monomodal Gaussian distribution peaked at a metallicity of –0.8) is consistent with a bimodal distribution in color.

The reason for the nonlinearity of the color-metallicity relation goes back to the evolution of stars of different metallicities. Old evolved stars pass through a helium-burning phase (the horizontal branch of the Hertzsprung-Russell diagram), which is predominantly blue at low metallicities and becomes rapidly redder as the metallicity increases from –1.0 to –0.5. The mean colors of the less-evolved giant and dwarf stars also become redder at higher metallicities, again in a nonlinear way.

Yoon *et al.* also sort out another aspect of cluster color. The fraction of clusters in each color mode, and the mean colors of the modes, are observed to vary with the brightness of the host galaxy. These variations are easily understood in the Yoon *et al.* picture. Brighter ellipticals have higher mean metallicities than fainter ellipticals; this has been known for decades. Yoon *et al.* show how the projection of different metallicity distributions affects the predicted color distribution. As the mean metallicity decreases, the fraction of clusters in the blue mode increases, and the colors of both modes become bluer, just as observed. Similar variations within individual ellipticals can also be understood simply as a consequence of the internal radial gradients of metallicity that have also been known for many years.

The conclusion from the argument of Yoon *et al.* is that two separate epochs of globular cluster formation in ellipticals may not be needed. A single broad distribution of cluster metallicity can produce a bimodal color distribution. This makes sense because broad distributions of metallicity arise naturally in galaxies, from their continuous chemical evolution. Although the results of Yoon *et al.* do not exclude the merger origin of ellipticals, color bimodality may no longer be strong evidence for the two epochs of cluster formation that were predicted in the merger picture.

Reference and Notes

1. K. Ashman, S. Zepf, *Astrophys. J.* 384 50 (1992).
2. Metallicity is the ratio of "metals" to hydrogen, where metals include all elements heavier than helium. It is usually expressed logarithmically relative to the Sun, so metallicities of 0 and –2 represent (1.00 and 0.01) × the solar metallicity.
3. S.-J. Yoon, S. K. Yi, Y.-W. Lee, *Science* 311, 1129 (2006).
4. S. Zepf, K. Ashman, D. Geisler, *Astrophys. J.* 443, 570 (1995).
5. Alternatively, some authors have argued that the metal-rich red mode of clusters are the original clusters of the underlying parent elliptical, whereas the metal-poor blue-mode clusters have been accreted from smaller in-falling galaxies.

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There are a number of arenas where quantum resources outperform their classical counterparts, but this improvement is particularly impressive in the theory of computation. Quantum computers can efficiently solve problems that are believed to be unfeasible on a classical computer, as they would need to run exponentially longer. What type of programs can be run on a quantum computer is a question that Nielsen *et al*. attack on page 1133 of this issue (*1*). Currently, we have only a handful of quantum algorithms, of which the most noteworthy are Shor's factoring algorithm (*2*) and Grover's search algorithm (*3*). To further our understanding, one of course wants to find more problems that can be solved faster on a quantum computer, and although progress has been made, this has proven to be a difficult task.

Although it is doubtful, it could even be that quantum computers can solve all problems in the class NP—those problems whose solutions can be efficiently checked on a classical computer (*4*). If such a thing were true, it would have radical implications not only for physics but for human thought in general. We believe that writing a great poem is more difficult than recognizing one, because many can do the latter but few the former. Likewise we believe that discovering a new theory of nature, which seems to require genius, is much harder than checking the correctness of the theory, a task that many are capable of. Yet at the moment we don't have a proof of the existence of problems whose solutions can be checked efficiently on a classical computer but not solved efficiently. Nor do we have a proof that quantum computers cannot solve such NP problems. Finding such an example is one of the great tasks of classical and quantum computer science.

What a computer does when it solves a problem is to implement a mapping between inputs to the computer and a set of outputs. Thinking of this in terms of a physical operation, one sees that the quantum computer is implementing a physical mapping from initial quantum states