LETTERS TO NATURE

PHYSICAL SCIENCES

Collapsed or Neutron Star Companions of Bright Stars

Cameron[1] and Stothers[2] have suggested that the companion to ε Aurigae is a collapsed star. Epsilon Aurigae is one of several binary stars with large mass functions and invisible secondaries and so far the primaries of two of the brightest of these, ν Sgr (ref. 3) and β Lyrae, have been found to have helium-rich atmospheres. This shows that mass exchange has occurred, and that the visible star has been stripped down to its hydrogen deficient core by transferring matter into the vicinity of the former secondary. This explanation for ε Aur is the third of four possibilities discussed by Stothers. The proof of it would be the discovery of anomalously strong He I lines, such as λ5876, which appear in cool helium rich stars like R Cr B (ref. 4). This spectroscopic check should be made.

Huang suggested an explanation for the low luminosity of the apparently more massive component of these systems when he showed that the geometrical eclipse of β Lyrae was consistent with the faint massive star being disk shaped (though with some central condensation[5]). I pointed out[6] that the reduced central pressure of a disk compared with a sphere would result in a lower luminosity. On a time scale imposed by transport of angular momentum inside the disk and to the circumstellar shell, the massive star would become more circular and luminous, eventually evolving into a system like V356 Sgr in which both components are visible. The problems of the secular stability of disk shaped stars are not well understood, but there is no good theoretical basis for denying their existence.

In a system which has undergone mass exchange, the star that is expected to collapse first through fuel exhaustion is the lower mass star, the primary. It is more luminous, less massive, and only has helium to burn, whereas the other star is an almost zero age, normal composition star. The relative amounts of fuel available for the two stars, and the anomalous luminosities of the two components, ensure that the star which is visible for the time being will burn out in a small proportion of the main sequence lifetime of the disk star which is becoming visible.

If there are two or three stars brighter than fourth magnitude in this anomalous state, there should be about 100 bright stars in the more advanced state in which the primary has burned out; the new primary should be about the same luminosity as the old. The visible component will usually be an O or B star near the main sequence. This number of bright O or B stars is remarkably similar to the total number known. It is certainly consistent with half the known B star binaries being relatively young, and the other half having their secondaries fully evolved. Because a high proportion of B stars are known to be binaries, it is possible, but somewhat less likely, that these evolved systems are B stars which now appear to be single.

There are arguments that the present primaries of these binary systems will be very inefficient at shedding more mass. Mechanisms known to be effective seem to depend on the presence of an outer hydrogen zone, either to provide a jump in molecular weight that extends the outer layers of the star, or to provide a shell source of energy. It seems that, with the hydrogen gone, the fate of these components will be implosion either to give a neutron star or a collapsed object. It would be useful if a selected group of the brightest B stars could be examined for pulsars at the same coordinates in order to examine these possibilities. A study of some of the nearest B stars by lunar occultation to discover whether the secondary component of single line binaries is indeed a visible star would also be of great interest. Close binary stars provide remarkably detailed information on the history and nature of their components. Full advantage of this fact should be taken in exploring the newer more exotic areas of astrophysics.

The evidence from infrared observations discussed by Cameron and Stothers might in principle be used to disentangle the radiation of the secondary from that of circumstellar gas and dust. Attempts to do this have so far been hampered by lack of understanding of the range of phenomena in single stars. Confusion has been added by the systematic errors of some of the earlier observations and the problems of disentangling these from genuine time variations of objects[7]. Observations of some of the binaries are reported in a tabulation of photometric observations[8]. The infrared studies are continuing but the other approaches suggested above may increase the rate of progress in the search for the physical properties of neutron stars and collapsed stars.

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Observed Abundance Distribution of Chemical Elements as a Test of Alfvén's Theory of the Origin of the Solar System

MAGNETIC fields act on the orbits of ions and Alfvén[1] suggested many years ago that this effect was important during the early history of the solar system. Neutral atoms and ions will follow different paths which may cause a separation effect. In the work described here, the ionization energy has been used as a parameter and the abundances of the chemical elements in ordinary chondrites, terrestrial magma and lunar rocks have been compared with solar abundances.