Stellar evolution

Are population II binary systems inherited or acquired?

from Virginia Trimble

ACCORDING to astronomical folklore[1-3], the oldest stars in our Galaxy have far less than their fair share of most kinds of binary system. These old stars, found both in globular clusters and scattered singly through the galactic halo, are collectively called population II, in contrast to younger, more metal-rich population I stars, such as the Sun, which are found in the galactic disc. Within the globular clusters, there are so far no convincing cases of either eclipsing binary systems[2-5] or radial velocity variables (spectroscopic binary systems[6-8]) while the scattered halo stars include only a few spectroscopic binary systems[9].

Two causes for the deficiency are possible: either binaries never formed (in which case we are learning something about how conditions of star formation have changed over the past 10 billion years) or the star pairs have somehow merged or broken apart (in which case we are learning about dynamical evolution of globular clusters and binary systems). Either would be interesting; and the recent identification of a new class of X-ray sources in globular clusters[10] may enable us to decide what is going on.

Oddly, while globular clusters lack normal binary systems, they are oversupplied with strong X-ray sources by a factor of about 100 (ref. 11) and with cataclysmic variables by a factor of 10 or more[2,3,12] relative to population I. And the best models of these X-ray sources and cataclysmic variables all invoke highly evolved binary systems with white-dwarf or neutron-star components[13-15]. What are we to make of this? Several groups of theorists[16-18] have concluded that the X-ray objects result from tidal capture of a main-sequence star by a previously single neutron star. Similar processes should clearly produce binary systems with other sorts of component star.

Hertz and Grindlay[10] believe that their new X-ray sources are the white dwarf–main-sequence star pairs (cataclysmic variables) formed by such tidal captures. They report 14 new point-like sources, distributed among eight clusters (one to five per cluster), with luminosities of 10^{32}–$10^{34.5}$ erg s^{-1} (0.5–4.5 keV), well separated from the $\geq 10^{36}$ erg s^{-1} globular-cluster X-ray sources previously known and attributed to accretion in neutron-star binaries. The new source locations, some of which are well outside their cluster cores, indicate masses of ≤ 1.0 solar masses, appropriate for white dwarf–main-sequence pairs in this context. The distribution of source luminosities is like the bright end of that for cataclysmic variables found in the galactic plane[19]; and extrapolation down to 10^{31} erg s^{-1} implies about 20 white-dwarf binary systems per typical cluster. This, with calculated capture rates[17], in turn implies about $10^{4.1}$ white dwarfs per cluster. These stars are too faint to observe directly in most clusters with current techniques, but models of globular cluster structure[20,21] suggest that the total number is about right.

Hertz and Grindlay[10] therefore conclude that the X-ray sources, bright and faint, and cataclysmic binary systems in globular clusters are the product not of normal binary-system evolution[13], but of tidal captures. They agree that tidal capture to form main-sequence and giant pairs must also occur, but believe that the pairs so formed will be concentrated in crowded cluster cores sufficiently to have escaped detection as either eclipsers or radial velocity variables. I have previously argued[22] that this would not be the case; but I may have been wrong. If so, then, evidently, globular clusters are not born with binary systems in place (which will require explanation in due course in any complete model of star formation) but acquire them late in life through tidal capture. □

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Protozoology

Gamete fusion in *Babesia*?

from F.E.G Cox

THE babesias, common blood parasites of mammals, cause serious diseases such as Redwater Fever in domesticated animals and occasionally infect man, often with disastrous consequences. For many years it was believed that the life cycle in mammals consisted solely of repeated asexual binary fissions within the red cells and although circumstantial evidence suggested that a sexual stage was involved, more direct evidence of gamete fusion has only just been forthcoming[1].

Babesias are transmitted by ticks and it is within their guts that the search for sexual stages began. In 1906, Koch[2] recognized unusual forms which he called Strahlenkörper (ray bodies). These seemed to consist of a head, tail and arms and bore a superficial resemblance to the microgametes of other sporozoans. These stages were largely ignored until the electron microscope confirmed their existence and in recent years the life cycles postulated for *Babesia canis*[3] in dogs and *B. bigemina*[4] and *B. bovis*[5] in cattle have included short-lived forms with spike-like projections as part of a sexual process. The various authors involved, however, have avoided the real issue by admitting an unwillingness to use the term 'microgamete' or by using such words as 'supposed gametes'.

The most recent evidence for the existence of sexual stages has come by a roundabout route. *Babesia microti* is one of the commonest blood parasites of small mammals[6] both in Europe and America but was largely disregarded until it was implicated as a sporadic cause of severe infections in man in the United States[7]. The tick vector involved was found to be a previously unrecognized species *Ixodes dammini*[8] and the availability of this tick, together with hamsters infected with *B. microti* from a human source, opened up avenues of investigation hitherto unavailable. It is this model that Rudzinska and her colleagues have now used in an attempt to provide definitive proof that babesias have a sexual stage[1].

Larval ticks were fed on infected hamsters and after 60 hours of feeding, parasites in the tick gut were still in the red blood cells, although some of them had developed new organelles, including an electron-dense 'arrowhead' at the anterior end. By examining serial sections to avoid mistaking division for fusion, Rudzinska *et al.* found that the arrowhead forms emerged from their red cells to fuse with other emergent forms without arrowheads. There is no doubt that the arrowhead forms are the equivalent of Koch's

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