pronounced in the two bands at shorter wavelengths ($\bar{\lambda}$ = 730 and 860 microns) for which the atmospheric zenithal transmissions varied from about 0.35 and 0.70 to about 0.03 and 0.15. This may be illustrated by the two spectra shown in figure 4. These curves represent the variation of the following quantity:

$$S_\nu = K\,[T_A(\tau_\nu)\,e^{-\tau_\nu} + (T_{BB} - T_A(\tau_\nu))]$$

where K is a constant,
$T_A(\tau_\nu)$ is the emission temperature of the sky depending on the optical depth τ_ν, and
T_{BB} is the blackbody temperature.

Thus, after the appropriate baseline correction and with the assumption of the atmospheric thermal profile, these spectra give access to the transmission. The upper spectrum was recorded on the first night at zenith, whereas the lower one corresponds to an air mass m = 1.29 at the end of the second night. The drastic changes seen between the spectra arise from both the changes in air mass and in the humidity content since the relative humidity at the ground level varied from 25 % to 52 % between the measurements.

Despite the unfavourable climatic conditions, we have acquired numerous high signal-to-noise ratio measurements of the fluxes of Venus, Jupiter and Saturn in the four bands. Uranus and Neptune, which are much fainter sources, hardly showed up in the 7–9 cm^{-1} filter.

Because of the simultaneous monitoring of sky emission in the direction of each source, and the intrinsic quality of the raw data, an improved precision on short millimetric brightness temperatures of the bright planets can be expected from these observations. This is of great interest in relation with the present and future space probe missions to Jupiter and Saturn (Voyager missions) and to Venus (Venera project) which will provide accurate measurements of the fluxes in the intermediate and near infrared (from 2 to 50 microns for Voyager and from 70 to 200 microns for Venera). The exploration of such a wide spectral range is obviously of great benefit to our knowledge of the atmospheric structures of these planets.

Simultaneous Spectroscopic and Polarimetric Observations of Be Stars

K. Metz and G. Pöllitsch

Some of the most enigmatic objects in our galaxy are the Be stars. They display a remarkable variety of features, ranging from variable emission lines to high degrees of polarization. How do they look like? Drs. Klaus Metz and Gerd Pöllitsch from the München Institute for Astronomy and Astrophysics visited La Silla in 1977 and this year and observed southern Be stars. They do not provide the final answer to the problem, but they here report interesting new results.

In 1866 A. Secchi reported that the stars γ Cassiopeae and β Lyrae showed very brilliant spectra which seemed to be inverse to those of other blue stars. This was the first discovery of emission in stellar spectra, but almost twenty years had to pass until E. C. Pickering started an objective-prism survey in that field. In 1911, R. H. Curtiss followed with the first observations and classification of emission-line stars. As a consequence of his work, the International Astronomical Union introduced the name *Be star* in 1922 at its first General Assembly.

More than half a century has now passed and many famous astronomers, among them a surprisingly high number of women, have been working on the problems of Be and shell stars. During the last years they extended the classical observations to the far UV and IR using high-speed photometers and polarimeters as well as spectral line scanners.

The result of these efforts is that none of the various models proposed for Be stars can now satisfy all different aspects which have been brought in by the new observations.

This is due not only to difficulties in understanding the physics of extended shells, but also to the fact that many Be stars act like prima donnas: Sometimes they behave eruptively. Or they can, nobody knows why and when, completely lose their shell and then look like a normal B star. They have proven to be variable in spectrum and polarization within a relatively short time or even within hours. For an astronomer it is really fascinating to look at this performance and to see how it is developing with time (figs. 1, 3).

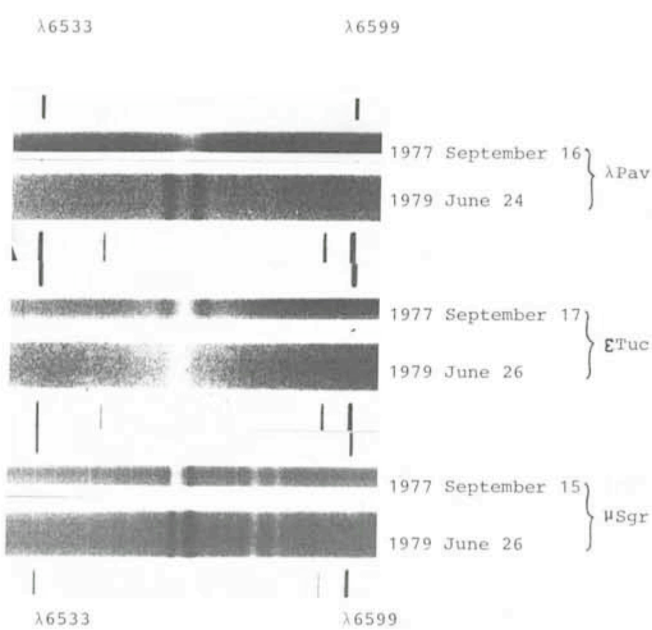

Fig. 1: *Hα line variation of three Be stars. The spectra have been taken with the ESO 1.5 m telescope, coudé, 12.3 Å/mm, 127-04 and IIIa-F emulsion respectively.*

Models of Be Stars

The first approach to an understanding of Be star phenomena was made by O. Struve. He suggested that the broadening of emission lines is due to rotation of a thin shell. Many objections have been made against this hypothesis and a long public dispute arose between Struve and Ambarzumian, in particular about how widths of emission lines shall be measured, a problem which does not yet seem to be solved. In Struve's model the high rotational velocity of a Be star should cause an equatorial break-up and the ejected material will form an emitting ring or disk, similar to our planet Saturn. In this case, broadening of emission lines would only be a function of the inclination of the rotational axis. If the disk is viewed edge-on, sharp absorptions will occur and therefore this model also explains the shell spectra[1] by inclination. Quantitative calculations have been carried out by Marlborough, Hutchings and others and they have been able to compute fairly realistic hydrogen line profiles.

However, there are other emission-line objects, like novae and planetary nebulae, the geometry of which can be resolved by telescopes. As a matter of fact, most of them show rather spherical geometries. This led one of us to compute line profiles of Be stars which were based on spherical envelopes. In this thesis he actually showed that spherical envelopes rotating differentially can also reproduce the observed Balmer lines, both with and without central absorption features.

The question is then: which shape do Be stars really have? Are they spheres or disks? An accurate knowledge of the geometry could help to draw conclusions about the mechanism forming the circumstellar shell. For example, an equatorial break-up or interacting binaries would form a disk or a ring-like shell. In turn, if radiative pressure or other symmetric forces account for the massflow, one would expect rather spherical shells. However, it should be emphasized that the study of line profiles only yields rough information about the geometry. See for example figures 2 a, 2 b: In figure 2 a three calculated line profiles are plotted. Figure 2 b shows the different geometries for which the calculation has been carried out. By comparison with the measured line profile (crosses) one can see that the fit is pretty good in all three cases. By variation of the relevant parameters within the limits given by physical conditions we finally derive:

(1) The observed Hα line profile may be produced by a shell extending at least 5 but not more than 25 stellar radii.

(2) The ratio of polar radius to equatorial radius lies between 0.5 and 1.

Polarization of Be Stars

As was first shown by A. Behr in 1959 for γ Cas, Be stars can exhibit a strong and variable polarization. Polarization of starlight, which is not generated by scattering of light within the interstellar medium, but is produced by the star itself or by scattering of radiation within an asymmetric stellar envelope, is called *intrinsic*.

The fact that normal Be stars do not show any significant intrinsic polarization, whereas Be stars do so, very soon led to the supposition that the envelopes must be responsible for the intrinsic effect. Indeed, the observed degree and wavelength dependence of polarization in Be stars can best be explained by electron scattering (independent of wavelength) but modified by absorption in a hydrogen plasma both before and after scattering.

It is clear that a resulting polarization will be produced only by an asymmetric distribution of scattering particles. Therefore the determination of the intrinsic polarization produced in the envelopes of Be stars should be a powerful

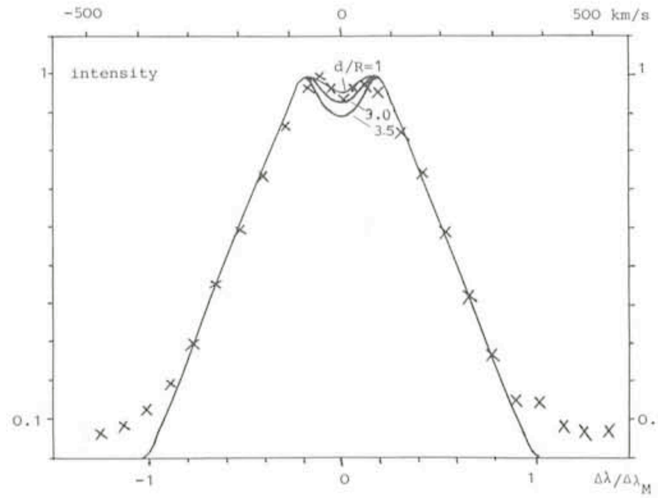

Fig. 2a: *Measured H α profile of π Aqr normalized to maximum intensity 1 for maximum emission (1977, Sept. 19, ESO 1.5 m coudé, 3.3 Å/mm). Solid line derived from model calculations for spherical and flattened shells as plotted in figure 2b.*

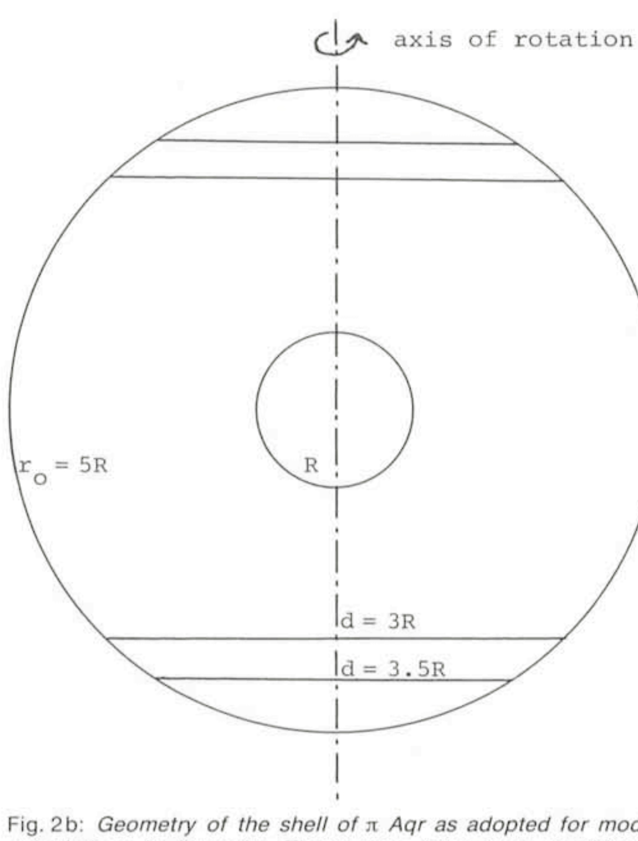

Fig. 2b: *Geometry of the shell of π Aqr as adopted for model calculations in figure 2a. Three cases have been considered: A spherical shell and a sphere cut off at a distance d = 3R and d = 3.5R. Hydrogen density is proportional $(1/r)^{2.5}$. Rotation is differential but with conservation of angular momentum ($v_\varphi [r] \cdot r = const.$)*

[1] Spectra showing both broad photospheric lines and very narrow lines are called shell spectra. Most of them also show emission.

means of studying the geometry of the envelopes themselves. At least this will be valid in the case where the electron density as well as the density gradient may be determined independently by simultaneous spectroscopic observations.

Simultaneous Observations at La Silla

In 1977 we started at La Silla a programme of simultaneous spectroscopic and polarimetric measurements for which ESO is able to offer excellent facilities. Discussing our observational routine, we had to decide whether to select a sample of only a few stars, each of them being observed over a long period, or to observe a larger number of stars, but spending only a relatively short observation time on each. Considering the great variety among Be stars, we decided upon the latter.

However, the long integration time, which is necessary for high-dispersion spectra, and also a narrow-band filter polarimetry, then restricts the observations to objects brighter than 6th magnitude. About 160 stars remain. Due to the concentration of young stars to the galactic plane, most of them can be observed at La Silla.

In our first run in 1977 we could observe 15 Be stars simultaneously. In 1979 we observed a further 15 stars and in addition 6 of the stars we had already observed two years earlier.

The repetition of observations turned out to be very illuminating because all six stars exhibited pronounced variations. For example, in 1977 λ Pav showed a normal B-type spectrum whereas in 1979 a marked double emission appeared. ε Tuc varied its spectrum quite contrary and the other stars changed their line profiles remarkably (see fig. 1).

Very surprising was the fact that five of twenty-one programme stars, known as emission-line stars, did *not* show any emission in Hα!

The Shell of π Aqr

Everyone who is concerned with calculations of extended envelopes knows by experience that it would be too optimistic to believe that the Be star problems can be solved quite simply by simultaneous spectroscopic and polarimetric observations. We soon had to learn this lesson from the shell star π Aqr. As was pointed out, the Hα line profile shows that the ratio of polar radius to equatorial radius lies within 1/2 and 1. On the other hand, we have the results of the polarization measurements (see fig. 3):

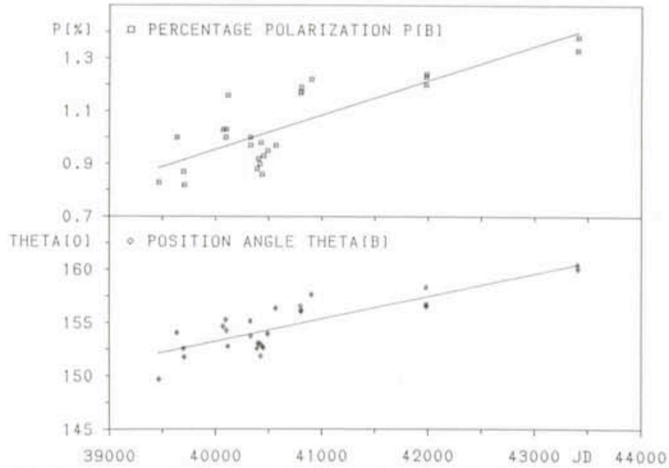

Fig. 3: *The variable polarization of π Aqr in the blue colour observed over a period of 12 years by different authors.*

Assuming simple electron scattering, the extremely high polarization of π Aqr requires this ratio to be between 1/3 and 1/5. What is wrong here? Perhaps the models used for both the line-profile calculations and also the continuum polarization are too simplified. Perhaps the polarization is caused not only by electron scattering but also by aligned grains. A confirmation may be the strong variability as well as the increase of polarization during the period of observation. However, which particles should be aligned and what is the physical mechanism responsible for an alignment of particles?

We have no answers to these questions at the moment. Therefore we are now trying to start calculations which take into account the known fact that the photosphere of a rapidly rotating star, like π Aqr, cannot be a sphere but must be flattened. This asymmetry of the geometry of the photosphere will cause a radiation flux which is also asymmetric in its geometry. Therefore, an additional polarization will result by electron scattering even within a spherical shell.

Acknowledgements

We wish to express our appreciation to all staff members at La Silla for their assistance during the simultaneous observations on two telescopes.

NEWS AND NOTES

Identification of Minor Planets

All over the world, every night, photographical plates are exposed with astronomical telescopes. And astronomical photography has become a great hit among amateurs who, for comparatively little money, can buy rather large, high-quality instruments.

As is well known to the readers of the *Messenger*, such photos may frequently show trails of minor planets. The fainter the limiting magnitude, the more trails are likely to be seen. Many professional astronomers are full-time "minor planet hunters" and with larger telescopes and better photographic emulsions more and more objects are being picked up. Many amateurs are now capable of reaching magnitude 15 or even 16 and have the fun of discovering new minor planets.

One of the major problems that confronts the astronomer who works in this field is to determine whether a trail belongs to a planet that is already known or whether it is new. The necessity of being able to answer this important question quickly and efficiently in connection with the research that is carried out at the Schmidt telescope on La Silla has led ESO astronomers H.-E. Schuster and R. M. West to develop a method that may be of interest to others.

ESO has several computer systems in Chile and in Geneva. Some of these control the telescopes on La Silla and others control the measuring machines in Geneva. There are, of course, also some systems that are used for "regular" computations. Some years ago, ESO decided to standardize its computer equipment, and after a careful study the Hewlett-Packard 21MX was chosen. This has the great advantage that programmes can be