symbiotic star. The present investigation suggests that this object is a pre-main-sequence star with a remarkable spectrum.

Special attention is given to the regions in the general area of the Southern Coalsack. If any of these bright nebulosities are associated with the Coalsack, they could guide us into local regions of star formation in the large dark cloud complex. They would be important starting points for infrared and radio studies. The spectroscopic material has not revealed any associated regions, however. In fact, certain regions that are seen in the middle of the Coalsack turn out to be very distant background objects. One small bright nebula at $\alpha = 12^h45^m33^s$, $\delta = -63°33'38''$ (Object No. 1) seems to be associated to the Coalsack, however. In this nebula there is no star. I took a series of direct plates in the prime focus of the 3.6 m of this nebula as well as of a few others. A comparison between V (visual) and I (infrared) plates reveals no extremely red objects in the area around Object No. 1. We are uncertain to the nature of this object. In other regions we have discovered some extremely red objects from the prime focus plates.

Horror in the Dark

The prime focus nights were quite exciting and once the instrument somehow got disconnected and started to move towards the horizon. I could see my whole life passing by when sitting in the cage and searching for the emergency switch. Also the nights at the Cassegrain focus were not entirely without instrumental problems. The present system with several visiting astronomers staying over a 17-night period is, I believe, to prefer at the moment. In this way there is a fair chance that you will have your observational material complete at the end of the run. Looking upon it in this way I am quite satisfied with my first run at the 3.6 m on La Silla.

RR Lyrae Stars

J. Lub

The variable RR Lyrae stars are among the most important distance indicators in the Galaxy and its nearest neighbours. To obtain the highest precision, it is, however, necessary to know the physical characteristics of the individual RR Lyrae stars. This knowledge in turn is very valuable for studies of the stellar system (galaxy or cluster) in which the RR Lyrae star is a member. Dr. Jan Lub from the ESO Scientific Group in Geneva has recently terminated a first phase of a large investigation of RR Lyrae stars. He summarizes what can be learned from the study of RR Lyrae stars by means of accurate photometry, sometimes supported by spectroscopy.

A quick look in Kukarkin's 1969 edition of the General Catalogue of Variable Stars shows a striking number classified as RR Lyrae variables. In fact about two-thirds of all the stars listed (more than 20,000) belong to the class of pulsating variable stars, the most common of which are the RR Lyrae with 4,433 entries. Apart from that, over one thousand have been found in the globular clusters belonging to our galaxy and more than a hundred have already been identified in the Magellanic Clouds.

Two types can be discerned among the RR Lyrae stars: either the *ab-type* with asymmetric ("saw tooth") light curves, visual amplitudes ranging from $1^m\!.3$ to $0^m\!.4$ and periods in the range $0^d\!.8$ to $0^d\!.3$ or the *c-type* with symmetric (sinusoidal) light curves, having amplitudes of $0''\!.5$ and lower, and periods ranging from $0^d\!.45$ to $0^d\!.25$. There is no physical difference between these two classes; the c-type RR Lyrae being first overtone pulsations, whereas the ab's pulsate in the fundamental mode. It goes without saying that the large amplitude of the light variation and the rather short period make the detection of these variables rather easy; a fact which largely explains the large number which have been found in the various surveys.

The Importance of Studying RR Lyrae Variables

The importance of the study of RR Lyrae stars is at least threefold: first they can be used as "standard candles" in distance determinations, and secondly they provide us with information on the chemical composition (helium and heavy element abundance) in the halo and old disk population of our galaxy. Finally, they are important test objects for a large amount of theoretical work in stellar structure and evolution and hydrodynamics. Accurate photometric data are a first prerequisite for such studies, because we need such quantities as mean light intensity, interstellar reddening, blanketing and especially in connection with the last and first points, temperature, surface gravity and radius variation.

As to the first point: on quite general grounds one expects the existence of a Period-Luminosity-Colour (Temperature) relation for any class of pulsating variable stars. For example, for the *Cepheids* with their wide range in age (and thus mass), this becomes the well-known *Period-Luminosity* relation: the colour (i. e. the width of the instability strip) being of secondary importance. This is in strong contrast to the case of the *RR Lyrae* stars where there exists a *Period-Colour* relation, the luminosities being rather similar, due to their approximately equal age (and thus mass). This luminosity has been derived by the method of statistical parallaxes or from main-sequence filling of globular clusters and an absolute visual magnitude of about $0^m\!.7$–$0^m\!.5$ is found in such a way.

A study of the strength of the Ca II K line in the spectra of RR Lyrae stars at minimum light by Preston revealed a large range in metal abundance. Moreover, he found a strong correlation between the kinematical properties of a group of field variables and their heavy element abundances in the sense that a larger solar motion and residual velocity dispersion is found for low metal-line strength. It is obviously of importance to study the dependence of other observable properties of RR Lyrae stars, such as the luminosity, the periods, the intrinsic colours upon metal abundance.

Such improved knowledge will make it possible to improve the determination of the distance to the Galactic centre, or even the Magellanic Clouds. Also RR Lyrae stars are suitable as a probe of the halo component of our galaxy, and could give important information on the densities and heavy element abundances at large distances to the galactic plane.

Photometric Observations

At Leiden Observatory, Dr. G. van Herk initiated a large survey of southern RR Lyrae stars as a follow-up to his detailed study of the kinematics and the statistical parallaxes of the field RR Lyrae stars. Starting from the late sixties, about 100 completely covered photoelectric light curves were obtained mainly by Dr. A.M. van Genderen using the Walraven five-channel simultaneous photometer attached to the 92 cm photometric telescope—"the light collector"—at the Leiden Southern Station near Hartebeespoortdam, South Africa. Some observations were also made by Drs. W. Wamsteker and J.W. Pel; the reduction and discussion of the material—the equivalent of over 200 complete observing nights—was done by myself. (An atlas of light and colour curves has been published in *Astron. Astrophys. Suppl.* **29**, 345, 1977.) As an example, we show in Fig. 1 the blue (B, $\lambda = 4325$) light curve of the extremely metal-poor variable V 675 Sgr. Note that these light curves are not featureless: in this case there is a strong hump at minimum light and a change in slope at mid-rising light. A quick glance through the above-mentioned atlas shows many more interesting features on the various light curves.

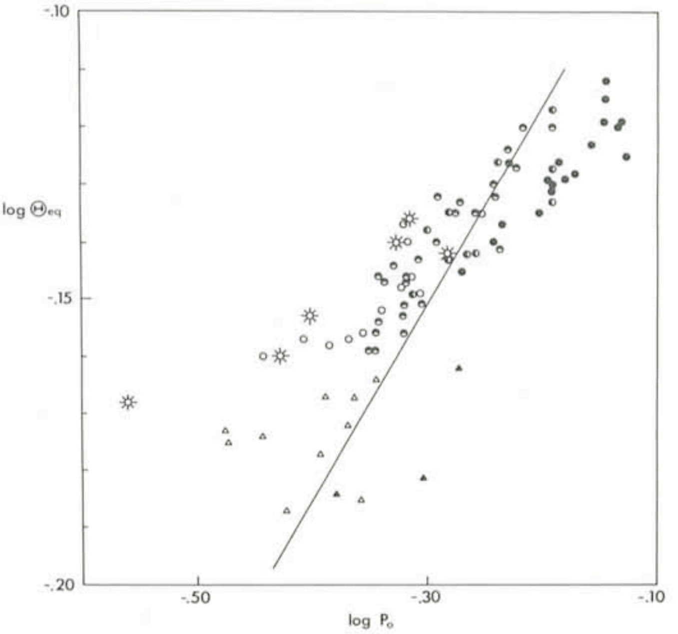


Fig. 2. — *The period-temperature plane for RR Lyrae stars. Along the vertical axis is plotted log Θ_{eq} where $\Theta_{eq} = 5040/T_{eff}$, and along the horizontal axis log P_0 where P_0 is the period in days. c-type variables have been plotted at the position of their fundamentalized period (= log P + 0.128) and are indicated by triangles. The metal abundance of the RR ab star is indicated by various shadings: ● $Z<3 \times 10^{-4}$; ◐ $Z \sim 5 \times 10^{-4}$; ◓ $Z \sim 10^{-3}$; ○ $Z \sim 4 \times 10^{-3}$; ☼: "solar abundance". The drawn line is the relation predicted from pulsation theory at a constant mass-luminosity ratio.*

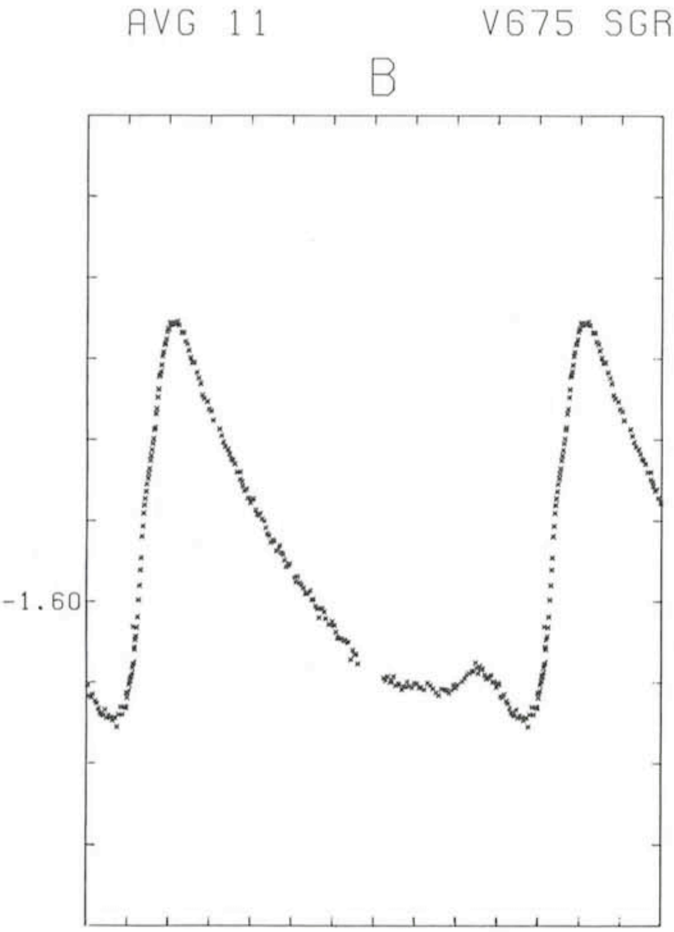


Fig. 1. — *B light curve (Walraven system) of the extremely metal-poor ab RR Lyrae variable V 675 Sgr. Each subdivision on the vertical scale is 0.10 in units of ^{10}log (Intensity). Phase is indicated on the horizontal axis ranging from 0.8 in steps of 0.1 to 0.2, including one full period.*

The Walraven System

An up-to-date description of the properties of the Walraven VBLUW photometric system has been given by J.W. Pel and the author in a paper published in *Astron. Astrophys.* **54,** 137 (1977). The characteristics of the photometric bands are summarized in the table below:

		V	B	L	U	W
effective wavelength	λ	5470	4325	3840	3630	3260
band width	$\Delta\lambda$	720	450	225	240	140

which has been taken from that paper. From multicolour photometry one can in principle deduce the three parameters which (mainly) determine the shape of the emergent stellar spectrum: the effective temperature, surface pressure (or gravity) and the abundance of the "heavy elements".

In the case of the RR Lyrae stars one measures T_{eff} and logg using (V–B) and (L–U), both expressed in units of ^{10}log (Intensity), while the blanketing due to the iron peak elements is derived from the amount of blanketing present in the L-band measured by (B–L). Of course the first two physical parameters mentioned do vary over the pulsation cycle, and in this respect the Walraven photometer is very well adapted to the study of variable stars, because all five intensities are measured simultaneously. One important complication should be mentioned here: due to the existence of interstellar reddening one needs at least three two-colour diagrams for the determination of the physical parameters; this is apart from the important question of how to fix the zeropoint of the colour excesses.

Along these lines we have succeeded in measuring very accurately the blanketing in the ab-type RR Lyrae stars as was ascertained by comparing with, for example, Preston's Ca II K line strength parameter ΔS. Accurate metal abundances can now be attributed to over 200 stars and a study of various subgroupings in order to determine solar motion and statistical parallaxes is well under way.

Possibly even more interesting is the fact that we can derive temperature and surface gravity variations for all stars on our programme over their pulsation cycle. Several roads to study are thus opened. Combined with the light curve variation it is possible to determine the relative variation of radius for each star. Unfortunately only a few (one in our case), well-covered (and accurate!) radial velocity curves are available such that we might derive the actual radius excursion, and finally the radius and absolute luminosity—this is known as the Baade-Wesselink method. However, combining our knowledge of radius and temperature variation, it is possible to determine the temperature of the equilibrium state of a pulsating star.

Physical Properties of RR Lyrae Stars

A study of the period-temperature plane reveals several important properties of the field RR Lyrae stars: as a function of metal abundance, well-defined regions are discernible in Fig. 2. At a heavy element abundance $Z = 10^{-3}$ by mass (compared with $Z \simeq 0.02$ for the Sun) we derive in this way a helium abundance by mass $Y \simeq 0.25$ and a visual absolute magnitude $M_v \sim 0.5$. The high temperature boundary of the instability region provides another estimate of the helium abundance which also comes out at about the same value $Y \simeq 0.24$. The main uncertainty in such a determination resides in the accuracy of the adopted temperature scale: errors of up to 100 K are likely and lead to a change in the estimated helium abundance by about 0.025. The possible uncertainty in the theory is very difficult to estimate, but should be kept in mind.

The existence of such a clear division among the metal-poor RR Lyrae stars is reminiscent of the two subgroups which one finds among the globular clusters containing RR Lyrae variables. It will thus be of interest to extend the present work with measurements of the variables in some of the nearby clusters, which in principle is possible with a 1 m photometric telescope; such observations were indeed already made by J. Pousen in 1962 using the present equipment.

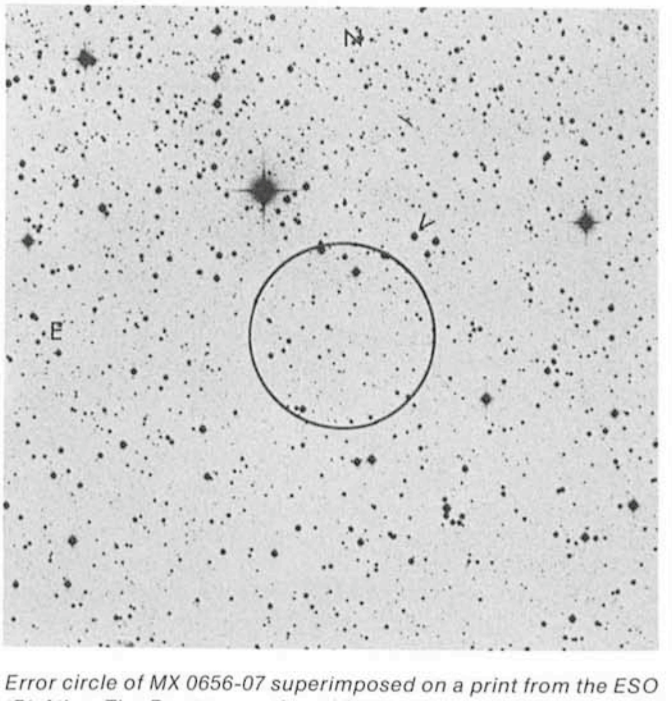
Optical Observations of Galactic X-ray Transients

M. Pakull

Dr. Manfred Pakull, of the ESO Scientific Group in Geneva, works on the optical identification of X-ray sources. During the past years, he has performed photometric and spectroscopic observations of stars near error boxes of X-ray sources. It is very difficult to be absolutely sure of an identification until synchronous variation of the X-ray and optical intensity has been demonstrated. He reports the possible identification of the transient X-ray source MX 0656-07, with a 12ᵐ star.

The number of known X-ray sources in the sky increases rapidly. The latest compilation of sources observed by the pioneering UHURU satellite (4U catalogue) comprises more than 300 entries. Their distribution shows a strong concentration towards the galactic centre, proving that a large fraction of the sources belong to our galaxy.

Except for the X-ray emitting supernova remnants (SNR), most of the galactic sources are strongly variable on time scales of milliseconds up to years. Some sources suddenly



Error circle of MX 0656-07 superimposed on a print from the ESO (B) Atlas. The Be star mentioned in the text is marked by the V.