ephemerides for space probe navigation as well as for "blind" infrared, radio and radar observations were stressed. Ground-based observations necessary to complement the observations by the Japanese, USSR and European space probes have been discussed. Emphasis has been put on the need of a close cooperation between astronomers observing with different techniques to optimize the scientific output of these observations. Finally, a lively discussion showed that it was the general feeling that a close cooperation between the European astronomers and the NASA International Halley Watch would be beneficial for all.

The proceedings of the workshop will be published by ESO in a few weeks. *P. V.*

The ESO/Uppsala Survey of the ESO (B) Atlas

by Andris Lauberts (ESO/Uppsala)

A systematic search for certain objects (NGC + IC galaxies, all galaxies with a diameter larger than about 1.0 arcmin, all disturbed galaxies, all star clusters in the Budapest Catalogue, and all listed planetary nebulae) has been carried out by means of the ESO(B) Atlas, covering the southern sky from –90 to –17.5 degrees. A total of 18,438 objects is listed; of these, about 60 % for the first time. Magnitudes and radial velocities are also given for a total of 2,102 galaxies.

Copies of the printed version are available for sale at the European Southern Observatory, Karl-Schwarzschild-Str. 2, D-8046 Garching bei München. The price of the volume is DM 40,–.

Copies of the magnetic tape version may be ordered from the Centre de Données Stellaires, 11, rue de l'Université, F-67000 Strasbourg.

PERSONNEL MOVEMENTS

STAFF

Arrivals

Europe

KAZIMIERZAK, Bohumil (B), Mechanical Engineer, 1.3.1982
MACFARLANE, Penelope (GB), Scientific Reports Typist, 24.5.1982
TKANY, Sylvia (D), Receptionist, 1.6.1982
BRISTOW, Pamela (GB), Scientific Reports Typist, 1.7.1982

Departures

Europe

DOBROFSKY, Sonngard (D), Clerk-Typist (Telephone and telex operations), 30.6.1982
HEUBES, Hannelore (D), Clerk-Typist (Telephone and telex operations), 30.6.1982

Chile

LUB, Jan (NL), Astronomer, 31.5.1982
HESSENMÜLLER, Egon (D), Optical Technician, 30.6.1982

FELLOWS

Arrivals

Europe

MOUCHET, Martine (F), 1.6.1982

Chile

JENSEN, Kaare (DK), 1.7.1982

ASSOCIATES

Arrivals

Europe

LAUBERTS, Andris (S), 1.6.1982

Near Infrared Observations of O Stars

Y. Andrillat, Observatoire de Haute-Provence

Introduction

During the last two decades, one could note an increasing interest for the O stars because the far ultraviolet observations had an important impact on the study of these objects, displaying principally mass loss phenomena.

In the visible region, the spectrum of the O stars is characterized by the presence of absorption lines of H, and ionized He, C, N and Si. A few of these lines appear in emission in some stars, exhibiting the presence of an extended atmosphere around them. These emissions are due to:

- N III λλ 4634–4640 in the Of stars where other emissions can also be present, for example He II λ 4686 and C III λ 5696
- H lines in the Oe stars which are not exhibiting other emissions (no N III . . .).

The O stars have been observed in a very large spectral range from ultraviolet up to the red region. Photographic plates were used, but since their sensitivity is faint beyond λ 8750, they were exceptionally employed in the near infrared region.

As far as O stars are concerned, the published data available in the 1μ region are quite scarce. Although it is poor in features, the spectral interval λλ 8700–11000 is very important because it presents new helium lines, principally He I λ 10830 and He II λ 10123.

For O stars, helium is the fundamental element. The classification criteria are deduced from the value of the intensity ratio He I/He II.

Fig. 1 shows the spectrum of ζ Pup (O4f I(n)) obtained by M. Dennefeld at La Silla. It is characterized by a few faint lines: the hydrogen Paschen lines are visible in absorption from P7 to P15. Some emissions are present: He II λ 10123, N IV, N V and Hα. Several absorption bands are due to the earth atmosphere.

Observations

For approximatively twenty years, the development of modern detectors has allowed us to reach the near infrared region, but there are still few observational data in this region.

Since 1975, in collaboration with J.M. Vreux, we have studied O stars in the λλ 8000–11000 interval. We have used a

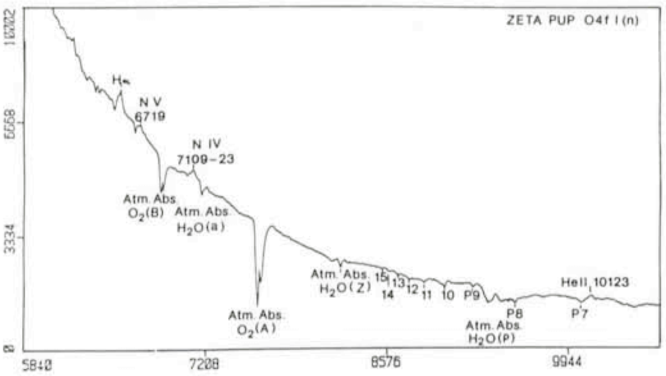

Fig. 1: *Spectrum of a typical Of star in the near infrared region (ESO 1.52 m telescope; Boller and Chivens spectrograph + Reticon; dispersion 228 Å mm⁻¹).*

cooled two-stage image-tube with a S1 photocathode attached to the grating spectrograph mounted at the Cassegrain focus of the Haute-Provence Observatory 1.93 m telescope. This spectrograph has its highest efficiency around 1μ to balance the sharp sensitivity drop-off of the receiver at wavelengths longer than λ 9500. The dispersion is small: 230 or 110 Å mm^{-1} and the covered spectral range is λλ 8000–12000.

However, the image-tube is not a very good receiver for the near IR study for it limits the investigation field because of several disadvantages: the biggest being the one inherent to the use of the photographic emulsions (sensitivity threshold, saturation, reciprocity law...). It is very difficult to obtain accurate photometric measurements (line intensities, equivalent widths, spectral distribution in the continuum).

In particular, it is not possible to take into account atmospheric absorptions and emissions which are present in the spectral range (Fig. 1): telluric absorptions of O_2 (A λ 7600 band – B λ 6870 band) and H_2O (Φ λ 11100 band – ϱ λ 9420 band – γ λ 9060 band – Z λ 8227 band – a λ 7190 band).

These molecular bands are superimposed to the stellar spectrum and risk to mask important stellar features (absorptions or emissions). Moreover the OH night sky emissions are numerous and intense principally from λ 7500 up to λ 12000. They are variable during the night and they are dependent on the position of the star, the period of the year and also the situation of the observatory.

Thus, it was important to have a detector which permitted to solve all these problems. This is the reason why, among all the possibilities, Haute-Provence Observatory and ESO have chosen to put into operation a silicon detector (Reticon). It has a linear response allowing an accurate photometry (1 % approximatively). At the end of the exposure time, the spectrum can be examined immediately. Then it is possible to add or subtract several spectra and by this process to take into account the atmospheric absorptions and emissions.

Helium Lines

About ten years ago, J. M. Vreux and myself began a systematic study of O stars in the near infrared region (λλ 8000–11000), in particular the one of the helium and carbon lines.

Our first aim was to make, with an image tube, a quick qualitative survey of a large sample of O stars in order to prepare quantitative observations.

The observations of the helium lines are extremely useful for the understanding of helium formation in O stars and the corresponding data are requested for the study of the ionization balance of helium in theoretical models of stellar winds.

(1) The λ 10830 He I line ($2s^3S-2p^3P$) is particularly interesting because the upper level is a metastable one. In the visible region, another metastable transition, λ 3888.6, exists, but this line is blended with the hydrogen line: H_8λ 3888.0.

We have observed the He I λ 10830 line in 67 northern O stars, principally Of stars, in order to find the physical conditions which are requested to produce this line in emission (Y. Andrillat, J. M. Vreux 1979, *Astronomy and Astrophysics,* **76,** 221.

We have plotted the observed behaviour of λ 10830 as a function of spectral types and luminosity classes (Fig. 2):

- filled circles indicate that the emission is well visible,
- half filled circles: that it is uncertain or variable and has not been found on all the spectra of the star,
- empty circles: that it is absent.

The underlined circles indicate peculiarities in the spectrum.

From Fig. 2, it appears that an emission is observed at λ 10830 in 74 % of the O4–O8 supergiants but it is seen only in 29 % of the dwarfs, all the latter exhibiting some peculiarities in their spectra: for example, the presence of an envelope with rapid rotation, or the presence of a companion.

We have also searched for a possible correlation between the mass loss rate and the intensity of the λ 10830 emission.

The available data show a good correlation between the 2 parameters in O5–O9 stars: this effect is temperature dependent.

This result is in good agreement with the theoretical conclusions of L. H. Auer and D. Mihalas (1972, *Astrophysical Journal, Suppl.* **24,** 193) which predict the progressive appearance of the He I λ 10830 emission when the temperature is high (Te > 25000 K) and the gravity is low (log g ≤ 3).

However, it is important to note that in four very hot supergiants (O4f–O5f) there is no emission or the emission is uncertain.

Moreover, the problem of He I λ 10830 is associated to that of He I λ 5875. There is no agreement between the observations of the latter line and the theory, and it has been necessary to introduce a microturbulence effect to reduce the discrepancy, but the consequence is a marked increase of the λ 10830 absorption, which is not observed.

Finally, our observations indicate that the most favourable conditions to push He I λ 10830 in emission are that the envelope has a large amount of material and that the central star has a temperature between 30,000 and 45,000 K. These physical conditions are typically the ones used in the theoretical models (R. Klein, J. Castor 1978, *Astrophys. J.,* **220,** 902)

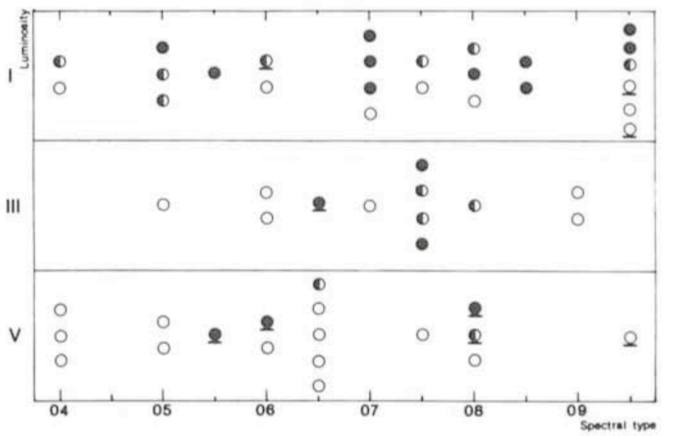

Fig. 2: *Distribution of the He I λ 10830 emission (filled circles) in terms of spectral types and luminosity classes. Half filled circles indicate that the emission is uncertain or variable and empty circles that it is absent. Underlined circles indicate peculiarities in the spectrum.*

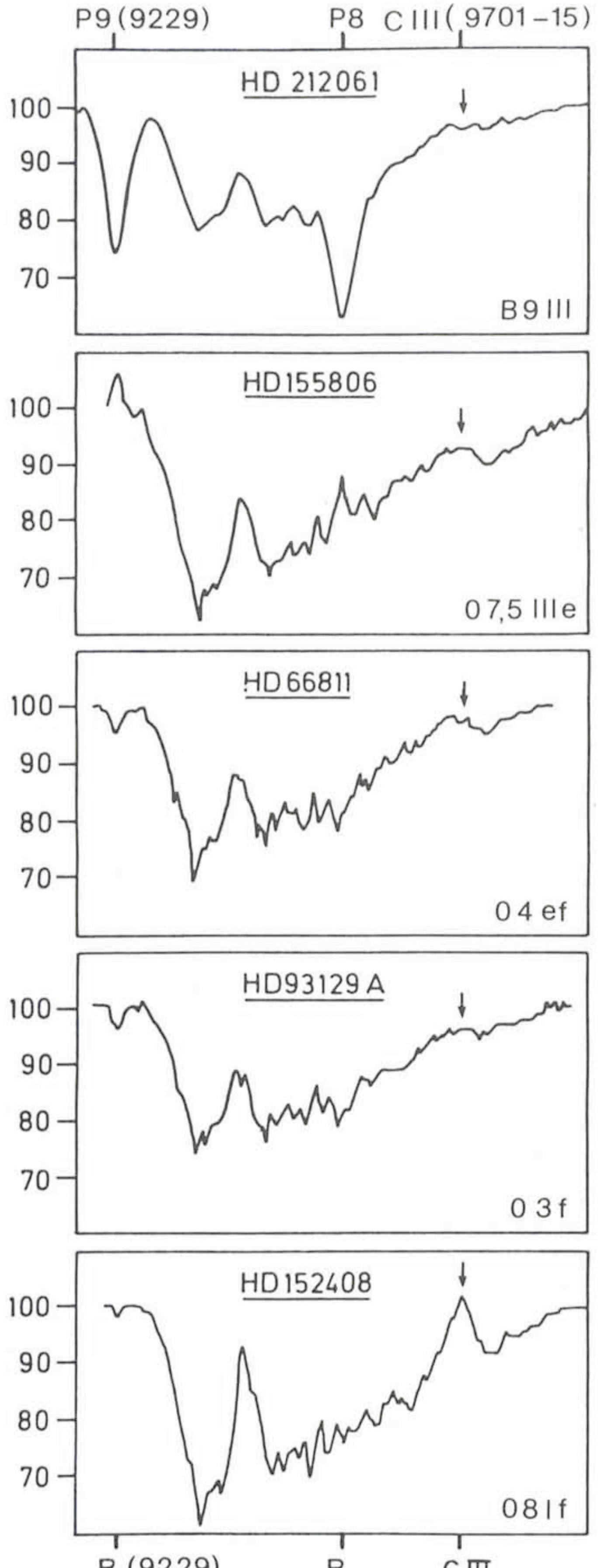

Fig. 3: *Spectra of 4 O stars around the C III λλ 9701–9715 lines. A B9 star spectrum given as comparison. All spectra corrected for instrumental sensitivity and referred to a normalized continuum. The arrows indicate the position of the C III lines.*

but we observe a higher intensity of the He I λ 10830 emission.

We have extended our observations to the southern O stars at the ESO Observatory, with the aim of clarifying the relation between the mass loss rate and the intensity of the He I λ 10830 line and, in the future, we plan to investigate the variability of this line which we have already observed in several stars.

The use of the ESO silicon detector (dual array RETICON) permits accurate intensity measurements. Owing to the linear response of this instrument, it is possible to take into account the atmospheric absorption H_2O λ 10832 and to subtract the OH λ 10828 night sky emission which are both superposed to the stellar line He I λ 10830.

Previously, our observations performed with an image tube had been limited to bright stars in order to have short exposure times and to prevent contamination of our spectra.

(2) He II λ 10123 line is the first member of the Pickering series (n = 4 ↔ n = 5). Observations of this transition are extremely important, in particular to decide which mechanism produces He II λ 4686 line (n = 3 ↔ n = 4): collision, deexcitation, pumping . . . It is interesting to know why the He II λ 4686 line is in emission in the spectra of some O stars while all the Pickering lines are in absorption.

According to the models of R. Klein and J. Castor, He II λ 10123 should be an intense emission in some O stars, stronger than the λ 4686 emission, the ratio of intensities λ 10123/λ 4686 ranging from 2.16 to 3.64.

Among thirteen O stars observed by D. Mihalas and G. W. Lockwood (1972, *Astrophys. J.,* **175,** 757), 2 stars exhibit λ 4686 emission and they are also the only ones with an emission at λ 10123, the value of the observed intensity ratio λ 10123/λ 4686 being about 1.3 (R. Klein, J. Castor).

Out of our large sample of O stars, we have observed emissions at λ 10123 in four other new Of stars and we confirm the small value of λ 10123/λ 4686 (J. M. Vreux, Y. Andrillat 1979, *Astron. Astrophys.,* **75,** 93).

Thus, it appears that the theoretical ratio is definitively too large. Unexpectedly strong λ 10123 absorption is observed in a few objects. This result raises again the question of pumping of the 2n–2n′ transitions of He II by the corresponding n–n′ lines of H.

It seems that, in some cases, a mechanism producing a similar effect takes place in O stars. If a pumping mechanism is not possible, D. Mihalas and G. W. Lockwood have suggested that the causes of the emission must involve chromospheric phenomena.

It is necessary to obtain good profiles of the He II λ 10123 and also a better determination of the intensity to decide which theoretical model is to be chosen. We have continued our observations in this sense and we have extended them to the southern hemisphere with the ESO Reticon.

The C III 9701–9715 Lines

It is very difficult to elaborate a theory concerning the mechanism responsible for the C III emissions in the O stars because very few observational data exist.

Indeed, there are only two C III emissions in the visible, λ 5696 and λ 4649, the two important other ones being situated in the near infrared: λ 8500, $3s^1S$–$3p^1P$ contaminated by P16 and λλ 9701–9715 contaminated by a strong water vapour atmospheric band (ϱ).

We have tried to observe the λλ 9701–9715 lines with an image tube but this is only possible when the lines are very intense (Y. Andrillat, J. M. Vreux, 1975, *Astron. Astrophys.* **41,** 133: detection in 3 Of stars).

The Reticon device is well adapted for these observations.

With this instrument, M. Dennefeld has obtained at the ESO 3.6 m telescope the spectra of 4 O stars (Fig. 3).

The corrections for atmospheric absorption have been achieved by standard photometric procedures (observations of a standard star at different heights above the horizon), but they are imperfect because these observations have been performed during the early phase of putting the instrument into service.

We do not detect any intense C III λλ 9701–9715 emissions in the 2 hot stars (O3 and O4) we have observed. These lines are also absent in the O7.5 IIIe star, but they appear as a strong emission only in HD 152408 (O8 If) which is one of the most "extreme" O stars with a very important extended envelope (Fig. 3).

Our results, deduced from a very limited sample (only four O stars) do not confirm the predictions of H. Nussbaumer (1971, *Astrophys. J.*, **170,** 93) that λλ 9701–9715 should be in emission in hot stars (T_{eff} = 40,000–50,000 K) without taking into consideration an extended atmosphere. On the contrary, our observations show that the presence of λλ 9701–9715 emissions depends essentially on the importance of the atmosphere, in better agreement with the theory recently developed by N. A. Sakhibullen, L. H. Auer and K. A. Van der Hucht who conclude that there is a temperature and a luminosity effect.

The Paschen Series Lines

P8 and P9 are very well visible on all our spectra: they are in absorption: strong in the classical B9 star which is normal, faint in the Of stars. These latter observations are compatible with the theoretical predictions. Klein and Castor have computed the contribution of the stellar envelope of O stars to the intensities of Paschen lines. In most cases, they obtain a strong emission contribution at Pα but a weak one at P6. If we extrapolate, it is normal to observe P8 and P9 in absorption.

Only the Oe star (HD 155806) exhibits P8 and P9 in emission but this star is related to Be stars which often present the Paschen series in emission.

Oe Stars

In the blue region, the spectra of Oe stars are similar to Be stars. So far, no Oe star has been observed up to 1,1 μ. It was interesting to fill this gap and to compare the spectra of Oe and Be stars in the near infrared (Y. Andrillat, J. M. Vreux, M. Dennefeld 1982, IAU Symp. No. 98 p. 229, Eds. M. Jaschek, A. G. Groth).

M. Dennefeld has observed HD 155806 (O 7.5 IIIe) with the Boller and Chivens spectrograph + Reticon at the ESO 3.6 m telescope in the spectral range λλ5900–11000.

The spectrum is very rich (Fig. 4) exhibiting many emissions: Hα is very strong and the Paschen series is visible up to P18. He I lines are present: λ 10830, not visible in Fig. 4, is intense; He II λ 10123 is absent; O I λλ 7772, 8446, Ca II infrared triplet, Fe II λλ 7515, 7712, 9997 are very well visible.

We have found all the elements identified in the Be stars. It appears that HD 155806 is related to Be stars of early type with

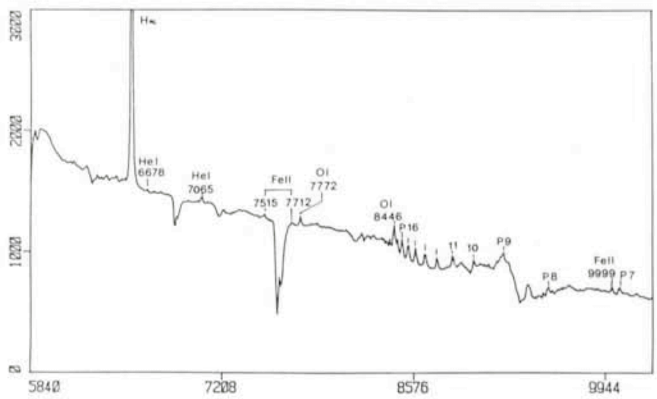

Fig. 4: *Spectrum of an Oe star in the near infrared: HD 155806 (O7.5 IIIe). (ESO 3.6 m telescope; Boller and Chivens spectrograph + Reticon; dispersion 228 Å mm⁻¹).*

a strong metallic envelope revealed by O I λ 7772 and Fe II λ 7712 both in emission and an Hα line very strong and without structure.

Moreover, a study concerning 68 Be stars (Y. Andrillat, L. Houziaux 1967, *Journal Obs.* **50,** 107 = Publ. OHP 9 n° 11) shows that the Paschen series and O I λ 8446 appear in emission in B0e, B1e, B2e . . . B5e stars but principally in B2e stars. He I λ 6678, visible in HD 155806, is present only in the B0e . . . B3e classes.

In conclusion, our observation confirms that HD 155806 initially classified as an O 7.5 IIIe is actually a Be star and very likely B2e or B3e star with strong metallic envelope.

Conclusion

In the evolutive scenario proposed by P.S. Conti, a link exists between the late-type O stars and the transition Wolf-Rayet stars. Some authors think that these WN7-WN8 stars have probably been formed from massive Of stars ($M > 35\ M_\odot$), binary or not, having lost their mass by stellar wind effect.

It is therefore important to complete our knowledge of physical conditions in the atmospheres and evelopes of O stars. So it was desirable to extend the observations to a larger spectral range, in particular to the near infrared region for which observational data were very scarce.

This has been possible owing to the development of modern receivers, principally the ones with a linear response.

Our first observations in the near infrared have specified the behaviour of helium lines in terms of spectral types and luminosity classes in order to help the elaboration of theoretical models. In this spectral interval we have reached the important lines of C III and we could bring observational data to the studies of the processus of line formation. Finally the similitude between the Oe and Be stars are confirmed by their infrared spectrum. Especially the observations we have performed at the ESO Observatory using a Reticon receiver have already brought important results which are only a first approach of a further study of O stars which appears as a very promising one.

White Dwarfs—the Dying Stars

D. Koester, Institut für Theoretische Physik und Sternwarte, Kiel

Introduction

White dwarfs are one of the possible end products of stellar evolution—perhaps not as exciting as neutron stars or black holes, but certainly much more numerous: more than 90 % of all single stars end their life as a white dwarf.