Binaries in Clusters, the Galactic Halo, and the Magellanic Clouds

TIDAL CIRCULARIZATION AMONG THE CLOSE BINARIES IN M67

David W. Latham
Harvard-Smithsonian Center for Astrophysics
60 Garden Street, Cambridge, Massachusetts 02138, U.S.A.

Robert D. Mathieu
Department of Astronomy, University of Wisconsin
475 Charter Street, Madison, Wisconsin 53706, U.S.A.

Alejandra A. E. Milone
Harvard-Smithsonian Center for Astrophysics and
Córdoba Observatory, National University of Córdoba
Laprida 854, 5000 Córdoba, Argentina

Robert J. Davis
Harvard-Smithsonian Center for Astrophysics
60 Garden Street, Cambridge, Massachusetts 02138, U.S.A.

In 1971 Roger Griffin and Jim Gunn began monitoring the radial velocities of most of the members brighter than the main-sequence turnoff in the old open cluster M67, primarily using the 200-inch Hale Telescope. In 1982 the torch was passed to Dave Latham and Bob Mathieu, who began monitoring many of the same stars with the 1.5-meter Tillinghast Reflector and the Multiple-Mirror Telescope on Mt. Hopkins. We have successively combined these two sets of data, plus some additional CORAVEL velocities kindly provided by Michel Mayor, to obtain 20 years of time coverage (*e.g.* Mathieu *et al.* 1986). Among the stars brighter than magnitude V = 12.7 we have already published orbits for 22 spectroscopic binaries (Mathieu *et al.* 1990). At Mt. Hopkins an extension of this survey to many of the cluster members down to magnitude V = 15.5 has already yielded thirteen additional orbital solutions, with the promise of many more to come.

The observed frequency of M67 binaries with periods less than 1000 days in the original survey is 18%. After correction for selection effects, the frequency drops to between 9% and 15% (Mathieu *et al.* 1990). The corresponding frequency among solar-type stars is 16 $\pm$ 3% (Abt and Levy, 1976, Duquennoy and Mayor 1991). Thus the cluster and field binary frequencies are not distinguishable at a statistically significant level. The binaries in M67 are centrally concentrated relative to the single stars; the projected half-mass radius of the binaries is 0.9 pc, and the half-mass radius of the single stars is 2.4 pc. The spatial distribution of the binaries is well fit by a 2 solar-mass component added to a multi-mass equipartition King model fit to the entire cluster, indicating that the central concentration can reasonably be attributed to relaxation and mass segregation. The three binaries lying in projection outside two core radii have orbital eccentricities of 0.44, 0.55, and 0.8. This suggests that the binaries in the cluster halo tend to have larger eccentricities, as might be expected for binaries ejected into higher-energy orbits through dynamical encounters.

Y. Kondo et al. (eds.), Evolutionary Processes in Interacting Binary Stars, 471–472.

In figure 1 we plot orbital eccentricity *versus* log period for all the binaries in M67 for which we have orbital solutions. The filled symbols denote the orbits already published (Mathieu *et al.* 1990). The orbit at 12.4 days appears to mark the lower limit for the transition between the close binaries whose orbits have been tidally circularized, and the wider binaries which have (more or less) maintained the eccentricity with which they were formed. When combined with the corresponding transition period of 18.7 days which we find for a very old population of halo binaries, this result supports the Goldman and Mazeh (1991) theory of tidal circularization on the main sequence (Torres *et al.* 1992) The two circular orbits with long periods are both giants, where the tidal mechanisms can be much more efficient. The blue straggler F190 has an eccentric orbit at a period of 4.2 days. The eccentricity of its orbit may be related to the mass transfer that probably made it into a blue straggler (Milone & Latham 1992).

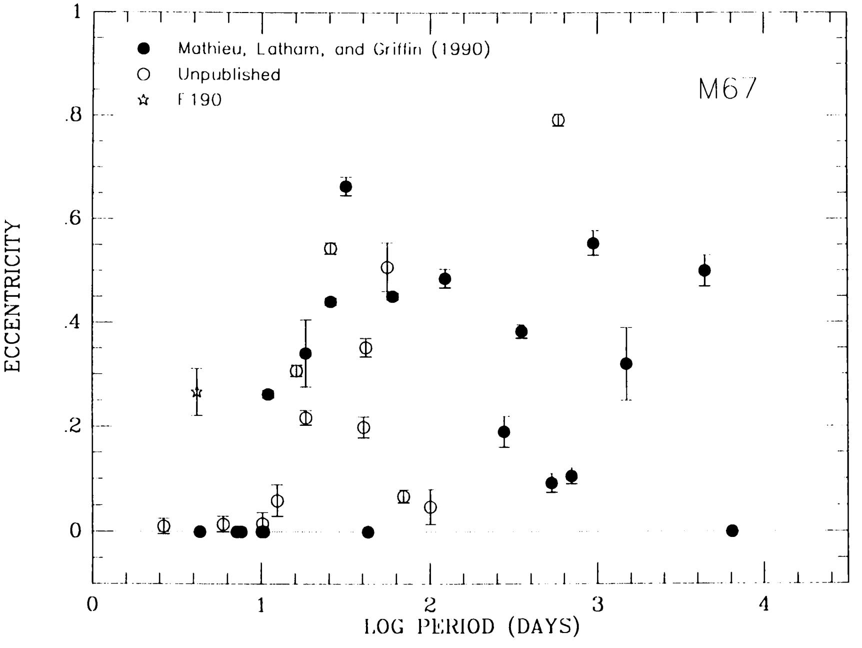

Fig. 1. Eccentricity *versus* log period diagram for all our orbital solutions in M67.

We thank Ed Horine and Jim Peters for making many of the observations used for this research.

REFERENCES

Abt, H. A., & Levy, S. G. 1976, ApJS, 30, 273
Duquennoy, A., & Mayor, M. 1991, A&A, 248, 485
Girard, T. M., Grundy, W. M., Lopez, C. E., & van Altena, W. F. 1989, AJ, 98, 227
Goldman, I., & Mazeh, T. 1991, ApJ, 376, 260
Mathieu, R. D., Latham, D. W. & Griffin, R. F. 1990, AJ, 100, 1859
Mathieu. R. D., Latham, D. W., Griffin, R. F., & Gunn, J. E. 1986, AJ, 92, 1100
Milone, A. A. E., & Latham, D. W. 1992, this volume
Torres, G., Latham, D. W., Mazeh, T., Carney, B. W., Stefanik, R. P., Davis, R. J., & Laird, J. B. 1992, this volume