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Light Curves of Miras Towards the Galactic Centre

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Introduction

Long Period Variables represent a late stage in the evolution of stars of intermediate masses. Mass loss, which leads them to planetary nebulae in a few 10^5 years, is a complex process and the object of many investigations. For instance, Vassiliadis and Woods (1993) suggest that mass loss could occur in brief superwind phases separated by long quiescent periods.

A First Step in the Inventory

Here we present the first results of a systematic study of variable objects in a field of about 10 × 10 degrees towards the Galactic Centre. The first step of our

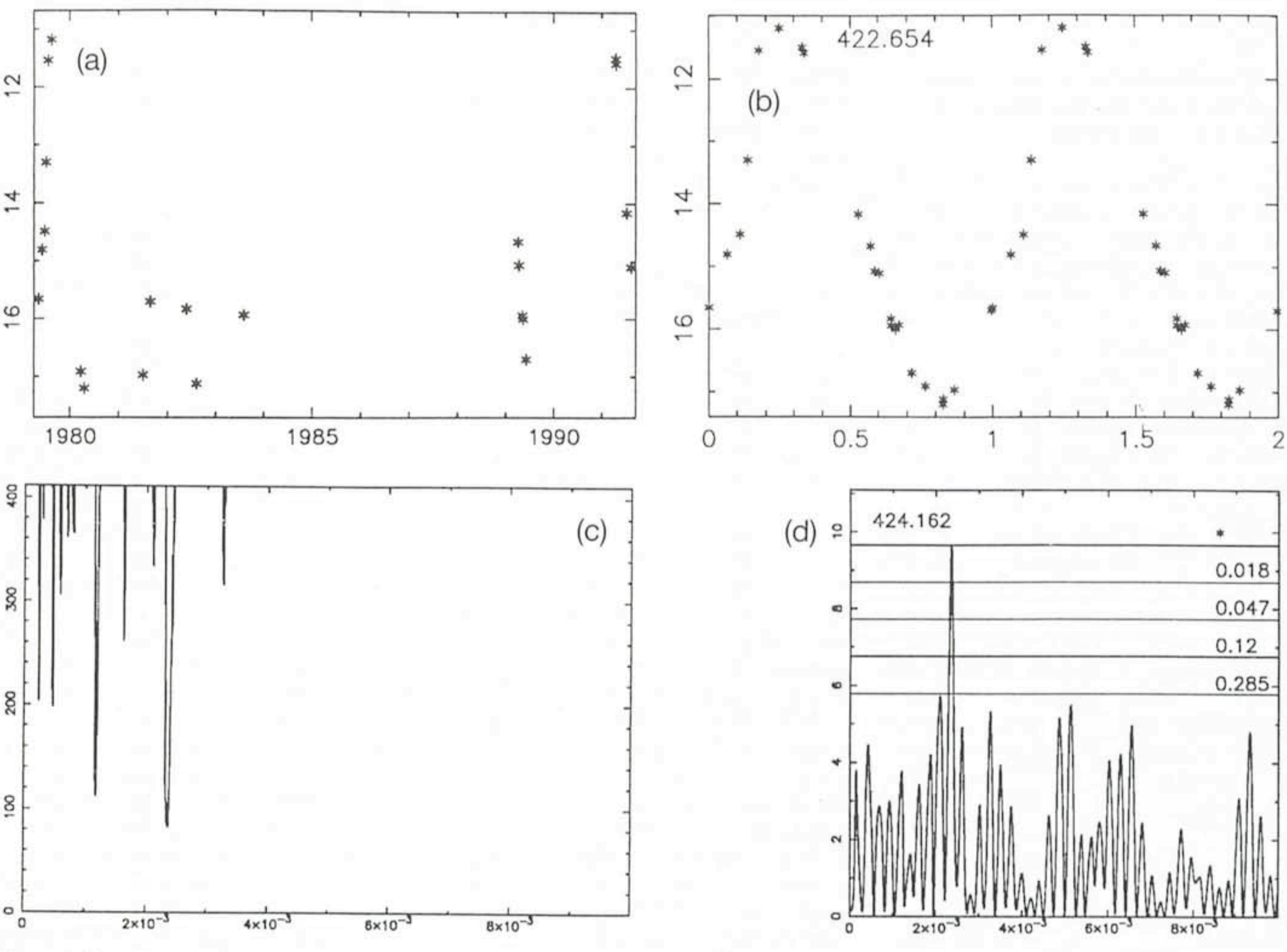

Figure 1: *Example of light curve derived from ESO Schmidt plate measurements. (a) time sampling of R magnitudes; (b) derived light curve; (c) Renson's method; (d) periodogram with Scargle's false alarm probability.*

investigation deals with the thousands of variable stars discovered by Terzan (Terzan, 1982, Terzan, 1990 and ref. therein) on ESO Schmidt plates. We have scanned 22 ESO Red Schmidt plates centred on the star 45 Oph., with the MAMA measuring machine (e.g. Guibert and Moreau, 1991). In this field, we have selected 150 variables with $\Delta m_R > 2$. The plates were calibrated with 55 photometric standards.

Light Curves

Two methods have been implemented to derive the light curves from the time sampling series. The first one (Renson, 1978), presents the advantage of not being too sensitive to gaps in the data. The periodogramme yields an estimate of the probability of false periodicity detection. Both methods lead to similar results in most cases, as exemplified by Figure 1. As a result, we have obtained light curves for 118 variables (80% of the stars under investigation).

Developments in Progress

This programme is being continued by a systematic search for variables in the whole 100-square-degree field. It will require additional plates to cover the whole range of periods, as well as near infrared and radio measurements. Interpretation of these data will lead to a better knowledge of the period-luminosity relations for various kinds of objects, and understanding of the relations between the shape of the light curves, mass loss and other properties of variable objects.

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NGC 4636 – a Rich Globular Cluster System in a Normal Elliptical Galaxy

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1. What Drives the Investigations of Globular Cluster Systems of Elliptical Galaxies?

In 1918 Shapley started to use the galactic globular clusters to explore the spatial dimensions of our Milky Way. Three quarters of a century later, we still cannot claim to have understood the properties of our globular cluster system (GCS) in the context of the early evolution of the Galaxy. This is mainly due to the fact that there are severe problems in disentangling age and metallicity, which are the most significant parameters in theories of galaxy evolution.

Given these problems with well observable clusters, what can we hope to learn from the study of faint images of globular clusters around distant galaxies, where individual clusters appear star-like and only integrated magnitudes can be determined?

Research on GCSs over the past 20 years showed that there is an amazing variety in the morphologies of GCSs (see Harris 1991 for a review). Most studies refer to elliptical galaxies, because globular clusters in spirals are normally much less numerous and they are difficult to identify due to the inhomogeneous background of bright stars or HII regions. Relating the properties of GCSs (such as total number of clusters, colour, and spatial distribution) to those of their host galaxies, the study of extragalactic GCSs leads to a new level of problems, which could not be foreseen by the study of the galactic GCS alone. One of the systematic patterns emerging from all previous studies is that the richness of a GCS depends somehow on the environment of the host galaxy. M87 became the first example of a giant elliptical galaxy, located in the dynamical centre of a rich galaxy cluster, found to be surrounded by a huge number of globular clusters (Baum 1955, Sandage 1961). Later on, very rich GCSs have been also discovered in the central giant ellipticals NGC 1399 in the Fornax cluster (e.g. Wagner et al. 1991), NGC 3311 in the Hydra cluster (Harris et al. 1983), and NGC 4874 in the Centaurus cluster (Harris 1987). Harris and van den Bergh (1981) introduced the "specific frequency" S as a quantitative measure: $S = N \cdot 10^{0.4(M_V+15)}$, where N is the total number of globular clusters and M_V the absolute visual brightness of the host galaxy. The above mentioned galaxies have S values between 12 and 18.

All galaxies that do not occupy central positions in galaxy clusters possess poorer GCSs, but a relation with the environment persists: e.g., the normal elliptical galaxies in the sparse Fornax cluster have a mean S value of 3, while for ellipticals in the rich Virgo cluster it is about 6. The interpretation of this tendency is far from being unambiguous, but the dependence on the environment suggests that interaction between galaxies may play a role.

Other morphological properties, for example the relation between the spatial distribution of clusters and the light profile of the host galaxy, or the luminosity function of globular clusters, also bear potential information which may finally lead us to an understanding of the formation history of GCSs and thus to gain deeper insight in the formation and structure of the host galaxies themselves. This field is still in the phase where the investigation of individual galaxies provides interesting and useful contributions to the general knowledge. The elliptical galaxy NGC 4636 appears to violate these general properties. NGC 4636 is supposed to be a member of the Virgo cluster of galaxies though it is lying well outside the main body of the cluster, in a region where the density of galaxies is quite low. Using photographic plates, Hanes (1977) determined a specific frequency of 9.9 ± 3 for the GCS of this galaxy, which is a surprisingly high value considering location and environment of NGC 4636. We reobserved NGC 4636 using CCD imaging to investigate the properties of its GCS with higher accuracy.