Those Tumbling Asteroids

Once a small planet has been discovered (see f. inst. Messenger *No. 6, Sept. 1976) and its orbit determined, we can keep track of it and find it again in the sky at any time as a faint speck of light, moving along between the fixed stars. Then we can study it further by spectroscopy and photometry (measurement of its magnitude and colours). Whereas its spectrum is normally very similar to that of the Sun (reflected sunlight from the asteroid's surface), its light-curve may tell us its rotation period, and possibly, after a long series of precise measurements, the shape and direction of the rotation axis. These quantities are not trivial; f. inst. the behaviour of minor planets of the same family (similar orbits) is of importance for our understanding of their origin.*

Drs. Anna *and* Jean Surdej *recently joined the ESO astronomical staff in Chile. The sympathetic couple has different backgrounds: specialized in solid-state physics, Anna has now become interested in astronomy and Jean, who was formerly at the Institut d'Astrophysique in Liège (Belgium), has a keen eye on the physics in comet tails. Soon after their arrival on La Silla, they started photometric observations of asteroids and this is their report on (599) Luisa:*

The light-curves of an asteroid are mainly observed to obtain information about its period of rotation, its shape and the orientation of its rotation axis in space. The relation found between the different spectral magnitudes, mainly U, B, V, and the varying phase angle are important in the study of surface textures of asteroids. Furthermore, the absolute magnitude V (1.0) of an asteroid, i.e. its V magnitude extrapolated at heliocentric and geocentric distances both 1 A.U. (150 million km) for a zero phase angle (angle Sun–asteroid–Earth = 0°), can be determined and so, a rough value for its albedo (ability to reflect light), its mean radius and mass.

Observations for such studies have been performed with the pulse-counting photometer at the ESO 50 cm telescope for a few, so far physically unknown, asteroids. We reproduce in Figure 1 one of the light-curves obtained for the minor planet 599 Luisa on September 9 during its 1976 opposition. In that figure are plotted the magnitudes of the asteroid, obtained by comparison with a constant-light star, against the observing time in Universal Time (U.T.).

When observing the photoelectric light-curves of 599 Luisa, we measured regularly two comparison stars chosen close to the asteroid and of similar coulours and magnitude. This allows to remove the extinction effects (i.e. dimming of the light from any celestial object during the passage through the Earth's atmosphere) from the light-curve of the minor planet as well as judging the quality of the night and sometimes finding variability of one or both comparison stars. The scatter of the comparison readings helps in evaluating the quality of the night at any moment. Figure 2 shows the count-rate in the V filter of one of the comparison stars (V = 0.9.35) against observing time in U. T. The maximum scatter for the night is found to be ± 0.006 magnitude. The general observing routine includes frequent observations of the sky, asteroid, comparison stars and of some standard stars in the U, B, V system (Johnson and Morgan) to determine the magnitudes of the asteroid.

The large amplitude of the light-curve reproduced in Figure 1 is mostly due to the changing shape of the asteroid during its rotation as seen from the Earth. The short time-scale feature appearing in the light-curve around 6 h U.T. corresponds very probably to topographic accidents (craters?, dark spots? . . .). A more complete study of this and other asteroids will be reported soon in the literature

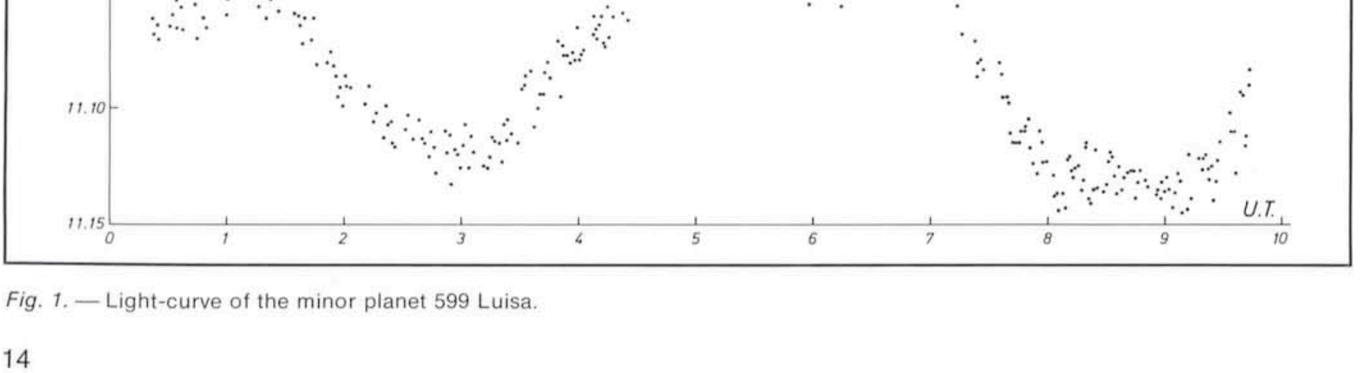
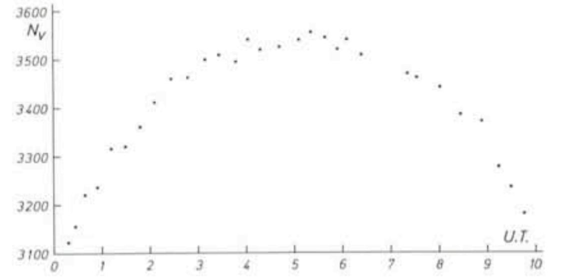


Fig. 1. — Light-curve of the minor planet 599 Luisa.

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