CLOSE BINARY SYSTEMS IN GLOBULAR CLUSTERS: A PRELIMINARY REPORT

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ABSTRACT

A brief survey of known eclipsing binaries and cataclysmic variables in globular cluster fields is presented. None of the 47 known or suspected eclipsing variables is a promising candidate, although a very few remain possible members. V101 in M5 is a good candidate for membership, among 5 known or suspected dwarf novae. Three novae have been discovered in globular cluster fields, of which two are almost certainly members. Attention is also called to the eclipsing binary V80, a system which appears to contain an RRc variable, in the dwarf spheroidal galaxy in Ursa Minor.

1. INTRODUCTION

The subject of the binary frequency in globular clusters has in recent years acquired new importance, owing principally to the discovery of X-ray sources in several clusters (Giacconi, et al. 1974; Clark, Markert, and Li 1975; Grindlay 1978), and to the realization that the presence of significant numbers of binaries in cluster cores could, via superelastic encounters, pump enough energy into the stellar system to delay or prevent core collapse (Heggie 1975; Hills 1975).

2. DISCUSSION

The difficulty in directly detecting eclipsing binaries in globular clusters has recently been reviewed by Alexander and Budding (1979). Searches for such variables in globular clusters have a long history of frustration. Baade searched for W Ursae Majoris systems on deep plates of M3 without success (Payne-Gaposchkin 1979), as did Trimble (1976) in M55. Budding and Alexander (1978) were likewise unable to identify any promising candidates in a survey of main sequence stars in NGC 6397. A search of ω Centauri by Niss, Jørgensen, and Laustsen (1978) turned up a few possible candidates, but the light curves of these objects, apart

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from one certain non-member (Liller 1978b), are far too fragmentary to establish with any certainty that they are in fact eclipsing binaries. The three most viable candidates listed in the Catalogue of Variable Stars in Globular Clusters (Hogg 1973) have now been eliminated as members on the basis of radial velocity studies: V65 in NGC 3201 (Geyer 1975), V78 in ω Cen (Liller and Lichten 1978; Geyer and Vogt 1978), and V3 in M71 (Liller 1978a). A search by the author of the General Catalogue of Variable Stars (GCVS: Kukarkin et al. 1969) and its supplements for eclipsing binaries and cataclysmic variables lying within the apparent tidal radii of globular clusters (Webbink 1979) revealed 26 eclipsing systems omitted from Hogg's catalogue. Of this number, however, only three (HI Ara in NGC 6397, V1555 Sgr in NGC 6528, and FX Sge in M71) satisfy the most elementary membership criteria (in terms of apparent brightness, form of the light curve, and apparent colors). All three of these binaries lie far from the cluster cores, however, and since all three clusters lie within 600 parsecs of the galactic plane, membership for even these variables is doubtful. A final discouraging note is added by Gunn and Griffin (1979), who, in a spectroscopic survey of 111 known members of M3, failed to find any evidence of duplicity, and set an upper limit of 6 percent to the binary frequency among giants lying above the horizontal branch.

A different impression emerges of the frequency or cataclysmic variables, however. Five apparent dwarf novae are known in globular cluster fields: V101 in M5, V9 in NGC 6712, V4 in M30, V2359 Sgr in M69, and V1431 Sgr in NGC 6522. This last variable is listed as a possible nova in the GCVS, but judging from its extreme faintness and rapid decline, it is more likely of U Gem type in the author's opinion. Of these dwarf novae, that in M5 stands as a very promising candidate: this cluster lies at high galactic latitude ($b = 47°$), and the variable conforms closely in range and magnitude with typical disk dwarf novae (cf. Warner 1976). Curiously, the other four candidates are all approximately $2^{1}/_{2}$ magnitudes brighter at maximum (if members) than disk systems; unfortunately, the details of the outburst mechanism in dwarf novae are too poorly understood to use this apparent coincidence as a criterion for or against membership.

The most convincing cases for membership occur among the three novae which have been observed in globular cluster fields: T Sco in M80; an anonymous nova in M14; and V1148 Str in NGC 6553. Indeed, this number is itself very suggestive, as a straightforward convolution of the apparent distributions of known novae and globular clusters yields a probability of less than 10 percent that <u>any</u> nova should have been seen in the field of any of the clusters which have been searched for variables (Hogg 1973), much less than two should have been seen within the cluster <u>cores</u>. Of these three novae, there can be little doubt that T Sco, although positively sighted by only three observers (independently) nearly 120 years ago (Sawyer 1938), is indeed a member of M80: it appeared only 4".80 from the cluster center, and conforms so closely to the rate of decline-absolute magnitude relationship for classical

novae that it is frequently used as a standard in its calibration (e.g., van den Bergh 1975). The nova in M14 (1938) was not recorded until well after maximum, but it too appears projected within the cluster core. Only in the case of V1148 Sgr (1948) is membership highly suspect: this nova appeared well out in the half of NGC 6553, only 6° from the galactic center. It is unique in having shown a K-type absorption spectrum at maximum (Mayall 1949).

In terms of the true nova rate in globular clusters, the very circumstances attending the discovery of these three lead one to suspect that, in comparison to the galactic disk, it is very high indeed. T Sco had the good fortune to lie in the same field as the long-period variables R and S Sco, two of only about four dozen variable stars known at the time of its discovery. It happened to be in outburst when Auwers observed M80 at the beginning of a three-year astrometric survey of bright northern nebulae and clusters. The nova in M14 was detected by Hogg and Wehlau (1964) on the first few plates in a series taken more than two decades earlier for the specific purpose of searching for variables in this cluster. Only V1148 Sgr, as it happens, was discovered during a routine patrol. In terms of the effect novae may have on the gas content of globular clusters (Scott and Durisen 1978), this inference that the observed rate in these clusters is very incomplete is clearly of profound importance.

3. A FOOTNOTE

The present discussion would be remiss without mention of one eclipsing system observed not in a globular cluster, but in an even more extreme Population I stellar system, the dwarf spheroidal satellite of our own galaxy in Ursa Minor. Unless it is a freak superposition of a foreground binary and a cluster variable, V80 in this galaxy is a $2^{d}.07$ binary with a primary which is itself an RRc type variable (Kholopov 1971). Only one other eclipsing binary is known of this type (RW Ari). This object deserves study in its own right, but also as the most promising candidate known at present for an eclipsing binary in a primordial stellar system.

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DISCUSSION FOLLOWING WEBBINK

de Loore: Just a small remark concerning the globular X-ray sources. These are most probably binaries, but they should not be considered as normal binaries. Probably they consist of a normal star and a captured neutron star, and were originally not binary systems. The fact that these "X-ray binaries" are found in clusters should not be used as an argument for the presence of binaries in clusters, and the fact that no binaries are found in globular clusters may not be used as an argument against the binarity of these X-ray sources.

Hack: The novae for which we have reliable evidence that they are

binaries are about 50-60% of the total number of novae, however we assume that all novae are binary systems, just because we do not have any better explanation for the nova phenomenon. So I am glad to see that you pose the question: is it true that all novae are binary systems? and that your data on globular clusters suggest that perhaps the answer is: no.

Whelan: Could you learn anything about binaries in globular clusters from blue stragglers? These may or may not be binaries but today we heard a theory that they are triple stars.

Webbink: I would rather not speculate about these stars. I have the impression that the less the contamination from field stars in the color-magnitude diagrams of these cluster, the less apparent is the blue straggler extension of the main sequence. Certainly in those cases where blue stragglers are apparently present, these stars should be carefully examined for evidence of duplicity.

Rajamohan (in response to Dr. Whelan's remark): The blue stragglers have probably nothing to do with close binary systems for the following reasons: (1) Not all of them are binaries; (2) Pendl and Seggewiss in IAU Coll. No. 32 "The Physics of Ap Stars" showed that a fairly large number of these objects are Ap stars. It is possible that blue stragglers are more magnetic than other cluster members and hence linger on the main sequence a little longer than do the others.

Budding: Can W UMa systems live as long as 10^{10} years?

Webbink: This is a question I attempted to address in a paper this January in the Astrophysical Journal. Certainly we do see W UMa systems in very old open clusters, for example, AH Cnc in M67, which is roughly half the age of the globular clusters. One cannot exclude that some contact binaries may arise out of the evolution of initially detached systems, but apart from that possibility, my inclination is that, though primordial contact binaries may survive 10 billion years, the mass ratio will necessarily have become so extreme in that time (to accomodate growth of the primary), that their low amplitudes and short periods will make them very difficult to detect.

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