CLASSICAL CEPHEIDS: PERIOD CHANGES AND MASS LOSS.

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INTRODUCTION.

The period is an ideal parameter for monitoring minute changes in the structure of a star passing through the instability strip, as it can be measured with an accuracy of up to one part per million. The view of Parenago (1956) that only abrupt period changes occur in cepheids is no longer prevalent, and it is generally accepted that random period changes are superposed on the secular variation due to evolution. One possible mechanism for the random fluctuations in period or phase is convection or semiconvection, which Sweigert & Renzini (1979) showed could account for the period changes of RR Lyrae stars. Other mechanisms include the influence of binary companions and mass loss. The latter mechanism forms the basis for a separate study involving the use of IUE spectra to search for evidence of matter being ejected from cepheids.

PERIOD CHANGES

Szabados (1977,1980,1981) found that for periods under 10 days, about 15% of period changes in galactic classical cepheids were secular, while for longer periods this fraction was nearer to 80%. In the present study, estimates for the mean fractional rate of change of period per day, d/dt(lnP), with errors, have been derived for 112 Magellanic Cloud cepheids, 81 in the large and 31 in the small cloud, using Dunsink Observatory observations (C.J. Butler (1976,1978) and Wayman et al. (1984)) in conjunction with Harvard (Payne-Gaposchkin & Gaposchkin (1966) and Payne-Gaposchkin (1971)) and South African Astronomical Observatory observations (Martin et al. (1981)). These estimates correspond, approximately, to the intervals 1940-1966 (denoted by H1), 1966-1976 (denoted by H2) and 1940-1976 (combining H1 and H2 and denoted by H3).

From Figure 1 (a), it is apparent that the larger period changes are concentrated at longer periods (P > 10 days). In Figure 1 (b), for galactic cepheids, this trend is also apparent. Figure 1 (c) uses the evolutionary tracks of Becker, Iben & Tuggle (1977) and Hoffmeister (1967) to construct a plot comparable with Figures 1 (a) and (b). The symbols correspond to crossings of the instability strip, with symbol area proportional to the duration of the crossing and y ordinate equal to the average daily fractional period change over that crossing. It is seen that the ratio of the total area of the symbols corresponding to the larger period changes relative to that of the smaller changes

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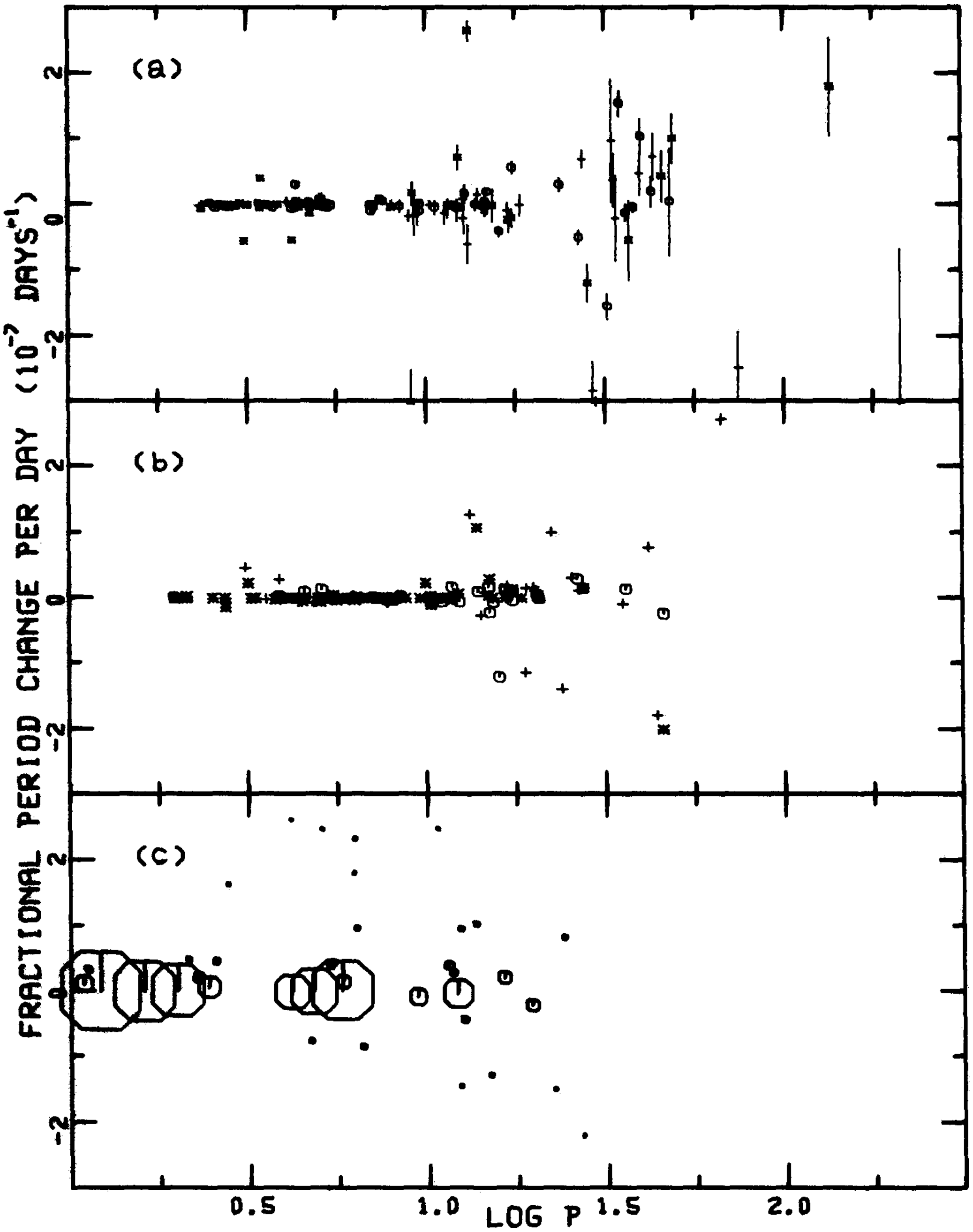

Figure 1.: Mean fractional period change per day for (a) Magellanic Cloud cepheids (using H3), (b) Galactic cepheids, where circles, asterisks, crosses represent data from Parenago (1956), Szabados (1977,1980,1981) and Erleksova & Irkaev (1980), respectively., (c) Evolutionary model calculations (see text for details).

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increases toward longer periods (>10 days), corresponding to the greater number of large observed period changes at these periods in Figures 1 (a) and (b). The low cut-off period of the models prevents comparison for periods longer than 30 days.

In Figure 2,the two estimates, H1 and H2, are compared. The LMC cepheids show some positive correlation, while the estimates for SMC cepheids tend to be anticorrelated, indicating non-evolutionary period changes. Comparing these results with those of Szabados (1977,1980,1981), who found a larger fraction of galatic cepheids with secular period changes, it seems that the frequency of erratic changes increases in the order Galaxy-LMC-SMC. This suggests a possible link with metal abundance.

MASS LOSS

Schmidt & Parsons (1984) have studied the Mg II h and k profiles of five cepheids using high dispersion IUE spectra. For several stars they found features corresponding to outflow velocities of the order of the escape velocities. Thus it would seem that mass loss may be occuring in cepheids, driven, possibly, by the pulsation (see Willson & Hill (1979)). A program is under way to search for evidence of such pulsation-related mass loss in classical cepheid variables. High dispersion IUE spectra have been taken of l Car and of two binaries, S Mus and V810 Cen. Preliminary analysis shows no evidence for V<R reversal in the Mg II h and k lines for l Car. For the binaries, it is possible that ejecta from the cepheids will show up in absorption in the ultraviolet spectra of their blue companions, as in the pioneering study of Alpha Herculis by Deutsch (1956).

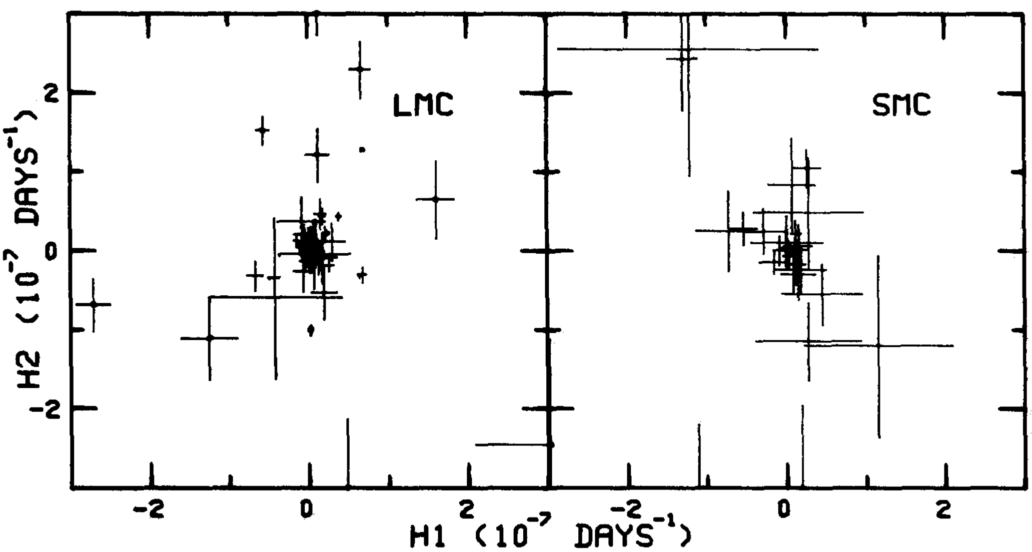

Figure 2: H2 against H1 for LMC and SMC cepheids.

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Comparison with previous IUE spectra should determine if there is a pulsation-related component to the mass loss.

CONCLUSIONS

Both abrupt and secular period changes occur in cepheids, with larger changes more prevalent at longer periods. This trend is in accordance with the predictions of stellar evolution models, as is the size of the changes. The fraction of period changes which are irregular increases in the order Galaxy - LMC - SMC, suggesting a link with metallicity. Mass loss, which is one possible cause of the period fluctuations, may be detectable using high dispersion IUE spectra.

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