orientations; or, more probably, these surfaces are triaxial ellipsoids which have the same orientation, but whose axes have different ratios. The twisting of the isophotes could then be considered as a projection effect. We see therefore that photometric studies bring a strong argument in favour of the triaxial ellipsoid hypothesis and that there are non-classical isolating integrals that may help elliptical galaxies to keep their shapes.

So there is no reason to suppose that elliptical galaxies are necessarily spheroids since the most general configurations are triaxial. As long as it was not realized that non-classical integrals exist that could shape lasting triaxial configurations, it was natural to believe that elliptical galaxies were spheroids. This is because an initial triaxial distribution could not be preserved after the dynamical mixing phase which lasts for less than 10^9 years. Now recent works seem to show that in order to produce a spheroidal rather than a triaxial galaxy one must start with peculiar initial conditions, that is from a configuration in which the isodensity surfaces have their same two main axes equal.

Let us mention a very recent work to be published by Miller and Smith. These authors suggest on the basis of numerical experiments that most elliptical galaxies have reached their present state in two steps. They may have taken first the shape of a bar (prolate spheroid) during a protogalactic collapse controlled by rotation. Then they would have been slowed down by tidal interaction with their neighbourhood to finally rotate as slowly as shown by observations.

Conclusion

The revolution in the field of elliptical galaxies is going on. But we are far from knowing for sure what are the actual shapes and the dynamics of these objects. Many questions remain unanswered. For instance:

If ellipticals are triaxial now, will they keep their shapes for a long time? We do not know how to write non-classical integrals and we are not sure whether they are isolating or non-isolating, stable, quasi-stable or unstable.

Are triaxial galaxies generally closer to oblate or to prolate spheroids? How are galaxies distributed among these varieties? What is the rotation of these systems as a whole?

Elliptical galaxies give rise not only to dynamical problems. We also would like to know about nuclei, interactions with the neighbourhood and resulting evolution, evolution of the stellar content, etc.

The least we can say is that, contrary to the idea which was prevailing not so long ago, elliptical galaxies are very complex systems.

The Pre-Main-Sequence Shell Star HR 5999 Unveiled

P.S. Thé and H.R.E. Tjin A Djie, Astronomical Institute, University of Amsterdam

The star HR 5999 is embedded in a dusty gaseous nebulosity and is surrounded by more than 10 faint T Tauri stars. From these facts and from studies so far made of the physical properties of HR 5999, we strongly believe that it is a very young pre-main-sequence object; it varies irregularly due most probably to changes in the properties of dust grains embedded in its circumstellar gas shell.

In 1978 a campaign of simultaneous observations of the variable pre-main-sequence shell star HR 5999 from several observatories in the world was organized. At approximately maximum brightness ($V = 7\overset{m}{.}0$) the star was observed in the ultraviolet with the IUE, in the visual with Walraven, Johnson and Strömgren photometers, in the red and the near infrared with photometers attached to the ESO 1 m telescope. Near infrared and visual measures were obtained at the South African Astronomical Observatory. Furthermore, polarimetric and spectroscopic observations were also made. A description of this international campaign was given in *Messenger* No. 16 (March 1979). In this article the first results of the study of the photometric data and preliminary notes on the spectroscopic material are described.

Interstellar and Circumstellar Extinction

HR 5999 (= V 856 Sco) is one of the brightest pre-main-sequence stars. We have been studying this star for several years now. Due to particularly favourable circumstances it is possible to penetrate deeply into the extended atmosphere of this irregular variable star. Before its light arrives on earth it has to go through circumstellar material and through foreground interstellar medium. The way this light is attenuated by the latter is well known, but the manner in which it is dimmed by circumstellar dust grains is often different. This, in general, entails the problem of separating both types of extinction. In the case of HR 5999 it is possible to estimate the amount of foreground extinction, because it has a common proper motion companion, HR 6000, separated at an angular distance of only 45″. The amount of foreground extinction suffered by the light of the companion is about the same as that by the light of HR 5999. Being located at a distance of approximately 270 pc only, the amounts of foreground colour excess and extinction are, actually, not excessively large: $E(B-V) = 0\overset{m}{.}06$ and $A_V = 0\overset{m}{.}19$.

The star HR 5999 varies in the visual often about 1 magnitude in brightness, simultaneously with its change in colour index, in the sense that the star becomes redder when its light weakens. In general, the determination of the extinction by circumstellar matter is difficult. In the case of HR 5999 there are, however, strong indications that it is this material which causes the star to vary in brightness irregularly, perhaps triggered by a phenomenon which occurs closer to the surface of the star. Additional evidence for such a phenomenon is provided by the observations of linear polarization made simultaneously with the photometric measurements. They indicate that the degree of polarization is varying in phase with the change in colour index.

Based on the way the variations in brightness and the simultaneous changes in colour index are correlated, it is possible to derive the character of the extinction law of the circumstellar dust grains. A value for the ratio of total to selective extinction, R = A_V/E(B-V), anomalously larger than for the normal interstellar dust grains was found: R = 4.37. Having also E(B-V) for the circumstellar matter separately, it is then not difficult to calculate A_V and A_B for this material: A_V = 0.17 and A_B = 0.21 at maximum brightness.

The Energy Distribution

Using the foreground interstellar colour excess discussed above it is possible to determine the interstellar extinction at the different passbands based on the normal extinction law.

The spectral energy distribution of HR 5999 at about its maximum brightness V = 7^{m}0, is depicted in Fig. 1 by the thick line. The ultraviolet part of this energy distribution was derived from low resolution IUE spectral observations, folded at the five ANS passbands. It should be noted that in order to obtain the true spectral energy distribution of HR 5999, the circumstellar extinction must be taken into account. Two points of the true spectral energy distribution are known at the effective wavelengths of the B and V passbands, using A_B and A_V obtained above. These points are indicated by black squares in Fig. 1.

From spectrograms we know that HR 5999 is of spectral type A7 III. In the literature we have found two bright unreddened stars of the same spectral type (θ Tau and HR 3270) which were observed by Johnson in the visual, red and near infrared, and by the ANS in the ultraviolet. From the mean value of these observations we have derived an extinction-free spectral energy distribution, which is also shown (thin line) in Fig. 1, normalized at the two extinction-free points (black squares) of HR 5999. For comparison purposes we also show, by circles, the spectral energy distribution derived by Kurucz for a star of T_{eff} = 7750 K and log g = 3.0. The agreement is quite good. We now assume that the true spectral energy distribution of HR 5999 is not much different from the above-mentioned one.

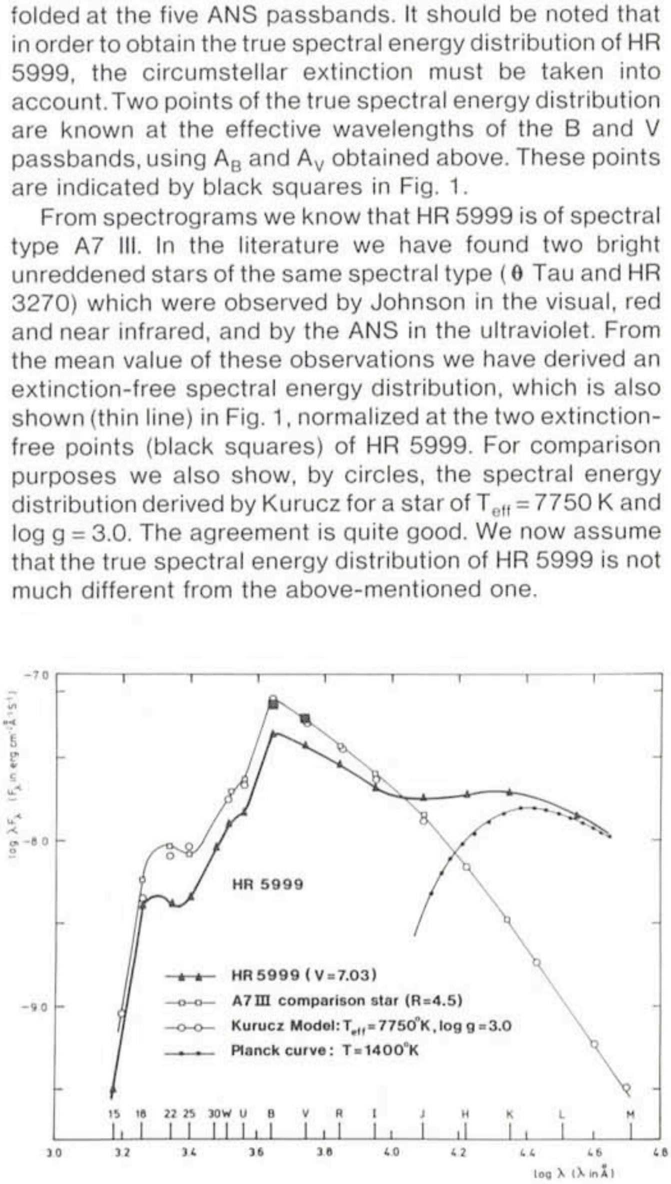

Fig. 1: *The spectral energy distribution of the star HR 5999 (thick line) freed from foreground interstellar extinction, compared to that of a Kurucz Model and of an unreddened mean A7 III comparison star. (Reproduced from* Astronomy and Astrophysics Supplement Series.)

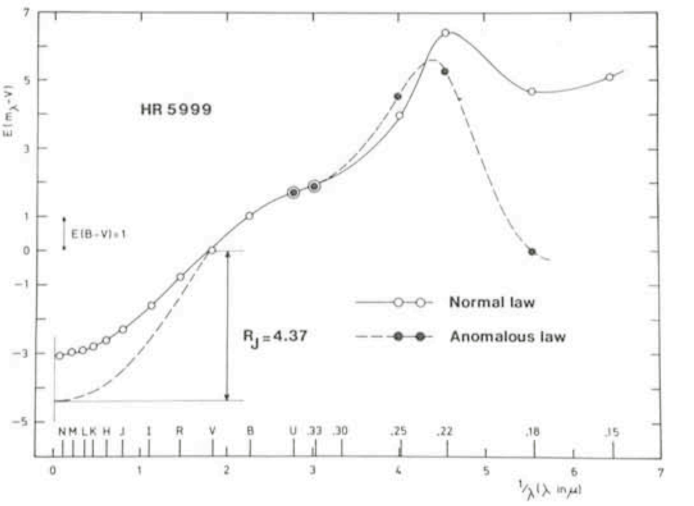

Fig. 2: *The extinction law of the circumstellar material of the star HR 5999. In the infrared as well as in the ultraviolet this law is anomalous. (Reproduced from* Astronomy and Astrophysics Supplement Series.)

The Energy Balance

Fig. 1 shows that the ultraviolet, visual and red energy emitted by the star HR 5999 is absorbed by the dust particles in the circumstellar shell. The total energy lost by the star to these dust grains, as estimated on earth, is about 1.5 x 10^{-8} erg cm^{-2} s^{-1}. This is about 25% of the total intrinsic energy of HR 5999.

From Fig. 1 it is also clear that the absorbed energy by the dust grains is re-emitted in the infrared spectral region. This re-emitted energy can also be estimated. Up to 5 μm it turns out to be about 1.7 x 10^{-8} erg cm^{-2} s^{-1}. More towards the infrared the amount of re-emitted energy becomes negligibly small. Considering the errors in their determinations, it can be concluded that the absorbed energy (UV, visual and red) is in good balance with the re-emitted energy in the infrared.

It is of interest to know the temperature of the absorbing dust grains. If we assume that the thermal dust radiation can be approximated by a Planck distribution, it is possible to fit the distribution of the excess infrared radiation at the long wavelength slope with a Planck curve. The temperature of the dust grains characterized by this curve is about 1400 K.

Other physical characteristics of the dust grains can be derived. If it is assumed that our previous determination of grain size, 0.16 μm, is not far from the truth and if it is further assumed that the grains are composed of C or Fe, then it can be calculated that the radiating grains are located about 1.8 AU from the surface of the central star. However, if the dust grains are composed of Si_2O_3 or Si C, then they are lying more than 3 times further away: 5.8 AU. The corresponding total dust shell masses are 4 x 10^{-11} and 9.5 x 10^{-10} $M_\odot$, respectively.

The Circumstellar Extinction Law

It has been shown that the circumstellar extinction law is anomalous. The value of the ratio of total to selective extinction is larger than normal: R_J = 4.37. This extinction law is depicted in Fig. 2. The question is then: How is the behaviour of the circumstellar law in the ultraviolet? To answer this question, the extinction-free and real ultraviolet energy distribution have been compared, so that the UV circumstellar extinction law of the star HR 5999 could be

Fig. 3: *The shell star HR 5999 unveiled. An artist's impression. Courtesy Mrs. M. Moesman.*

derived. It is shown in Fig. 2 as an extension of the visual part of the law. Compared to the normal extinction law of interstellar matter, the behaviour of the UV circumstellar law is completely different. The 2200 Å bump is somewhat lower and shifted towards larger wavelengths Furthermore, at about 1800 Å it is very much lower, resembling that for the star σ Sco reported by Savage.

The Spectrum

A study was made of the red and blue spectral plates (12 Å/mm) of HR 5999 taken in May 1978. Many lines of H I, Ca I, Fe II and Ti II are present and are composed of a broad photospheric component and several blue-shifted shell components. There are, however, lines which are purely photospheric (e.g. Mg II λ 4481) whereas other lines have only shell components (Na I D). The H-alpha line is in emission and has variable double structure. This variation appears to be in antiphase with the brightness changes of the star. Low resolution IUE spectra, taken also in May 1978, show in the short wavelength range ($\lambda <$ 2000 Å) the presence of emission lines of O I, C II, C IV and probably Al II; in the long wavelength range (2000 Å $< \lambda <$ 3000 Å) there are indications of strong and broad absorption features. A steep drop-off of the continuum at about 1800 Å is in agreement with the spectral type A7 derived earlier from the red and blue plates. High resolution IUE spectra of the long wavelength region, taken more recently by Hack and Selvelli, reveal the presence of many shell lines from multiplets of Fe II, Cr II and Mn II in absorption and strong emission of the Mg II λ 2800 doublet with a double structure, comparable with that of H-alpha.

The radial velocities of the shell components on the blue and red plates vary in time between –40 and –5 km/s, more or less in phase with the variation of the dust extinction. Because of the large width of photospheric lines their radial velocites are more difficult to determine. The values vary between –20 and +20 km/s.

Although many details of the spectra are still being studied, the spectral data support our believe in the existence of a hot emission shell (C IV emission line) around the star, surrounded by a cooler, less dense shell region, where the shell absorption components are formed and in which the circumstellar dust is embedded. If this is true, one can imagine that the dust extinction and polarization variations are the result of changes in the character of the dust grains due to perturbations in the photosperic or hot shell region, which are propagated outward supersonically through the cooler dusty surroundings. The cause and the characteristics of the perturbations are not yet clear, but the existence of instabilities in the shell of HR 5999 can be expected in view of the evolutionary stage of this pre-main-sequence star.

A Supernova Discovered at La Silla

Dr. André B. Muller from ESO recently described (*The Messenger* No. 19, p. 29, 1979) a new system allowing an easy and efficient monitoring of galaxies for the detection of supernovae. Using this system, H.E. Schuster discovered a supernova in NGC 1255 on December 30, 1980 (*IAU Circular* No. 3559, 1981). At the time of discovery its magnitude was 17. This was the first supernova found on La Silla.

Thanks to the kind collaboration of Visiting Astronomers Dr. W. Seitter and Dr. H. Duerbeck, an immediate follow-up was carried out, showing that it was a type II supernova.

P. V.

ESO/ESA Workshop on "Optical Jets in Galaxies"

With the aim of encouraging European cooperation and coordination in the use of the Space Telescope within some fields of research, ESO and ESA have arranged a series of workshops on the use of the Space Telescope and coordinated ground-based observations. The second of these workshops, entitled "Optical Jets in Galaxies", took place in the auditorium of the new ESO Headquarters in Garching on February 18–19, 1981.

Thanks to active contributions from 50 participants from different institutions in Europe and the USA, the meeting was very successful. Optical, radio and ultraviolet observations of jets were discussed in great detail. One of the results of the meeting is that the Space Telescope is expected to play a key role in the study of jets because of high resolution and UV sensitivity. The workshop proceedings will be published in a short time by the ESA Press.

M. T.

ALGUNOS RESUMENES

Observaciones "Speckle" en infrarrojo realizadas con una cámara de televisión

En principio, los grandes telescopios, como el de 3.6 m de la ESO, tienen una resolución angular mejor que 0.1 segundo de arco, vale decir, que detalles asi de pequeños pueden ser vistos; pero comúnmente éste no es el caso. Las mejores fotografias tomadas con grandes telescopios pocas veces muestran detalles más pequeños que 1 segundo de arco (un segundo de arco es la separación angular de dos puntos separados por un milimetro a una distancia de 200 metros); ésto se debe a la presencia de la atmósfera que es turbulenta, y esta turbulencia produce una imágen borrosa del objeto.