by the authors in collaboration with H. Debehogne (Royal Observatory, Uccle, Belgium). Asteroids are in the greatest number among the small planetary bodies which can provide valuable information concerning the early evolution of our solar system. It is the wish of a lot of us to observe more of them in the near future.

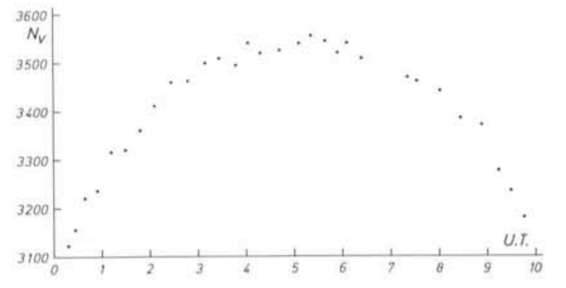


Fig. 2. — Numbers of pulse-counts per second for the comparison star. Note how there are first relatively few counts (the star is in east at low altitude and the atmospheric extinction is large). As the star rises higher and higher, the number increases and it reaches a maximum when the star culminates (passes the meridian). Then, as it descends on the western sky, the extinction again increases and the count number becomes smaller. This extinction effect has been removed from the light-curve in Figure 1. ▶

Why are Binary Stars so Important for the Theory of Stellar Evolution?

A good theory needs a good observational basis.

The truth of this statement is accepted by both theoretical and observational astronomers, but the history of astronomy nevertheless shows many theoretical studies which have been founded on insufficient or even inaccurate observations. Our present knowledge of stellar evolution is best visualized as the movements, as time passes by, of stars with different masses and chemical compositions in the Hertzsprung-Russell (temperature versus luminosity) diagram. This theory is very complicated and rests heavily on observations of luminosities, colours and sizes of amazingly few, well-studied stars. Dr. Henning E. Jørgensen *of the Copenhagen University Observatory has studied the problems of stellar evolution with fast computers and is well aware of the necessity of extremely accurate observations in support of the theoretical studies. He explains why eclipsing binary stars are particularly suited for this purpose and informs about some of the recent observations of southern binaries from La Silla.*

New, Improved Observations Needed

In 1971 it was decided to start an observing programme on eclipsing binaries with the 50 cm reflecting telescope at La Silla belonging to the Copenhagen Observatory. Further there was the possibility of obtaining accurate spectroscopic elements from 12 Å/mm plates using the ESO 1.5 m telescope.

Extremely many observations of eclipsing binaries of all sorts are published in the literature, but still we know accurate masses, radii and luminosities for very few stars, certainly fewer than ten. Several accurate light-curves have been published but in most cases for systems with complications like strong deformation of the components or surrounding gas, for which no acceptable model is developed. Published masses and radii cannot be trusted. Moreover, the light-curves were usually obtained with broad-band filters far from being monochromatic; often the instrumental systems are badly defined. Those of us who do stellar-evolution calculations are left with the feeling that the hundred thousands of observations of eclipsing binaries scattered through the literature are of very little value to us.

How to Check Stellar Models

The stellar-evolution people are left with a bad problem: how to check the stellar models? There are several parameters to play around with in the models, and uncertainties in opacity tables and nuclear cross sections are not easy to evaluate. The only check we have is the neutrino flux from the Sun and we all know of the difficulties this experiment has given to us. However, we think that the models are not *too* bad, without knowing *how* bad. The checking of stellar models is important in several respects. Let me only mention the age determination, and that we use ages of stars when studying the chemical and dynamical evolution of our galaxy. The accuracy of ages ist hard to estimate.

To get a real check of a stellar model we must determine *mass, radius, luminosity, age* and *abundances* (Y, Z) of stars by observation. This is obviously very difficult to do and our check cannot be a very accurate one. Using binaries, however, we may check if the two components lie on an isochrone (have the same age) and if the mass ratio is right. This tells us if the evolutionary speed through the HR diagram is calculated correctly. Knowing from observation the parameters, mass, radius, temperature (or luminosity) and abundance of heavier elements Z, we derive a helium content Y adopting the stellar models. The helium content is an important quantity in cosmological problems.

Accuracy...!

Which are the requirements on the observationally determined parameters? Let us consider an example. We wish to derive the helium content Y of an unevolved binary with a mass of around two solar masses with an accuracy of $\varepsilon(Y) = 0.03$. From homogeneous stellar models we find immediately that the mass must be known to 2 %, the heavier elements to 25 % and luminosity to 10 % as a typical combination of uncertainties. The situation is a bit more complicated when we consider evolved stars.

This high precision can be obtained only if we carefully select the most simple photometric and spectroscopic systems. The components must be well separated with small deformations. The eclipses must be deep, if possible a total eclipse. The luminosity of the two components should be nearly the same and not differ more than half a magnitude, since radial velocities of both components cannot be derived with sufficient accuracy if the luminosity difference is too large.

Several systems on the southern sky are observed in the Strömgren four-colour uvby system with a simultaneous four-channel photometer on the 50 cm telescope, giving four essentially monochromatic light-curves. The metal index m_1 gives the content of heavier elements Z to an accuracy better than 25 % for F stars, while we have little check on Z for the earlier-type stars. Radial-velocity measurements are done in parallel to the photometric work.

SZ Centauri

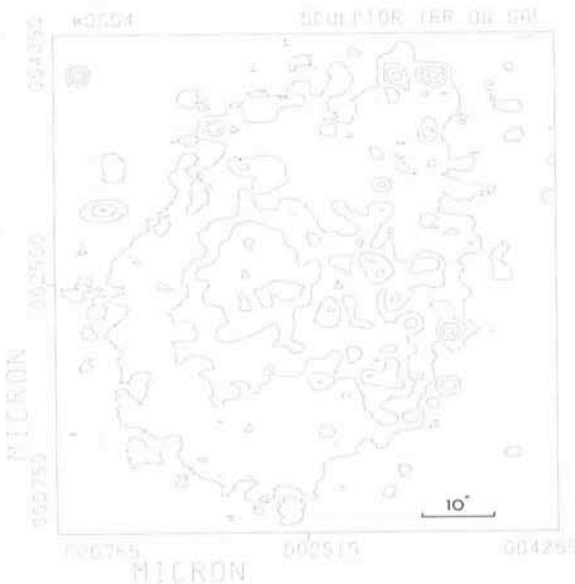
The details of the individual systems shall not be given here, but SZ Centauri is worth mentioning as it poses some interesting problems to theoreticians. The spectrum is A7 III and the masses ($\cong 2.30\ M_\odot$) are very nearly equal and known to an accuracy of 1 %. The primary minimum is a total eclipse and the luminosity ratio of the components is known very precisely. The photometric elements are derived by the classical Russell-Merrill method and by the modern model-simulation method by Wood. The two independent methods give consistent results and the radii of the two components are determined better than 1 %. The surface gravities are then also known very precisely (2 %). The temperature difference is small and well defined. Both of the components have left the central hydrogen burning phase, when comparing with standard evolutionary tracks. The tracks and isochrones are nearly horizontal in this phase and the stars move to the left at constant luminosity in the HR diagram. It is simply impossible to account for the observed luminosity (or gravity difference) of the components and the evolutionary tracks may perhaps be very wrong. However, the properties of SZ Cen are understood if there is mixing in a region much larger than the classical convective core. If this explanation is correct, we are forced to a considerable revision upwards of stellar ages. We are presently not very happy about this situation.

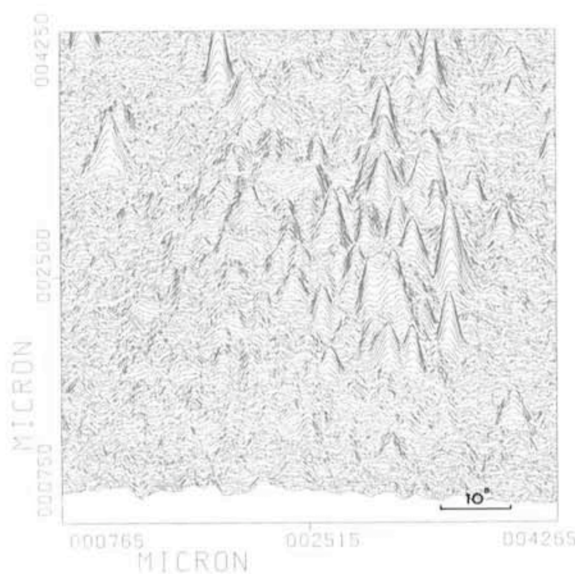
AI Hydrae

Finally another interesting system should be mentioned. At least one of the components of the eclipsing binary AI Hydrae is a δ Scuti star with a period of 0.138 day. For the first time we derive observationally a pulsation constant Q to an accuracy of 1 %. The Q value corresponds very precisely to a radial first overtone pulsation, showing that a least one δ Scuti star pulsates in a radial mode and not in a non-radial mode as preferred for δ Scuti stars by many authors during the last few years. The discussion of this system together with B. Grønbech is not yet finished.

TWO NEW IRREGULAR DWARF GALAXIES

During the past year, two new southern dwarf galaxies were discovered on ESO Schmidt plates. The first object, in the constellation Phoenix, was first believed to be a distant globular cluster (cf. *Messenger* No. 4, March 1976), but recent observations by American astronomers at the Cerro Tololo Interamerican Observatory now show the Phoenix





The analysis of astronomical photos involves much more than just looking at the objects on the plates. As an example, we show here a computer-drawn contour map of the Sculptor Irregular Dwarf galaxy, made from the photo on the frontpage of this issue of the *Messenger*. The upper part shows a smoothed isophote that corresponds approximately to the outer boundary of the galaxy. In the lower figure, the intensity across the galaxy is visualized by a three-dimensional (X, Y, density) plot. The higher the "mountains", the stronger the intensity. It is fairly easy to compare directly the photo and the drawing. The positions on the original 3.6 m plate are given in microns at the abscissa and ordinate axes. The plate was scanned by the S-3000 measuring machine at the ESO Sky Atlas Laboratory in Geneva (aperture 100 x 100 microns) and the measured densities were computer-processed in the ESO HP computer system by means of an interactive programme developed by Frank Middelburg. Such scans serve for many purposes: to determine the extent of the galaxy, to integrate the intensity over the whole surface, and to determine the magnitude of individual member stars are just some of these.