ISSN 0296-3140

Be STAR NEWSLETTER

NUMBER 22

May 1990

Editor: Geraldine J. Peters
Space Sciences Center
University of Southern California
University Park
Los Angeles, CA 90089-1341
U.S.A.

Produced at the European Southern Observatory

CONTENTS

The Be Star Newsletter is open to all contributions concerning early-type stars. Please send manuscripts and all correspondence to the editor's address given on the front page. In the case of very urgent late contributions directly contact the technical editor via one of the fast links listed below. The Newsletter is distributed free of charge to all astronomical institutions which request it. If you wish that the Newsletter is also received at your institute, write to the technical editor:


```
                                |  Phone: +49-89-32006-388
Dietrich Baade                  |  Telex: 528 282 22 EO D
European Southern Observatory   |  Fax:   +49-89-3202362
Karl-Schwarzschild-Str. 2       |  Bitnet/EARN: BAADE@DGAESO51
D-8046 Garching                 |  SPAN:  ESOMC1::BAADE
W. Germany                      |  X25:   PSI%0262458900924::BAADE
```


Normally only one copy per institute will be mailed. By default, it will be sent to the institute's library; please name a contact person if this is not desirable.

Acknowledgements: The Be Star Newsletter is produced at and financially supported by the European Southern Observatory. We thank Pam Bristow and Harry Neumann for their active help in administrative and technical matters.

EDITORIAL

* * * * *

As we begin the 1990s the *Be Star Newsletter* enters into its second decade of publication. This tenth anniversary issue contains some special features as well as the familiar Working Group Matters, Contributions, What's Active/Inactive?, Observations . . . Theoretical Support Wanted/Available, Preprints Received, and Bibliography. I tribute the success of the *Newsletter* to my colleagues who send contributions and help with the compilation of the bibliography and I would like to extend to you a very *special gratitude* at this time. Occasionally we miss citing a paper or make a clerical or printing error, but as always, if you call my attention to the omission/error I will correct it in the next issue.

With this special issue we are initiating a series of invited review and commentary contributions which will include papers of a historical nature and those expressing opinions on the direction of future research. I am happy to be able to begin this series with papers by Mercedes Jaschek, John Percy, and Arne Slettebak.

The first issue of the *Be Star Newsletter* was published in January of 1980 with Mercedes Jaschek as editor. I am pleased to publish an account of the early history of the budding *Newsletter* by Mercedes Jaschek. On behalf of the Be star community I would like to once again thank Mercedes for her effort in initiating the *Newsletter* and successfully publishing it for six and a half years.

I searched Issue No. 1 of the *Newsletter* for a paper that one might consider *avant-garde* in the sense that it reported an observation or idea that would have a profound impact on our concept of the Be phenomenon during the decade of the 1980s. The paper that I feel best fits this criterion is "Short-Period Light Variations in Be Stars" by J. R. Percy, S. M. Jakate, and J. M. Matthews (*Be Star Newsletter*, No. 1, p.7, 1980). For this tenth anniversary issue I am reprinting this paper along with an update on the topic of "rapid" variability by John Percy.

In this issue Arne Slettebak summarizes the changes that he has witnessed in Be star astronomy in the past 40 years. We also include reports on an apparent difference between the rotation properties of the envelopes of high temperature versus lower temperature Be stars, a continuing attempt to learn the causes for the "travelling profile bumps", and the recent resolution of the Balmer line envelope in γ Cassiopeiae.

Biannual publication of the *Newsletter* continues to be favored by the readership. Since we plan to send the next issue to press in November, contributions for Issue No. 23 should be received by:

October 1, 1990

Lengthy contributions should be submitted in a camera-ready format (see Issue No. 14 for instructions), but for short communications I especially recommend FAX mail (telephone number: 213-746-5684), Electronic Mail (CYGNUS::PETERS, SPAN or gpeters@astron.usc.edu, Internet), or telex (4720490 USC LSA).

I wish you a productive and happy summer and hope you announce your new discoveries in the *Newsletter*. Thanks again to the European Southern Observatory for their continued financial support.

Gerrie Peters, Editor

WORKING GROUP MATTERS

*****

Let me briefly discuss two subjects the Working Grouping at the moment probably should feel concerned with, the XXIst IAU General Assembly in 1991 July in Buenos Aires and the definition of a new, dedicated international Be star meeting.

Following the tradition of previous IAU General Assemblies, I have asked the President of Commission 29, Prof. Peter Conti, which had sponsored our past meetings to include a half-day meeting for our working group in his request to the IAU Executive Committee. A small part of the proposed meeting will have to be set aside for general business, incl. the election of a new Organizing Committee. For the scientific agenda I have asked the members of the present Organizing Committee for suggestions, and I am now extending this question to all other members of the Working Group.

Up to now only a few suggestions have been received. One comment was that it is difficult to make detailed plans because one does not know sufficiently long in advance who would be able to attend. This would call for a relatively unconstrained agenda with a broad mix of Be star related subjects. Such an approach may derive its attractiveness from the more or less rigid schedule and limited scope of more formal meetings.

A more explicit proposal (by Luis Balona) is to invite a few speakers to give their definition of current problems in Be star research and/or their evaluation of ongoing projects. Since the idea is to identify the most urgently needed but also most promising research subjects the discussion should not be limited to mere presentations but through new/renewed personal contacts provide the incentive for collaborations. In my personal view, this concept comes very close to what a working group should be and is very promising, provided sufficiently many colleagues can attend the meeting who would serve as nuclei/catalysts for joint activities.

Furthermore, after a meeting as the one suggested by Luis Balona we may have a somewhat clearer view of whether or not we want a new general meeting on Be stars at the IAU level and what we expect from such a meeting. This question relates to the more basic one whether progress in science is achieved by a meeting or whether a meeting only reflects past advances. Perhaps, the truth is somewhere between these two extremes. However, the argument that I have heard the most often (and even that not often in abolute numbers) in favour of a new generic Be star meeting was that the past meeting of this type were held at intervals of about five years and the next meeting could now take place only more than five years after Boulder (1986). I am sure that there are better arguments, and once again I invite all of you to communicate your views to me or any other member of the Organizing Committee.

I end with a short commercial for an ESO workshop on *Rapid variability of OB-stars: Nature and diagnostic value* which will held Oct. 15-17 at the ESO Headquarters in Garching, W. Germany. As the title indicates, the scope of the workshop goes much beyond Be stars. On the other hand, it once more turned out that Be stars are among the best observed early-type stars and therefore figure quite prominently on the agenda. The implicit speculation is of course that the variabilities of different groups of stars have sufficiently much in common that conclusions can be abstracted from the particular type of stars from which they were obtained and be combined to a more general model. In turn, work on a subgroup, and Be stars might be a very good example, would eventually benefit from the application of such generalized concepts. The preliminary program (designed by the Scientific Organizing Committee which consists of H. Ando, D. Baade, C.T. Bolton, H.F. Henrichs, and L.B. Lucy) and a registration form are attached to many copies of this edition of the Newsletter (if you need more, write to me).

Dietrich Baade

CONTRIBUTIONS

* * * * *

THE EARLY HISTORY OF THE Be STAR NEWSLETTER[1]

Mercedes Jaschek
Centre de Données Stellaires
Observatoire de Strasbourg
F-67000 Strasbourg

G. Peters asked me to write on the occasion of this anniversary a few comments on the early history of the *Newsletter*, since I happened to be its first editor. To arrive at the Newsletter, perhaps a few lines are necessary to explain how my involvement with Be stars started. The history starts thus way back in the fifties in Argentina. At that time neither American not European telescopes existed in Chile and the southern skies were explored only by the Radcliffe, Cordoba and La Plata reflectors. The last one was the one we had available; it was the smallest of the three, with its aperture of 80 cm and a two-prism spectrograph built by Hussey in 1910's. For some years this was the only spectrograph available at La Plata. It was very slow, so that fifth-magnitude stars constituted about the limit of the Universe. The camera could observe however at Hα (with a dispersion of about 180 A/mm), so that we decided with Kucewicz to observe all southern B-type stars, to find out how many of them showed emission. Since this was the first systematic survey carried out with a slit spectrograph, we got a series of interesting objects.

Obviously we started re-observing them at Cordoba, where the 152 cm telescope of Bosque Alegre had an excellent spectrograph providing 42 A/mm. This generated over the years a series of descriptive studies, which filled a much needed gap in the then available time coverage. Between the Lick survey carried out in Chile in the 1920' and 30's, nobody had observed systematically Be stars!

At about this time Feinstein and his collaborators started observing photoelectrically at la Plata, so that the spectroscopic survey could be completed with the first series of modern photoelectric studies of Be stars.

What we also discovered was that in any systematic study of time variability of an object, one is obliged to know what has been published on a given star. Since SIMBAD at that time did not exist, this meant that one had to spend hours in the librar digging out references. As a partial solution we decided to continue Merrill's (and Burwell's) bibliography and this could be published before we left Argentina.

Once installed in Europe, I tried to continue our survey studies of the southern sky, but modern observatories are not too enthusiastic on survey programs, as everybody knows. So I turned naturally to the most comprehensive survey made of northern Be stars, made at Meudon Observatory

[1]The first of a series of invited contributions to appear in the *Be Star Newsletter*.

by Mrs. Herman and her group. She had had the excellent idea to follow more than 100 Be stars over 23 years! This is certainly a mine of information, which has been only partially explored with the beautiful Atlas of Hubert-Delplace and Hubert.

By that time -mid seventies- Mrs Herman had serious health troubles ad as a consequence the IAU Working Group on Be stars chaired by her for several years practically came to rest at the IAU General Assembly at Grenoble (1976). With the help of a number of colleagues interested in Be stars, a successful attempt was made in 1979 at the General Assembly of Toronto to resuscitate the WG and I was elected as Chairperson. Among the several initiatives included in the program of the WG, two were of importance -one to held a symposium and the second to create a Newsletter. Of the two, the organization of the symposium turned out to be the easier one, thanks to the efficient collaboration of Prof. Growth from the Munich Observatory, where the meeting took place.

The Newsletter started in 1980, with two issues per year. N.1 and N.2 were rather easy to put out, but, as it happens with all Newsletters, the real difficulties lie between N.3 and N.7, because the Newsletter is not yet an established publication, known by everbody in the field. Therefore the number of contributors is uncertain and each issue is a struggle-for-life. But the number of subscribers kept growing, and the Director of the Strasbourg Observatory, A. Florsch, gave a wholehearted support to the Newsletter.

When I left the chair of the WG in 1982 at the Patras General IAU Assembly, the Newsletter stood on somewhat firmer grounds. The new chairperson, A. Slettebak, encouraged me to keep editing it, because he thought that a change of editor and of place could be fatal at this stage. So I accepted to go on, until 1987 (:) when I felt that the Newsletter was well-established and could digest a change of editor and place.

I think that the vitality of the Newsletter testifies of the vitality of the WG, ie of the community of Be star fans. In fact this community is now much larger than thirty years ago, although one could say that this is what happened with all astronomy. But thirty years ago spectroscopy in the $\lambda\lambda$3700-4800 region was practically the only well-established technique to learn about Be stars, whereas now we can oberve the whole spectrum from X-rays to the far infrared. Obviously we can turn now to monographic multiwavelength studies of isolated objects, instead of being obliged to use survey methods in just one stretch of wavelengths. Because of the many different approaches used in Be star studies, the Newsletter represents a very effective link between all Be star observers and merits the support of all colleagues interested in the subject.

And so let me end with

"Long live the Be star Newsletter".

SHORT-PERIOD LIGHT VARIATIONS IN Be STARS[2]

J.R. Percy, S.M. Jakate, and J.M. Matthews

Department of Astronomy
University of Toronto

Be stars are known to vary in brightness on a time scale of months or years, and in a few cases (V923 Aql, EW Lac) on a time scale of a day or less. Our studies of Be stars are part of a survey of short-period light variations in all the early B stars within 500 pc of the sun. We have so far observed about a dozen Be stars, and have found short-period light variations ($0^m.02$ to $0^m.1$) in almost all of them. Some of the observations are already reported in Astron. J. 82, 353 (1977) and IAU-IBVS no. 1530 (1979); others will be reported in a forthcoming paper.

Although the amplitude of the variations may vary with time, in some stars there is a persistent quasi-periodicity, ranging from $0^d.25$ in 25 Cyg and HR 9070, through $0^d.5$ in λ Eri and 28 Cyg, to $0^d.8$ in V923 Aql and EW Lac. We have not yet demonstrated strict periodicity in any of these stars. We have only limited information on short-period colour variations in these stars, but in most cases $\Delta(B-V)/\Delta V$ seems to be small. Our observations of these and other Be stars are continuing.

It would be premature to speculate about the cause of the variations, but the range of quasi-periods ($0^d.25$ to $0^d.8$) seems to rule out pulsation or rotation as the sole mechanism. There may be some connection between these variations and the non-radial pulsations which M.A. Smith has found in many B stars; the range of periods is quite similar.

---

[2]Reprinted from the *Be Star Newsletter*, Issue No. 1, p. 7, 1980.

SHORT-PERIOD LIGHT VARIATIONS IN Be STARS[3]

John R. Percy
Department of Astronomy
University of Toronto

Light variations on a pulsational/rotational/orbital time scale of 0.2 to 2 days have been observed in Be stars for almost 50 years, but largely ignored until a decade ago. Several factors have contributed to a renewed interest in them: the detection of absorption line profile variations in B and Be stars (primarily but not entirely due to new detector technology), a series of catalytic conferences (Munich 1981, Nice 1981...), and the effects of UV satellites such as IUE on our interest and understanding of hot stars in general. The role of the IAU Working Group on Be Stars, and this Newsletter, has also been significant.

It is apparent, from surveys by Balona, Stagg and others, that most Be stars vary on time scales of about a day, with an amplitude of a few hundredths of a magnitude in U, B and V. In a few of these stars, an underlying periodicity has been found (see Stagg et al 1988: MNRAS 234,1021 for instance), but the observations are complicated by irregularities in the amplitude and shape of the light curve, the inconvenient time scales, and the longer-term light variations in the same stars. The surveys by Balona and his colleagues have been especially interesting and productive: they reveal light curves with characteristic, stable double wave shape, and periods clustering around a day.

As Balona has eloquently argued, the light curves strongly suggest that the variations are due to rotation. The absorption line profile observations (many of which are unfortunately not yet published) equally-strongly suggest nonradial pulsation (NRP). Proponents of the rotational model ask how NRP can produce double-wave light curves, with periods concentrated near the rotation period. Proponents of the NRP model ask how rotation can produce light curves with changing amplitude and shape, and absorption line profile variations which look like NRP. These are the two competing models. How are they to be resolved?

On the observational side: we need intensive spectroscopic and photometric observations of a few "typical" short-period-variable Be stars, at both visible and UV wavelengths. Such observations have already been organized and carried out by Peters and her collaborators, and should provide at least a partial solution to the problem. On the theoretical side: we need realistic predictions of the spectroscopic and photometric variations to be expected in rotating or nonradially pulsating B stars. Given the complexity of B stars (especially the rapidly-rotating Be stars), this may not be possible - at least at present.

The definitive review article (or book) on short-period variations in Be stars has yet to be written, but there are several interesting and relevant papers in "The Physics of Be Stars" (Cambridge U.P. 1987).

---

[3]One of a series of invited contributions to appear in the *Be Star Newsletter*.

CHANGES AND INNOVATIONS IN Be STAR ASTRONOMY[4]

Arne Slettebak
Department of Astronomy
The Ohio State University
Columbus, OH 43210

Gerrie and Dietrich have invited me to write a page or two for this 10th Anniversary Issue of the Be Star Newsletter on "... how you have seen Be star astronomy change during the last 30 or 40 years." I'm relieved that they did not suggest that I begin with the days of Father Secchi, since I do not go back quite that far. I do remember Struve and his research on Be stars very clearly, however, and also had the privilege of meeting and discussing Be stars with Merrill and McLaughlin. There have indeed been many changes and innovations in Be star astronomy since those years.

First and perhaps most obvious is the opening of new windows to the electromagnetic spectrum. Ultraviolet spectroscopy from the Copernicus and IUE satellites has shown the existence of a hot, variable, low-density, expanding component of the Be-star circumstellar envelope, unknown in Struve's time. At still shorter wavelengths, X-ray satellites have been used to discover a group of Be/X-ray binaries which consist of a Be star with a neutron star component. The neutron star, which passes through the Be-star envelope periodically, gives rise to X-ray bursts, and can be used as a probe to determine the physical characteristics of the envelope. In the infrared region of the spectrum, observations with the IRAS satellite have confirmed that the observed infrared excess in Be stars is due to free-free radiation from circumstellar material, as opposed to dust, and have also permitted calculations of the density distribution in the circumstellar envelope.

Another major innovation in the study of Be stars has been the introduction of fast, linear detectors for high-resolution spectroscopy. The use of photoelectric scanners, Reticons, and CCD detectors has permitted the acquisition and analysis of accurate Balmer and Paschen emission-line profiles for the determination of the envelope properties. These detectors have also made possible variability studies, both in colors and in line profiles, with an accuracy which was not attainable in previous years. We now observe "bumps, wiggles, dimples, and ripples" in line profiles, which may be interpreted in terms of non-radial pulsations, magnetic loops and knots, and/or rotational modulation. While there is no general agreement as yet, it is

[4]One of a series of invited contributions to appear in the *Be Star Newsletter*.

significant that we now have the possibility of obtaining observational data which may lead to the causes of Be-star rapid variability.

Another area of Be-star research which, although not new, has led to important advances in recent years, is polarimetry. Perhaps the strongest observational evidence in support of the rotating flattened disk models for Be-star envelopes comes from polarization measurements.

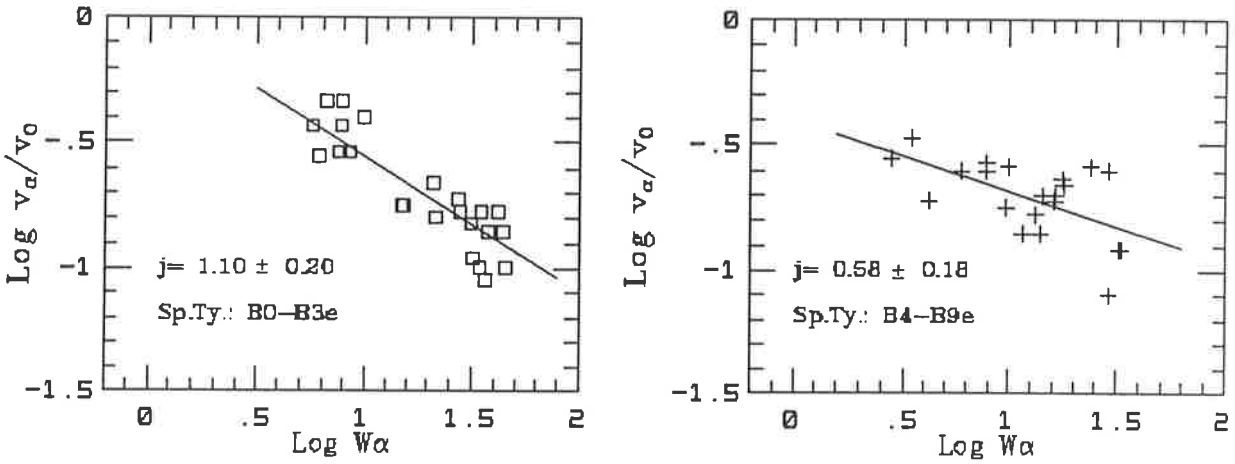
Of course, what we would really like to do is make direct measurements of the shapes and dimensions of Be-star envelopes. This is now becoming possible with the introduction of lunar occultation and interferometric techniques, and we can expect more results in the next decade or two.

Finally, I would like to comment on the importance of observing "campaigns" in the study of Be stars. Variability is an essential component of the Be phenomenon and one problem during earlier years has been the availability only of sporadic observations. More recently, we have seen coordinated efforts to observe individual Be stars over extended periods of time and simultaneously over several wavelength domains. This has already resulted in signficant progress in our understanding of Be stars and we may expect more of the same. Surely Secchi, Struve, Merrill and McLaughlin would approve!

TEMPERATURE EFFECT ON ROTATION LAW OF BE STARS ENVELOPES

R.E. Mennickent
Astrophysics Group
Pontificia Universidad Católica de Chile
Casilla 6014, Santiago. Chile.

From the peak separation and the equivalent width of the Hα emission lines of several Be stars, evidence for the disk model of the emitting envelope was found and the rotation law was derived. The method was similar to that used by Hanuschik et al. (1988) but the rotation law assumed was $v(r)= v_o(r_\star/r)^j$, where $v_o=\sqrt{Gm_\star/r_\star}$ and j is a rotational exponent to be determined. The following linear relation is then expected for disk type geometry of the emitting region: $\log (v/v_o)= (j/2)\log (aN_e^2)-(j/2)\log (W)$, where $v/v_o= 350\ c\ \Delta\lambda/(2\ \lambda\ v_o\ v_\star \sin i)$. W and $\Delta\lambda$ are the equivalent width and peak separation of the emission line, λ is their wavelength and c is the velocity of ligth. N_e is the mean electron density in the envelope and a is a constant; $v_\star$ was assumed to be 350 km/s for all Be stars. Hα data for 50 Be stars were collected from the literature and separately analyzed for early and later spectral types. In both cases the linear relation mentioned was obtained. The rotation law (given by j) was found to depend on the temperature of the central star (see figure). The Hα envelopes of B0-B3e stars rotate with approximate conservation of the angular momentum law ($v(r)\propto 1/r$) suggesting radial motions in the envelopes. In contrast those of B4-B9e stars display a nearly Keplerian rotation ($v(r)\propto 1/\sqrt{r}$) suggesting more stable envelopes. The mean electron density of the envelopes for each subgroup of Be stars varies only by a factor 2, as derived from the maximun desviation of the points from the linear fits. The different rotation laws found may be a consequence of the higher pressure of radiation in earlier Be stars and can explain the higher mean time of dissipation of later Be stars envelopes (higher than 10-20 years as was showed by Hirata and Hubert-Delplace: 1981) and the shorter duration of the shell episodes observed in B1e stars (less than 1 year) in contrast to those of B6-B9e stars (about 5 years; Dachs: 1987). This contribution is based on a poster presented in the VI Reunión Latinoamericana de Astronomía de la IAU held in Gramado, Brazil, during October 16-20, 1989. A detailed publication is in preparation.



References:

Dachs J.: 1987, in 92nd Colloquium of the IAU "Physics of Be stars" p. 149, A. Slettebak and T. Snow (edts.), Cambridge University press.

Hanuschik R.W., Kozok J.R., Kaiser D.: 1988, Astronomy & Astrophysics 189, 147.

Hirata R. and Hubert-Delplace A.: 1981, in "Workshop on pulsating B stars" p. 217, G.E.V.O.N. and C. Sterken (edts.), Nice Observatory.

An attempt to unravel the mystery of travelling bumps which failed

Petr Harmanec, Gordon A.H. Walker, Jaymie M. Matthews

Department of Geophysics and Astronomy, University of British Columbia

129-2219 Main Mall, Vancouver, B.C., V6T 1W5 Canada

Since their discovery by Walker, Yang and Fahlman (1979) in the spectrum of the O9.5Ve star 13 ζ Oph, travelling sub-features have been found within the stellar absorption lines of a number of OB stars. (For reviews, see, e.g., Smith 1986 or Baade 1987). Walker et al. originally interpreted these features as arising from inhomogeneities on or above the stellar surface carried across the stellar disk by rotation. Later, Vogt and Penrod (1983) suggested that the bumps are caused by high-order nonradial pulsations (NRP), and this idea has gained wide acceptance by the astronomical community. The idea of corotating structures has since been revived by Harmanec (1989), who argues that the observations of travelling features in ζ Oph and 45 ϵ Per (a B0.5V star which apparently does not show emission) can be reconciled with single periods equal to the stars' rotational periods.

It is difficult to distinguish between "spots" and travelling waves for rapidly rotating stars since we lack secure knowledge of the basic physical properties like equatorial radii or inclinations of rotational axes. Furthermore, NRP models find that the phase velocities of the inferred travelling waves are much smaller than the stars' rotational velocities. It is therefore almost impossible to decide if travelling sub-features have non-zero phase velocity since the answer can be either YES or NO within the range of allowed physical parameters for a given star.

To attack this ambiguity, we decided to observe a totally eclipsing binary with an early-B rapidly rotating primary, both during and outside eclipse, in an effort to detect and analyse any travelling bumps in the spectral lines of the B star. The observations during the course of the eclipse would permit at least one-dimensional spatial sampling of the phenomena. Since both the inclination and radius of the primary can be obtained independently from the orbital and light-curve solutions, one could compare directly the

observed acceleration of the bumps with the purely rotational acceleration following from V sin i and radius of the B star. An implicit, but reasonable, assumption in this approach is that the inclinations of the rotational and orbital axes are identical. The data should also discriminate between a surface velocity field and corotating structures *above* the stellar photosphere.

We soon discovered that - though the idea appears simple - it is actually very hard to find a suitable binary. One requires a rapidly rotating early-B primary with a much cooler secondary to avoid serious contamination by the companion of the spectral lines of the B primary during the critical phases of the eclipse. The simultaneous requirement of a total eclipse thus calls for an **evolved** cool secondary. The obvious candidates are among Algol systems with well determined physical elements. Such a requirement is, of course, a *contraditio in adjecto* since the Algol systems are interacting binaries with various complications due to circumstellar matter. Fortunately, a thorough study of 12 such systems providing reasonably reliable elements has recently been published by Popper (1989). There is just one obvious candidate in the list: RY Per, a totally eclipsing B3e + F binary system with an orbital period of 6.86 days.

We therefore monitored the spectrum of RY Persei with a CCD detector on the Cassegrain spectrograph of the 1.83-m telescope of the Dominion Astrophysical Observatory. Although we planned to observe the binary during a primary eclipse, bad weather restricted us to one series of 10 spectrograms on Feb. 14, 1990 U.T. 03:34 to 07:21, one night after eclipse. The exposure times were 1000 seconds each. The linear dispersion of the spectrograms was 15 Å/mm (0.225 Å/pixel) and the wavelength range was 4305 to 4545 Å. The spectrograms were reduced using IRAF software and smoothed by a 5-point box-car filter. In the accompanying Figure, we show the mean rectified spectrum and two of the residual (i.e., individual - mean) spectra: one from the beginning and one from the end of the series. The principal lines of the B3e star seen in the mean spectrum are (from the left to right) Hγ , He I 4388, He I 4471 and Mg II 4481 Å. The emission line to the red of the Hγ line is mercury 4358 Å emission from city lights. It is obvious from the mean spectrum that the primary is indeed a rapidly rotating B star and that weak lines of the

secondary are also present. There is no clear evidence for any sub-features moving in a systematic way through the line profiles of the B star down to a level just under 1 per cent of the continuum. The full width at half minimum of the He I 4471 line in our spectra is 5.7 Å, which translates to V sin i = 200 km/s if we use the calibration by Slettebak et al. (1975) for B3-B5 stars. Adopting the values of $i = 81°$ and $R_{B3e} = 4.1\ R_\odot$ derived from the orbital and light-curve solution, we estimate the rotational period of the B3e primary of RY Per to be about 24 hours. This implies that our time coverage of 3.5 hours should have been sufficient to detect any sub-features present. However, we were only able to achieve a S/N ratio of about 100 in our spectra, given the high time resolution, faintness of the star ($8.^m5$) and the size of the telescope we used. It is possible that weak travelling sub-features ($\leq$0.5 per cent) escaped detection in our data.

Thus, our first attempt to unravel the puzzle of the moving features with the help of a very promising eclipsing binary failed, at least on the level of accuracy we were able to achieve. And because of the generally later spectral types of other Algol primaries, we believe the chances of finding travelling sub-features in the other systems are correspondingly lower.

Nature has once again guarded its secrets well ....

References

Baade D. 1987 in *Proc. IAU Col. 92 "Physics of Be Stars"*, Ed. by A. Slettebak and T.P. Snow, Cambridge Univ. Press, p. 361

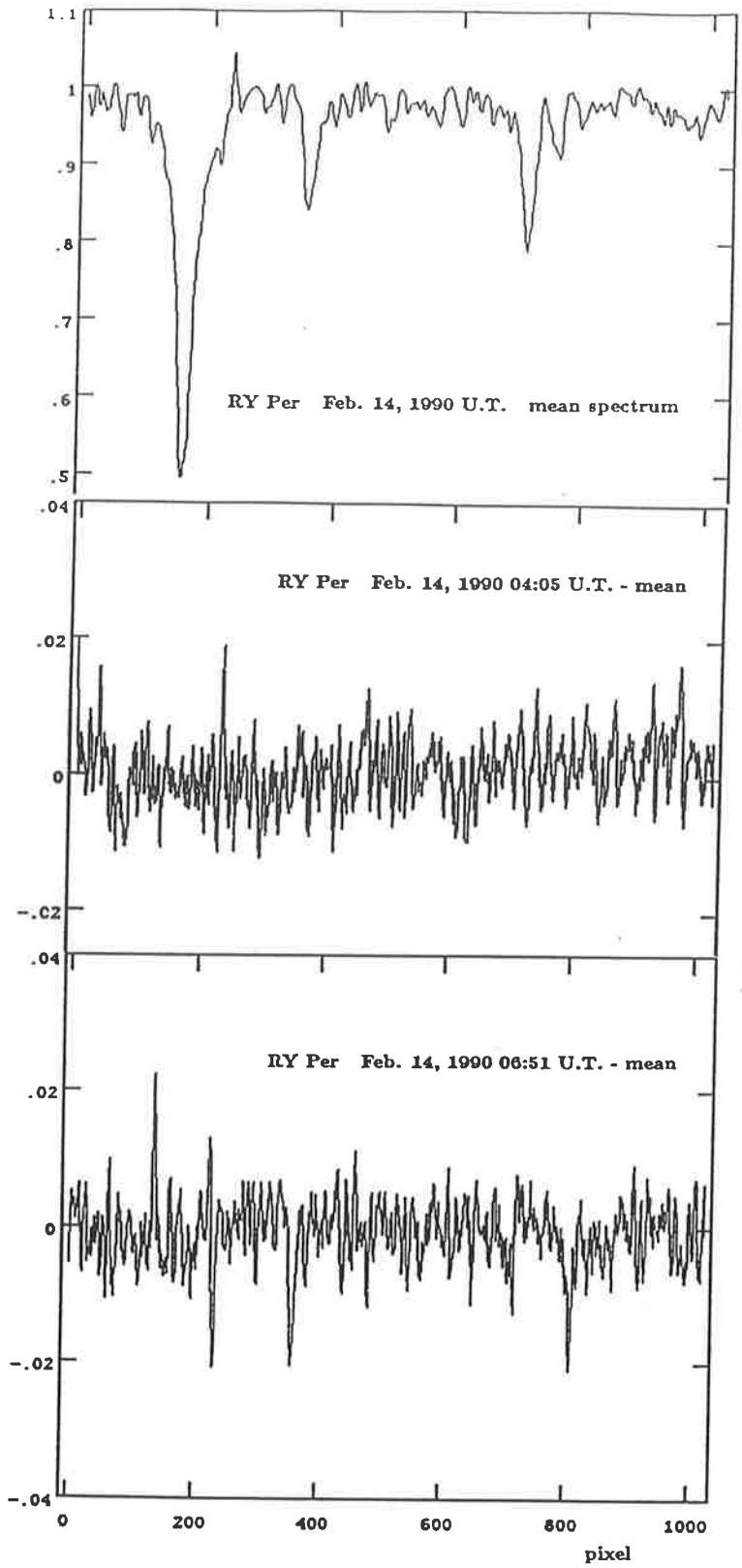
Harmanec P. 1989 Bull. Astron. Inst. Czechosl. **40**, 201

Popper D.M. 1989 Astrophys. J. Suppl. **71**, 595

Slettebak A., Collins G.W. II, Boyce P.B., White N.M., Parkinson T.D. 1975 Astrophys. J. Suppl. **29**, 137

Smith M.A. 1986 in *Hydrodynamic and Magnetohydrodynamic Problems in the Sun and Stars*, Ed. by Y. Osaki, Univ. of Tokyo, p. 145

Walker G.A.H., Yang S., Fahlman G.G. 1979 Astrophys. J. **233**, 199


RY Per Feb. 14, 1990 U.T. mean spectrum
RY Per Feb. 14, 1990 04:05 U.T. - mean
RY Per Feb. 14, 1990 06:51 U.T. - mean
pixel

ABSTRACT

THE ROTATING ENVELOPE OF THE HOT STAR GAMMA CASSIOPEIAE RESOLVED BY OPTICAL INTERFEROMETRY

D. Mourard*, I. Bosc*, A. Labeyrie*, L. Koechlin* and S. Saha+

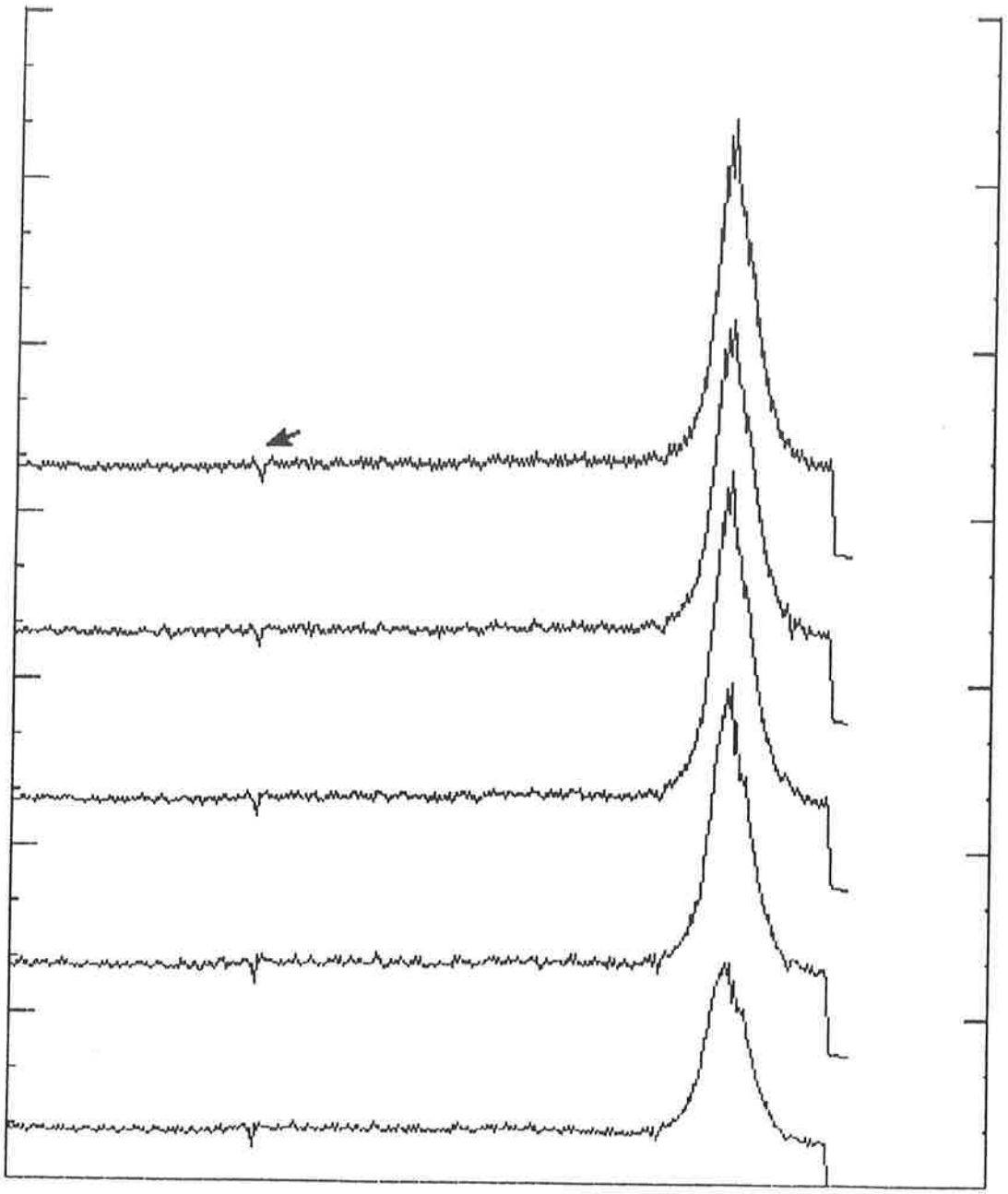
* Observatoire du Calern, Caussols, 06460 Saint Vallier, FRANCE
+ Indian Institute of Astrophysics, Bangalore 560034, INDIA

Certain hot stars, belonging to the Be class, may have an envelope of hydrogen gas, possibly in the form of a rotating disk or spheroidal shell. Other models involve elliptical rings or close binary systems where the Roche lobe of the companion is filled with hydrogen. The angular size of these features is too small for direct detection by conventional telescopes, and attempts to resolve the structure using speckle interferometry (a technique that restores the diffraction-limited resolution otherwise degraded or spoiled by the atmosphere) have failed. The various models of the structure of the hydrogen envelope are based on spectroscopic data, together with polarisation and variability measurements.

After a century of spectroscopic observations, which showed considerable but little-understood variations, the hydrogen envelope of the star gamma Cassiopeiae was angularly resolved by the prototype interferometer I2T in 1986. Here we report observations from its successor GI2T, which show further high-resolution details of the hydrogen envelope. The data clearly show the envelope in rotation and approximately fit a disk model. Thus, the GI2T yields optical information capable of constraining astrophysical models on a milliarcsecond scale.

Published in NATURE, Vol.342, n°6249, pp 520-522, (1989)

Gamma Cassiopeiae emission variations during one night: 29 DEC 88: 1->17:25 2->17:55 3->18:35 4->19:05 5->20:00 (TU). The small feature (narrow) at the left of the spectrum is an artefact due to the CCD detector used. No flat field was made on this data and such variation has never been observed since.



* * * * *

Hα OBSERVATIONS AT KITT PEAK NATIONAL OBSERVATORY

This report continues a series of updates on the variations in Hα and He I 6678 in selected Be stars of current interest to the community. Observations were made with the Coude Feed Telescope at KPNO during 1990 January 9 - 15, February 17 - 19, and March 31 - April 3 with the TI3 CCD detector and camera No. 5. The resolution for a line width of 2 pixels is 0.44 Å, and the S/N for the observations range from 100 - 200 averaged over twenty pixels. The observations described below will be compared with those reported in previous issues of the *Be Star Newsletter (BSN)*. As in previous reports, the V/R that is quoted is I_V/I_R (not the historical $(I_V - I_c)/I_R - I_c)$).

γ Cas - There has not been much change in this star within the past 2-3 years. In January the Hα emission remained at 4.3±0.1 I_c (cf. *BSN19,20*). The profile continues to be triangular with a weak core on the red wing. He I 6678 is nearly filled-in with double emission with V < R (V=1.01 I_c, R=1.02 I_c). Apparently there is a trend toward weaker He I emission.

28 Tau - On January 10 Hα showed a peak intensity of 5.1 I_c. A central reversal was apparent and V<R (R=4.8 I_c). No emission or structure was seen in He I 6678.

λ *Eri* - See discussion below.

HR 2855 (FY CMa) - In January and February Hα displayed its typical centrally reversed emission profile with V > R (V=1.90±0.05 I_c, R=1.75±0.05 I_c). Except for an exposure at 2:45 UT on February 17, when R≈V=1.85 I_c, there was very little activity in Hα. He I 6678 continued to show an impressive P Cygni profile but there were conspicuous profile variations on a time scale of one day (R varied from 1.05-1.12 I_c during the course of the observing runs (V emission continued to be seen below the continuum level). A single observation on April 2 revealed weaker emission overall (Hα : V=1.75 I_c, He I : R=1.01 I_c). Observations obtained on April 16 during a KPNO *request night* (just two weeks after the ones reported above) revealed a strengthening of the V lobe of Hα (V=2.0 I_c, R=1.6 I_c) and a striking change in the profile of He I 6678. A reverse P Cygni profile was seen, there was *no* visible emission on the red side of the line, and V=1.09 I_c!

μ *Cen* - See discussion below.

χ *Oph* - The Hα emission seen on April 2 was slightly weaker (8.0± b5T0.1 I_c) but the usual profile with weak cores flanking both sides of the profile prevailed. Structure was seen in the absorption profile of He I 6678 possibly due to ongoing nonradial pulsations.

66 Oph - The slow secular increase in the peak intensity of the Hα emission continues. By late March the emission had reached 10.0±0.1 I_c! During the January run the peak intensity of Hα displayed daily variations (8.7-9.5 I_c) and two observations on February 18 revealed a peak intensity of 9.8 I_c. The red side of the line continues to display conspicuous absorption as reported in *BSN19,20,&21*. Double emission continues to be seen in He I 6678 (peak value of 1.03 I_c) however during January (when the Hα emission was *slightly* weaker) R > V unlike its typical character. The peak intensity of Hα remained at 10.0 I_c on April 16 (KPNO *request night* observation).

59 Cyg - On January 12, the Hα emission feature showed a *flat top* with at least two very weak absorption cores visible. The peak intensity was 1.85±0.05 and the profile appeared very similar to the one seen on May 2, 1987 (*BSN16*, Fig. 2). The He I line continued to be filled with emission but the V component was slightly above the continuum.

π Aqr - Observations in January revealed that the V/R ratio has undergone a reversal since 1989 April-June (*BSN21*). V=3.0 I_c, while R=4.0 I_c. Conspicuous double emission is still seen in He I 6678 (V=1.05 I_c, R=1.15 I_c).

o And - Double albeit weaker Hα emission was observed on January 9 (V=1.03 I_c, R=1.00 I_c). The shell absorption has increased since my last report (*BSN21*). The core in Hα showed a r_v of 0.25. Structure but not emission continues to be seen in He I 6678.

Gerrie Peters

THE LATEST OUTBURSTS IN λ ERIDANI AND μ CENTAURI

Between mid-February and April 2 major outbursts occurred in λ Eri and μ Cen (these especially active Be stars performed in phase!). The nature of the profile changes in Hα and He I 6678 is shown in Figs. 1 and 2.

During the February observation λ Eri displayed at best very weak Hα emission (Fig. 1), which becomes apparent when the profile is compared with that of a non-emission B2 star. The He I 6678 line was only in absorption but variable structure indicative of ongoing nonradial pulsations was evident. Observations in January showed slightly stronger Hα emission. However by April 2 double emission is clearly seen in both lines. The strength of the emission suggested that an outburst of *moderate* strength was in progress. An observation obtained during the KPNO *request night* on April 16 revealed no change in the emission status.

Recently μ Cen has been showing incipient double Hα emission between outbursts. This was observed in January and February (Fig. 2). He I 6678 displayed its typical variable absorption structure (behavior attributed to nonradial pulsations and also some transients) but with no emission. Contrast the spectrum from mid-February with that observed on April 2 (Fig. 2). Conspicuous double emission developed in Hα (1.18 I_c) and He I 6678 (1.04 I_c). The peak intensity of the Hα emission was typical for recent outbursts in this star, but the He I emission was abnormally strong. An Hα exposure obtained during the KPNO *request night* on April 16 revealed no change during a two-week period.

Gerrie Peters

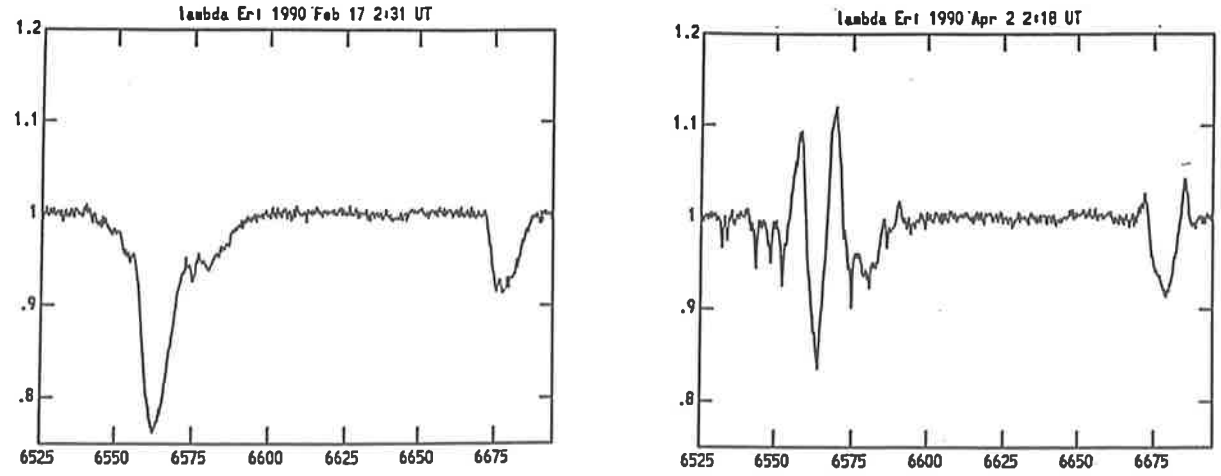


Fig. 1 - Observations of λ Eri in the spectral region containing Hα and He I 6678 with the TI3 CCD detector and Coude Feed Telescope at KPNO reveal that a mass loss event occurred sometime between 1990 mid-February (left panel) and April 2 (right panel). This recent outburst appears to be similar to previous ones including the episode of 1988 November (*BSN20*).

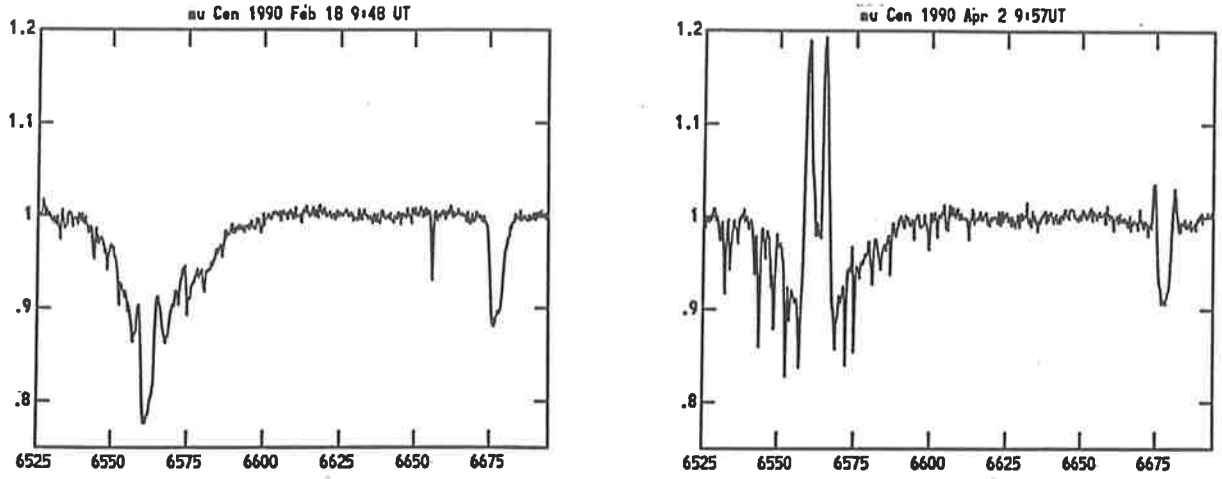


Fig. 2 - CCD observations from KPNO during 1990 mid-February (left panel) and April 2 (right panel) recorded the most recent outburst in μ Cen. Although the Hα strength is typical for recent mass loss episodes, the He I 6678 emission was slightly stronger. The last outburst (of comparable strength) occurred in 1989 June (*BSN21*). The sharp features in the vicinity of Hα are telluric water vapor.

* *

88 HERCULIS

A coude spectrogram of 88 Her (V744 Her, HD 162132) obtained by P. Hadrava with the Ondrejov 2-m telescope on JD 2447975.474 shows the presence of a strong metallic shell, quite comparable to that observed on cycle 300 of the 86.72 day period (c.f. Doazan *et al.* 1982 Astr.Ap. 115, 138). A secular light decrease preceded the development of the previous metallic shell and this sequence of events seems to repeat once more. Doazan reported a light decrease of the star in an IAU telegram in December 1988 which will be further documented by the Hvar UBV photometry to be soon published by Yugoslav and Czechoslovak observers.

P. Hadrava, P. Koubsky and J. Horn, Ondrejov Observatory

* *

* * * * *

CALL FOR OBSERVATIONS IN SUPPORT OF WUPPE/ASTRO-1

The Astro-1 mission consists of 3 ultraviolet instruments, including the Wisconsin Ultraviolet Photo-Polarimeter Experiment (WUPPE), the Hopkins Ultraviolet Telescope (HUT), and the Ultraviolet Imaging Telescope (UIT), as well as the Broad-Band X-Ray Telescope (BBXRT). It is scheduled to fly aboard the space shuttle (STS-35) for a 9-10 day mission, and is currently scheduled for launch May 31/June 1 1990.

Among the objects planned for observation by WUPPE (with co-observation by HUT) are 6 Be stars: π Aqr, FY CMa, HD 208682, P Car, ϵ Cap, and 48 Lib. Our observations will obtain spectropolarimetry (spectral resolution is about 6 Å) in the range 1300 - 3200 Å. HUT will obtain spectra in the range 425 - 1850 Å with about 3 Å spectral resolution.

In order to have better information about the state of the Be stars at the time of the WUPPE observations, other ground-based (or space-based) observations any wavelength range near the time of the mission would be quite helpful. High- to medium-resolution spectra (particularly of Hα and Hβ), photometry, and polarimetry would be especially useful. We are soliciting observations from anyone interested in supporting this effort. Those interested in participating should contact Karen Bjorkman at the University of Wisconsin for more information.

Karen Bjorkman
Space Astronomy Laboratory
University of Wisconsin
1150 University Ave.
Madison, WI 53706

phone: (608) 263-4681
or (608) 263-4680
SPAN: madraf::kbjorkman
Internet: karen@sal.wisc.edu
Fax: (608) 263-0361

* *

REQUEST FOR GROUND-BASED OBSERVATIONS OF 4U0115+63

I would like to issue another appeal to the Be community for ground based observations of 4U0115+63. As I reported earlier, this system went into X-ray outburst 5 February 1990. Maximum light was reached near 9-14 February when the source reached 400 mCrab (IAU Circ #4967). At this time the X-ray flux is still 130 mCrab. We have been able to get radio and optical (photometry and spectra) observations during the rising and maximum phases of the outburst, but we still need optical observations during the decline. The two previous optically monitored X-ray outbursts were poorly sampled during the declining phase of the outburst; therefore, detailed comparisons between the optical and X-ray decays are not possible. UBV photometry and Hα spectra for at least the next month or two are especially sought.

Diane Roussel-Dupre
Los Alamos National Laboratory

* *

ANNOUNCEMENT OF A MULTIWAVELENGTH CAMPAIGN ON η CENTAURI

During the spring of 1991 we will undertake a multiwavelength campaign on the southern Be star η Cen, which has been undergoing some spectacular photometric and spectroscopic variations recently. Cuypers, Balona, and Marang (*Astr.Ap.Suppl.* **81**, 151, 1989) found that the optical photometric variations were best fit with a *triple-wave* light curve with a period of 1.927 days and a full range in brightness of 0.1 mag! Data in the *IUE* archives reveal large fluctuations in the strength of the C IV wind line (EWs 2-3 Å), and large profile variations have been observed in the optical spectrum (Baade, *Astr.Ap.* **124**, 283, 1983; Dachs *et al.*, *Astr.Ap.Suppl.* **63**, 87, 1986).

To investigate the cause for the striking variability in η Cen and compare short-term modulations in mass loss with those observed in previous campaign stars (which display single or double-wave light curves with smaller amplitudes) we plan to carry through 64 hours of continuous coverage of the activity with *IUE* (eight contiguous shifts) . Tentatively the *IUE* observations are scheduled to begin with US2 (17:00 UT) on March 30, 1991. Secondary targets for the program include μ Cen, χ Oph, and 48 Lib.

Current participants in the project include D. R. Gies, H. F. Henrichs, D. McDavid, J. R. Percy, G. J. Peters, and M. A. Smith, and we invite interested observers to join our effort. We plan simultaneous *IUE* and ground-based spectroscopic, photometric, and polarimetric observations. If you are interested in participating in this campaign, please contact either John Percy, Department of Astronomy, University of Toronto, Toronto, Ontario M5S 1A1; Canada (photometric observations) or Gerrie Peters, Space Sciences Center, University of Southern California, Los Angeles, CA 90089-1341; USA (spectroscopic observations).

* *

PREPRINTS RECEIVED

*****

A Survey of Be Stars in the Infrared. II. Determination of Envelope Dimensions
ANDRILLAT A.[1] - JASCHEK M.[2] - JASCHEK C.[2]; 1. Laboratoire d'Astronomie USTL, F-34060 Montpellier Cedex, CNRS UA 672, France, Observatoire du Pic du Midi, URA 654, Observatoire de Strasbourg, France; 2. Observatoire de Strasbourg, CDS, ULP, F-67000 Strasbourg, CNRS URA 654, France.
To be Published in: *Astronomy and Astrophysics*
Preprints: A. Andrillat at the first address.

Abstract: We have described plate material concerning 34 Be stars in the λλ8309, 8791, observed at the O.H.P. Observatory at 33 Å mm^{-1} dispersion. We have summarized the descriptions of these stars, complemented by those of paper I. As a result we can base our conclusions upon almost 70 objects, which constitutes the largest sample so far observed in this spectral region. Emissions are frequent in all Be stars, but are more concentrated in early type (<B5) stars. The same phenomenon is found for the Ca II emissions; here we notice a positive correlation of Ca II emission and large infrared excesses measured with the IRAS satellite. Also the O I and N I emissions are more frequent in early type stars. We have also analyzed the emission line structure based upon the equivalent widths, half widths, and emission peak separations of a large number of lines. We have determined the outer radii of the emission region and find them to lie between 2 and 4 stellar radii. As for the internal radius, it lies close to the stellar surface for all lines.

The Infrared Spectrum of HD 141569
ANDRILLAT Y.[1] - JASCHEK M.[2] - JASCHEK C.[2]; 1. Laboratoire d'Astronomie, Université Montpellier II, Place Eugène Bataillon,F-34095 Montpellier Cedex 2, France; 2. C.D.S., Observatoire de Strasbourg, 11 rue de l'Université, F-67000 Strasbourg, France.
To be Published in: *Astronomy and Astrophysics*
Preprints: C. Jaschek at the second address.

Abstract: Spectroscopic data in the blue, red, and infrared regions of HD 141569 are presented. The star has a spectral type A0 and presents the exceptional behavior of having the Paschen series in absorption and O I λ7772 in strong emission. A discussion of other relevant data and the fact that no photometric variability was detected makes it difficult to assign the star to any one of the groups of emission line stars. Probably it corresponds to the quiescent phase of a "Herbig Ae-Be" object.

A Simple Criterion to Identify Rapidly Rotating Stars Viewed at Small to Intermediate Inclination Angles

BAADE D.; European Southern Observatory, Karl-Schwarzschild-Str. 2, D-8046 Garching, W. Germany

To be Published in: *Angular Momentum and Mass Loss for Hot Stars* (Proceedings of a NATO Advanced Research Workshop, second in a series on "Dynamical Phenomena in Stars and Circumstellar Environments", held in Ames, Iowa, USA, 1989 October 23-27), ed. L. A. Willson and R. Stalio

Preprints: D. Baade at the above address.

Abstract: Weak, roughly central quasi-emission bumps have been discovered in various absorption lines of a few B-type stars. Various explanations are discussed. Since the features have nearly zero velocity, they are probably evidence of differences between the line spectra of polar and equatorial regions. Rotationally induced temperature and gravity gradients or polar spots are the simplest explanation at the moment; a reliable discrimination requires observations of a larger number of ions. Regardless of the true physical cause, geometric projection effects and limb darkening let smooth equator-to-pole variations have a noticeable effect on observed line profiles only if the pole is not too far from the center of the visible stellar disk. Therefore, the phenomenon provides an easy-to-use criterion for the identification of (rapidly rotating) stars seen at small to intermediate inclination angles.

Short-Period Variability in Be Stars

BALONA L.A.; South African Astronomical Observatory, P.O. Box 9, Observatory 7935, Cape, South Africa.

To be Published in: *Monthly Notices Royal Astronomical Society*

Preprints: L. A. Balona at the above address.

Abstract: A highly significant correlation is found between the projected rotational velocities and the photometric periods of Be stars. We show that this correlation may be readily understood if the photometric period is equated with the rotational period. If the nonradial pulsation hypothesis (NRP) is correct, we show that g-modes with radial order exceeding 50 must be involved and that half the Be stars are pulsating with azimuthal spherical harmonic order m=-1, the other half with m=-2. According to current NRP theory, these results indicate that the Be stars rotate like solid bodies. On the basis of some recent observations which show that considerable magnetic activity is present and a particular episode in the Be star κ CMa, we suspect that NRP is unlikely to be the cause of low-order periodic variations in Be stars. We suggest a model of rotational modulation caused by active areas. These are speculated to be the footprints of open magnetic field lines along which enhanced mass loss is occurring.

On the Correlation Between Pulsation Amplitude and Shell Activity in the Be Star λ Eridani

BOLTON C.T.[1] - STEFL S.[2]; 1. David Dunlap Observatory, P.O. Box 360, Richmond Hill, Ontario L4C 4Y6, Canada; 2. Astronomical Institute, Czechoslovak Academy of Sciences, CS-251 65 Ondrejov, Czechoslovakia.

To be Published in: *Angular Momentum and Mass Loss for Hot Stars* (Proceedings of a NATO Advanced Research Workshop, second in a series on "Dynamical Phenomena in Stars and Circumstellar Environments" held in Ames, Iowa, USA, 1989 October 23-27), ed. L. A. Willson and R. Stalio

Preprints: T. Bolton at the first address.

Abstract: During the period 1974-1988 the radial velocity of the Be star λ Eridani varied with a period of 0.701715±0.000005 days. The amplitude and mean velocity of the velocity curve change on a time scale of years, but there is no evidence that these changes are correlated with the level of emission activity.

Infrared Observations of Upsilon Sagitarii

JASCHEK M.[1] - ANDRILLAT Y.[2] - JASCHEK C.[1]; 1. C.D.S. Observatoire de Strasbourg, 11 rue de l'Université, F-67000 Strasbourg, France; 2. Laboratoire d'Astronomie, Université Montpellier II, Place Eugène Bataillon, F-34095 Montpellier Cedex 2, France.

To be Published in: *Astronomy and Astrophysics*

Preprints: M. Jaschek at the first address.

Abstract: Infrared observations of upsilon Sagitarii are presented together with a spectral classification of the object in different wavelength regions. It is shown that the spectral features in all ranges can be explained by a combination of an A-type supergiant and of a B-type object. A discussion of the behavior of elements in the infrared region shown that strong oxygen lines are present. This eliminates one of the difficulties found when trying to explain the evolutionary status of the object.

Long-Term Study of Stellar Wind Variability of O Stars

KAPER L.[1] - HENRICHS H.F.[1,2] - ZWARTHOED G.A.A.[1] - NICHOLS-BOHLIN J.[3]; 1. Astronomical Institute "Anton Pannekoek", University of Amsterdam, Roetersstraat 15, 1018 WB Amsterdam, The Netherlands; 2. Universitäts Sternwarte, München, W. Germany; 3. Astronomy Program, Computer Sciences Corporation, Greenbelt, MD 20771, USA.

To be Published in: *Angular Momentum and Mass Loss for Hot Stars* (Proceedings of a NATO Advanced Research Workshop, second in a series on "Dynamical Phenomena in Stars and Circumstellar Environments" held in Ames, Iowa, USA, 1989 October 23-27), ed. L. A. Willson and R. Stalio

Preprints: L. Kaper at the first address.

Abstract: As part of our study of rapid variability in UV P Cygni profiles of early-type stars, we present results from three successful observing campaigns with the *International Ultraviolet Explorer* in 1986, 1987, and 1988. About 215 high resolution spectra of four O stars are presented in the form of an atlas of gray-scale pictures, facilitating a rapid overview of subtle and systematic changes in the spectra as a function of time. The morphological behavior of this variability is

described for each star. The main conclusions are: 1) the behavior of the "discrete absorption components" is different for each star, and 2) for a given star the behavior is rather similar over a timescale of years. This is consistent with a rather constant mechanism that controls the rapid structural changes in the wind. The ultimate goal of this study is to understand the origin of the widely-observed variable nature of stellar winds in early-type stars.

Multicolor Polarimetry of Selected Be Stars: 1986-1989
McDAVID D.; Division of Earth and Physical Sciences, University of Texas at San Antonio, San Antonio, TX 78285, USA.
To be Published in: *Publications of the Astronomical Society of the Pacific* (July 1990 issue)
Preprints: D. McDavid at the above address.

Abstract: Annual monitoring of the wide-band visible continuum linear polarization of a sample of the brightest northern Be stars over a period of three years demonstrates that large and readily identifiable variations in polarization are most commonly detected on a year-to-year time scale. No clear cases of night-to-night variability were found at the level of precision on which the polarizations of the standard stars could be assumed constant. Because of the complexity of the Be phenomenon, any model-dependent interpretation of polarimetry data by itself may be misleading. It is therefore hoped that theoreticians will be able to use the data presented here in combination with observations obtained by other techniques and in other spectral regions to develop a more general understanding of the process at work in Be stars.

He II λ1640 as a Diagnostic for Assessing the Extent of Rapid Rotation in Be Stars
PETERS G.J.; Space Sciences Center, University of Southern California, Los Angeles, CA 90089-1341, USA.
To be Published in: *Angular Momentum and Mass Loss for Hot Stars* (Proceedings of a NATO Advanced Research Workshop, second in a series on "Dynamical Phenomena in Stars and Circumstellar Environments" held in Ames, Iowa, USA, 1989 October 23-27), ed. L. A. Willson and R. Stalio
Preprints: G. J. Peters at the above address.

Abstract: To look for evidence of a substantial enhancement in the polar temperature of Be stars, which one might expect if these stars were rotating near their critical velocities, the strength of the He II λ1640 absorption line has been investigated in a restricted group of objects (B1.5-B2.5 IV-V). The fact that no correlation was found between the equivalent width of He II λ1640 and $v \sin i$ argues against the presence of significant polar brightening. He II λ1640 is variable in an individual star, but does not correlate well with the strength of the wind. It may be a signature of enhanced photospheric activity.

ERRATUM: In Issue No. 21, p. 18 the authors for the paper "*The Ultraviolet Spectrum of Eta Carinae*" should read: VIOTTI R.[1] - ROSSI L.[2] - CASSATELLA A.[2] - ALTAMORE A.[3] - BARATTA G.B.[4];
1. Istituto Astrofisica Spaziale (CNR), Frascati, Italy; 2. IUE Observatory, European Space Agency, Madrid, Spain and Istituto Astrofisica Spaziale (CNR), Frascati, Italy; 3. Istituto Astronomico, Universita' La Sapienza, Roma, Italy; 4. Osservatorio Astronomico, Roma, Italy

BIBLIOGRAPHY

* * * * *

(Compiled by A. M. Hubert, J. Jugaku, P. Koubský, G. J. Peters, M. Ruusalepp, and A. Slettebak)

Radiatively Driven Winds with Azimuthal Symmetry: Application to Be Stars
de ARAUJO F.X. - de FREITAS PACHECO J.A.: MNRAS 241, 543 (1989)

A Search for Line Profile Variability in Dwarfs and Giants of Spectral Types B8 - B9.5. II. Results and Discussion
BAADE D.: AA 222, 200 (1989)

Outbursts of the Be Star ω Orionis during 1987-1989
BERGIN E.A. - BURNS J.F. - GUINAN E.F. - McCOOK G.P.: IBVS, No. 3358 (1989)

Is the MK Standard η UMa an Incipient Be Star?
BOPP B.W. - CAPLINGER J.R. - CROSBY N.A. - MAHONEY D.F. - O'BRIEN S.P.- DEMPSEY R.C.: IBVS, No. 3347 (1989)

Optical Observations of the Unusual Interacting Binary V644 Monocerotis (HD 51480)
BOPP B.W. - DEMPSEY R.C.: PASP 101, 978 (1989)

Hα Spectroscopy of the Be Star ω Orionis during 1986-1987
BOPP B.W. - DEMPSEY R.C.: IBVS, No. 3387 (1989)

Photometric Multiperiodicity of the Be Star 120 Tauri
BOSSI M. - GUERRERO G. - BIANCHINI G.: IBVS, No. 3348 (1989)

Stellar Occultation of Polarized Light from Circumstellar Electrons: I. Flat Envelopes Viewed Edge On
BROWN J.C. - FOX G.K.: APJ 347, 468 (1989)

Analysis of the Velocity Law in the Wind of the Be Star Lambda Pavonis
CHEN H. - RINGUELET A. - SAHADE J. - KONDO Y.: APJ 347, 1082 (1989)

Temporal Polarization Variation of Be Stars. V. Comments on the Similar Behavior of Gamma Cassiopeiae and Kappa Draconis
CLARKE D.: AA 227, 151 (1990)

Intensive Photometry of Southern Be Variables. I. Winter Objects
CUYPERS J. - BALONA L.A. - MARANG F.: AASS 81, 151 (1989)

Search for Rapid V/R Variability in Eta Cen
GHOSH K.K.: MNRAS 240, 637 (1989)

Search for Rapid Spectral Variability in Be Stars: Alpha Columbae, P Carinae and Eta Centauri
GHOSH K.K. - PUKALENTHI S. - JAYKUMAR K. - KUPPUSWAMY K. - SANJEEVKUMAK T. - MUNIANDI A.: AASS 82, 557 (1990)

Spectroscopic Observations of the Be Star ζ Tauri
GUERRERO G. - BOSSI M. - SCARDIA M.: ASS 161, 27 (1989)

Be Variable 59 Cyg: Rapid Light Variations Detected
HADRAVA P. - HARMANEC P. - HORN J. - KOUBSKY P. - KRIZ S. - PERCY J.R. - BOZIC H.: IBVS, No. 3386 (1989)

Photometry of HD 51480 = V644 Monocerotis: A Be Binary System
HALBEDEL E.M.: PASP **101**, 995 (1989)

Recent Photometric Behavior of the Unusual Be Star HD 45677 = FS Canis Majoris
HALBEDEL E.M.: PASP **101**, 999 (1989)

Stellar V sin i and Optical Emission Line Widths in Be Stars
HANUSCHIK R.W.: ASS **161**. 61 (1989)

Spectrophotometric Observations of HR 8107
JOSHI S.C. - OJHA D.K. - SRIVASTAVA J.B.: JAA **10**, 113 (1989)

Spectral Energy Distribution of Be Stars. II. Determination of Be Star Parameters by Comparison between Measured and Model Spectra
KAISER D.: AA 222, 187 (1989)

Are There Many Be Star Binary X-Ray Pulsars in the Galactic Ridge?
KOYAMA M.J.L. - KONDO H. - MAKINO F. - NAGASE F. - TAKANO S. - TAWARA Y. - TURNER M.J.L. - WARWICK R.S.: PASJ **41**, 483 (1989)

Emission Line Stars in the Magellanic Clouds: Infrared Spectroscopy of B[e] and Ofpe/WN 9 Stars
McGREGOR P.J. - HYLAND A.R. - MCGINN M.T.: AA 223, 237 (1989)

Observaciones Espectroscopicas de Siete Estrellas Be
MENNICKENT R.E.: RMAA **19**, 107 (1989)

The Rotating Envelope of the Hot Star Gamma Cassiopeiae Resolved by Optical Interferometry
MOURARD D. - BOSC I. - LABEYRIE A. - KOECHLIN L. - SAHA S.: NAT **342**, 520 (1989)

Detection of Rapid V/R Variations in the Be Star EW Lacertae
PAVLOVSKI K. - SCHNEIDER H.: AA 228, 361 (1990)

Theoretical Balmer Line Profiles in the Spectra of Stars with Moving Envelopes Taking into Account the Spectral Dependence Hydrogen Absorption Coefficient
POGODIN M.A.: AF **31**, No. 1, 150 (1989)

Ultraviolet Observations of Stellar Winds in Be and Normal B non-Supergiant Stars
PRINJA R.K.: MNRAS 241, 721 (1989)

X-Ray Timing and Spectral Measurements of X Persei
ROBBA N.R. - WARWICK R.S.: APJ **346**, 469 (1989)

Faint H-alpha Emission Objects Near the Equatorial Selected Areas
ROBERTSON T.H. - JORDAN T.M.: AJ **98**, 1354 (1989)

Be-Herbig Star HD 200775 and the Related Compact Region of Star Formation (RSF) 1 Cep
RUUSALEPP M.: AZ **66**, No. 5, 941 (1989)

Modelling the Dust Grains around the Peculiar Be Star HD 45677
SORRELL W.H.: MNRAS 241, 89 (1989)

The Determination of Absolute Luminosities of Circumstellar Envelopes Around Be Stars
STIFF T. - JEFFERS S.: BAAS 21, 1197 (1989)

Microvariability of RX Cas
TODOROVA P.N. - KHRUZINA R.S.: IBVS, No. 3367 (1989)

Numerical Experiments on the Broadening of Emission Lines Formed in a Disk
UNDERHILL A.B. - NEMEC A.F.L.: APJ 345, 1008 (1989)

Photoelectric Photometry Results of the Algol-Type Eclipsing Binary System RS Vul
WASATONIC R.: IBVS, No. 3350 (1989)

X-Ray Light Curves of Be/X Ray Binaries
WATERS L.B.F.M. - de MARTINO D. - HABETS G.M.H.J. - TAYLOR A.R.: AA 223, 207 (1989)

Gamma Cassiopeiae and Be Stars
WHITEHORNE M.L.: JRASC 83, 277 (1989)

The Peculiar B[e] Star MWC 623: a Binary System with a Li-Rich K Star
ZICKGRAF F.J. - STAHL O.: AA 223, 165 (1989)

Abbreviations used for the Publications

AA	Astronomy and Astrophysics
AASS	Astronomy and Astrophysics Supplement Series
AAS	Acta Astrophysica Sinica
AF	Astrofizika
AJ	Astronomical Journal
APJ	Astrophysical Journal
APJS	Astrophysical Journal Supplement
ASS	Astrophysics and Space Science
AZ	Astronomicheskii Zhurnal
BAAS	Bulletin of the American Astronomical Society
BAC	Bulletin of the Astronomical Institutes of Czechoslovakia
BASI	Bulletin of the Astronomical Society of India
CRASP	Comptes-Rendus de l'Academie des Sciences de Paris

IAJ	The Irish Astronomical Journal
IAUC	IAU Circular
IBVS	Information Bulletin on Variable Stars
IGAOP	Izvestia Glavnoi Astronomiceskoj Observatorii Pulkovo
IKAO	Izvestia Krimskoj Astrofiziceskoj Observatorii
JAA	Journal of Astrophysics and Astronomy
JRASC	Journal of the Royal Astronomical Society of Canada
MNRAS	Monthly Notices of the Royal Astronomical Society
MSAI	Memorie della Societa Astronomica Italiana
NAT	Nature
OBS	The Observatory
PAAO	Publications of the Alma-Ata Observatory
PAJ	Pisma Astronomical Journal
PASJ	Publications of the Astronomical Society of Japan
PASP	Publications of the Astronomical Society of the Pacific
QJRAS	Quarterly Journal of the Royal Astronomical Society
SS	Southern Stars
RMAA	Revista Mexicana de Astronomia y Astrofisica