far the most preferred explanations today are ones that increase the mass of a star long after the cluster originally formed.[9] In this way, the star can be old and blue at the same time. One idea is that blue stragglers were part of a binary system in which the larger star exhausted its core hydrogen and dumped its mass on the smaller star. An alternative is that the binary pair lost angular momentum and coalesced. Another thought is that two stars collided and joined together. Such stellar collisions have been proposed to explain the large number of blue straggler stars observed in M80:

> '… in the September 10th *Astrophysical Journal* … they turned up 305 blue stragglers in this image of the 7th-magnitude cluster taken with the Hubble Space Telescope's Wide Field and Planetary Camera 2 … There is no clear correlation between the numbers of blue stragglers and the overall stellar density in other clusters, write the scientists; thus the implication of M80's preponderance of stragglers is unclear. Ferraro's team suggests that M80 is in the middle of an evolutionary phase in which stellar collisions are generating the huge population of blue stragglers that are retarding the overall collapse of the cluster's core. Further study, such as tallying the cluster's binaries, is needed to support this scenario.'[11]

A Creation framework

How long did it take for the 160 or so globular clusters to form? Evolutionists believe it took at least 3 billion years. But from Genesis 1:14–19, 1:31–2:3, and Exodus 20:11 it is clear that they formed in much less than one Earth day during Creation week. This would feature an abrupt formation process for globular clusters. Evidently, no new globular clusters are evolving in the Milky Way, suggesting that the globular cluster formation process has changed significantly since the Milky Way formed or is not operating in our galaxy today.

Stellar models based on a 6-Day Creation are very different from those based on billions of years of evolution. Additional variables become relevant once a young universe is assumed. For example, energy supplied by gravitational collapse might be a major source of stellar radiation within a creationist model. Furthermore, issues of design and purpose need to be considered. Creationists do not need to invent special theories to explain the presence of blue stragglers in globular clusters. Blue stragglers could simply be higher mass stars (e.g. spectral class A, main sequence) and indicators of youth. In fact, there is evidence that blue stragglers are indeed higher mass stars.

So, how much stellar evolution has taken place in the Galaxy's globular clusters since their origin? According to stellar evolution theory, at least 13–15 billion years' worth, beginning with the birth and death of Population III stars before the globular clusters formed.[12] However, from a creationist perspective very little change would have occurred in the globular clusters since they were formed rapidly some 6,000 years ago. And since globular clusters have completed much less than one orbit of the Galaxy there has been little dynamical time and change in them since. The compact size of globular clusters reflects their abrupt, rapid formation process, and their youthfulness.

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