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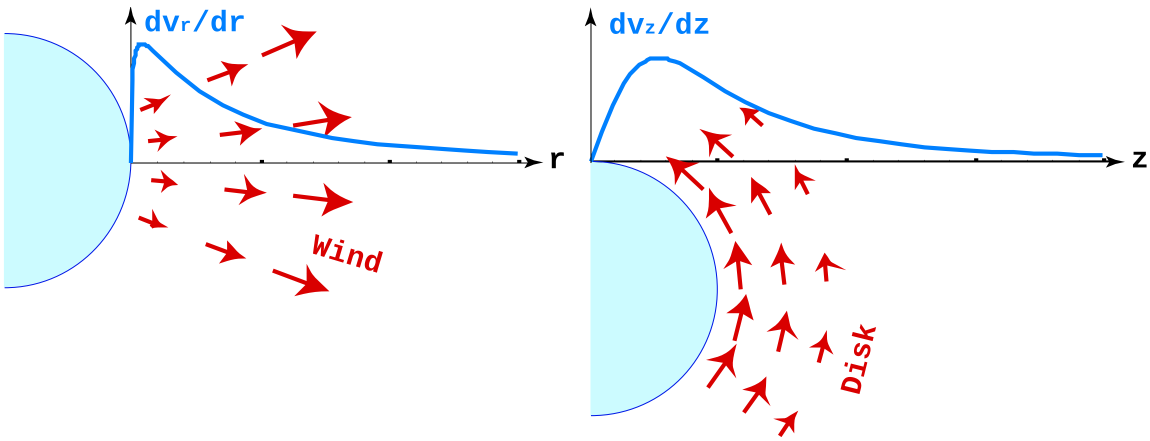

Be STAR NEWSLETTER

NUMBER 35 - February 2002

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1. EDITORIAL

For the past three years we have adopted the policy of publishing hard copy issues of the *Be Star Newsletter* irregularly, after we have accumulated a sufficient number of contributions. Our electronic version of the *Newsletter* enables us to distribute new contributions, abstracts, and meeting announcements quite rapidly. Subject to internal review by the editors, we are usually able to post new items within 48 hours of receipt. This issue contains material posted on our website since 2000 June.

With the transition into the new millennium the attention of the Be star community seemed to focus on one object. δ Sco was all the rage of 2000. The sudden brightening by $0.4^{\rm m}$ accompanied by the development of Hα emission initially reminded the community of the historic activity of γ Cas in the 1930s. When the phenomenon seemed to be tied to periastron passage in a long-period binary, the enthusiasm waned somewhat. This indeed serves as a reminder that some aspects of the Be phenomenon may be caused from binary interaction, but in this case it could be amplification of the star's NRP at periastron! Watch for more on δ Sco. In this issue we present the first formal report on the recent activity in this interesting object. In this issue we also feature a new discussion about the potential importance of radiative line forces in controlling the disks of Be stars and their variability. The community can also find reports on the most recent activity in μ Cen and results from the long-term monitoring of the Hα emission in bright Be stars of interest to our readership.

Look for some new features and changes in the *Newsletter* in 2002. We will continue to place contributions and abstracts on our website as they are received, but we plan to return to a publication frequency of 2–3 issues per year. The bibliography will be discontinued after this present issue, as most researchers can now access this information through the NASA Astrophysics Data System (ADS) website. Of course, if there is a popular demand for the bibliography, we would consider again including this feature. In 2002 we will begin a series of invited review articles in the *Newsletter*. We are open to suggestions on topics and contributors.

Please send contributions by Electronic Mail to: **benews@mucen.usc.edu** with a copy to **mcdavid@limber.org** either as LaTex or postscript/pdf files. We are now **requiring** that abstracts be submitted as LaTex files using the template provided on our website. We prefer that illustrations be sent by E-mail as postscript files.

The editors wish to thank all who contributed to this issue. More than ever your contributions are essential to the continued success of the *Newsletter*. We are especially interested in articles on currently active stars such as δ Sco, μ Cen, and ω CMa and new theory to interpret the behavior in Be stars.

We appreciate the continuing support from the Department of Physics & Astronomy at Georgia State University for the production of the paper edition of the *Newsletter*.

Gerrie Peters, Editor-in-Chief

2. WORKING GROUP MATTERS

2.1. Organizing Committee Election

With the forthcoming XXIVth IAU General Assembly in Manchester, also the mandate of the current Organizing Committee (OC) of the Working Group (WG) Active B Stars comes to an end.

The OC has decided to partly move away from the OC election procedure followed more recently (when the new OC members were elected by the previous OC) and more closely into the direction of the procedure applied before:

- The OC consists of 8 elected, voting members. In addition, one voting member each can be nominated by the sponsoring IAU Commissions Nos. 29 and 45. The respective outgoing Chairperson (if any) and the editor of the Be Star Newsletter are non-voting members.
- OC members are elected for 2 consecutive 3-year terms. Immediate re-election is not possible.
- Elections are held around the time of each IAU General Assembly. At each election, 4 of the eight previously elected OC members leave the OC because their mandate has expired; they are replaced by 4 newly elected members.
- OC members are elected by the members of the WG who may vote for up to 4 different persons.
- Since there is no formal register of members of the WG, the announcement of the election is sent to all subscribers of the Be Star Newsletter.
- The 4 persons with the largest numbers of valid votes are elected. The 4 new and the 4 continuing OC members determine among themselves the new Chairperson.

Because this year 5 members rotate off the OC, exceptionally 5 new members need to elected. The 4 with the highest number of votes will be elected to two 3-year terms while the fifth will be elected for one 3-year term (and eligible for election next time). This procedure will restore us to the 4 on / 4 off pattern in the next election 3 years from now.

Prof. Douglas Gies (outgoing member of the present OC) has kindly accepted to act as Election Officer and to receive and count the votes. Therefore, if you wish to participate in the election, please send an e-mail to gies@chara.gsu.edu. The following rules apply:

- The message must in the subject line include the string: "OC elections IAU WG Active B Stars (2000)" or similar.
- The maximum number of names is 5 (five).

- Each name will be counted only once.
- Each person can vote only once (i.e., if you have sent one vote with fewer than 5 names, you cannot send a second one with additional votes; changes of previously cast votes are not possible).
- The message must bear the senders name. The Election Officer will eliminate votes received from people evidently not related to the scope of the WG Active B Stars.
- Messages containing any further remarks are considered invalid votes.
- Votes arriving after August 8 (UT) are not counted.

Any judgments made by the Election Officer in application of the above rules are final.

The current members of the OC are:

- D. Baade (chair) (NOT re-electable)
- J. Bjorkman (elected for one more 3-year period)
- J. Cassinelli (NOT re-electable)
- D. Gies (NOT re-electable)
- H. Henrichs (NOT re-electable)
- M. Marlborough (NOT re-electable)
- V. Niemela (nominated by Comm. 45)
- A. Okazaki (elected for one more 3-year period)
- G. Peters (non-voting, editor of Be Star Newsletter)
- M. Smith (non-voting, previous chairman)
- S. Štefl (elected for one more 3-year period)

Finally, a personal remark: It is one of the fundamental principles of the IAU to strive for the broadest possible regional coverage in all matters. Independent of whether there is such a formal rule, it is simply good practice to aim for a proper regional balance. It would be nice if the composition of the new OC would be an illustration of a successful collective application of this philosophy.

Dietrich Baade
WG Chairman

2.2. Organizing Committee Election Results

Attached is the list of new and continuing members of the Organizing Committee (OC) of the Working Group on Active B Stars. The first task for the new OC is to elect a Chair from among the names listed below. The new Chair would consult with Dietrich Baade (the outgoing Chair) on the current status of the Working Group activities, and would work with the OC to plan future activities (primarily related to future meetings).

Dr. Gerrie Peters will be Chairing a meeting of the WG at the IAU General Asssembly on Monday afternoon, August 14, and it would be ideal if she could announce the names of the members and Chair of the OC at that time.

Douglas Gies
Acting Election Officer for the WG

Organizing Committee

- C. Aerts (through 2006)
  conny@ster.kuleuven.ac.be
- D. Baade (non-voting, previous chairman)
  dbaade@eso.org
- J. Bjorkman (through 2003)
  jon@physics.utoledo.edu
- D. McDavid (through 2003, eligible for re-election then)
  mcdavid@limber.org
- V. Niemela (nominated by Comm. 45)
  virpi@fcaglp.unlp.edu.ar
- A. Okazaki (through 2003)
  okazaki@elsa.hokkai-s-u.ac.jp
- S. Owocki (through 2006)
  owocki@bartol.udel.edu
- G. Peters (non-voting, editor of Be Star Newsletter)
  gjpeters@mucen.usc.edu
- J. Porter (through 2006)
  jmp@astro.livjm.ac.uk
- T. Rivinius (through 2006)
  triviniu@eso.org
- S. Štefl (through 2003)
  sstefl@sunstel.asu.cas.cz

2.3. Manchester Meeting of the Working Group

I. Introductory Comments

The Working Group on Active B Stars held a lightly-attended meeting during the IAU General Assembly on Monday afternoon, August 14, 2000 beginning at 14:00 in the Blackett Theater of the Schuster Laboratory. The meeting was chaired by G. J. Peters and called to order at about 14:10. The outgoing chairperson of the Working Group, D. Baade was unable to attend the IAU General Assembly. We held a minute of silence in honor of Arne Slettebak, Carlos Jaschek, and Don Penrod, members of the Be star community who passed away since the last IAU General Assembly in Kyoto, Japan. Having just learned that a proposal to continue our status as a working Group of the IAU was due by 17:00 on the day of this meeting, G. Peters agreed to prepare a one-page summary of our accomplishments during the past three years and submit it to the IAU along with the required names of the SOC by the deadline.

Myron Smith announced that the proceedings of the Alicante meeting, IAU Colloquium No. 175, will soon be published by the Astronomical Society of the Pacific Conference Series (No. 214) and will run nearly 800 pages.

II. The SOC Elections

An election to replace the current members of the Scientific Organizing Committee whose terms expire at the end of the IAU GA was conducted by e-mail in 2000 July. The results are:

Term expiring in 2003:

J. Bjorkman*
D. McDavid*
A. Okazaki
S. Stefl

Term expiring in 2006:

C. Aerts
S. Owocki
J. Porter*
T. Rivinius*

Non-voting Members

G. Peters, editor-in-chief of Be Star Newsletter
D. Baade, outgoing chairperson of WG

*These WG members are currently not members of the IAU and will be proposed as consultants in accordance with the IAU rules.

Ratification of the SOC will be considered when the IAU Executive Committee meets at the end of the IAU GA. The chairperson will be announced in 2000 September.

There were some objections to the voting procedure, especially the compressed schedule. The call for votes came out when many were on vacation and the deadline occurred before they returned home. G. Peters asked if we should adopt a set of by-laws for the WG. It was commented that we could have them, but it was not necessary if there was more planning in advance.

III. The Be Star Newsletter

G. Peters presented a summary of the status of the Newsletter. The current editors are:

G. J. Peters, editor-in-chief
D. R. Gies, Technical Editor
D. McDavid, Webmaster

Since the Kyoto meeting, two large paper issues, No. 33 & 34 have been published and we have launched the electronic newsletter: http://www.limber.org/benews. Most contributions, abstracts, and meeting announcements are posted within 48 hours of receipt, pending internal review by the editors. Our current procedure is to post new items on the web site, then prepare a paper edition, including a bibliography, after we accumulate enough material. The paper edition therefore comes out irregularly and continues to be produced and financially supported by the Department of Physics and Astronomy at Georgia State University.

IV. The Definition of a "Classical Be Star" (presented by M. Smith)

M. Smith proposed the following straw man definition for a classical Be star:

"A classical Be star is a non-accreting B III-V star which has shown some history of Hα emission and which has exhibited properties consistent with a flattened envelope during those times".

It was suggested that the WG consider whether we should even have such a definition. It was acknowledged that any definition beyond "Be star" necessitates some interpretation of the phenomenon.

V. Other Issues

L. Balona asked the editor-in-chief of the Newsletter if we could publish more than one issue per year. G. Peters replied that the establishment of the new electronic version addresses concerns of timeliness and that although the editors would like to publish two issues or more per year they are dependent on the community to submit material. It was commented that one possibility is that two electronic issues could be published per year but only one double paper copy. The editors will take the above comments into consideration.

The meeting was adjourned at 14:50.

Geraldine J. Peters

2.4. Chairman's Message

Five months have already passed since the new Organizing committee of our WG was elected. Thanks to David McDavid's prompt editions of our Be star Newsletter, you were immediately informed about the new elected members. According to my view, it is a very encouraging fact that many relatively young astronomers became OC members and that the present OC reflects the contemporary trends in the research on active B-type stars. We have a good chance that this OC can combine the skill of more experienced members and the enthusiasm and unconventional approach of newcomers. I would like to thank all of you who took part in the election for your votes. It was too tempting to accept the honour to be the chairman of this team.

We had to start with some formal but so far unclear points concerning the status of our WG. The OC decided that IAU Division IV should be our main sponsoring division, but we would like to be linked also to Division V and its two commissions 27 (Variable stars) and 42 (Close binaries). We expect the IAU authorities to confirm this status during the next weeks. In Division IV, we are interested to collaborate closely with commissions 29 (Stellar spectra), 36 (Theory of stellar atmospheres), and 45 (Stellar classification). I expect that problems represented by Commission 35 (Stellar constitution) will become really attractive for us, after data from the *MONS* and *COROT* missions are available. In fact, the above sketched links of our WG to the IAU divisions and commissions does not mean any serious change. The last activities of the OC were needed in order to fix and clarify the formal status.

I believe that our activities in the coming months and years will move mainly to astrophysical problems. As we concluded in the end of the Alicante meeting, we can expect significant progress from new echelle spectrographs placed in optimal observing sites. High quality data, e.g. from *FEROS* at La Silla or *GIRAFFE* at Sutherland, allow us to study physical processes in more detail than we could do for lower resolution multi-line studies. We are all lucky to witness the beginning of the wonderful *VLT* project. The first pioneering papers using multi-object observations from *UVES* have already appeared. They give us a chance to study individual stars in other galaxies and to test e.g. theories on driving mechanisms of stellar pulsation. The *MONS, COROT*, and Eddington missions will fulfill an old dream of the photometrist and provide us with a continuous and accurate photometric monitoring of many targets, unaffected by atmospheric effects. We all impatiently expect new results from interferometric projects and from searches for magnetic fields, the measurements of which are greatly needed to assess the roles of nonradial pulsation and magnetic fields in stellar activity and particularly in the Be star outbursts. All these observations should enable us to test recent encouraging steps achieved in the theory of circumstellar disks and X-ray binaries.

Not only the most grandiose projects, but also hundreds of small telescopes operated by advanced amateurs can contribute to the progress in our field. We can meet amateur astronomers, who show incredible enthusiasm and remarkable knowledge, and who own photometric or spectroscopic facilities producing data of nearly professional quality. These amateurs could at least partly close the gap which appeared after many smaller telescopes at professional observatories were closed. The present age of the Internet enables them to be involved in professional projects. Please, forget about our professional conceit and lend a helping hand to these people, who devote their free time, energy, and money to astronomy. In the present world of pragmatic business and cheap amusement, they deserve our sincere respect.

I would like to appreciate the dedicated job that Gerrie Peters, Doug Gies, and David McDavid do for our Be Star Newsletter and ask you all to help them. They can edit promptly the electronic version, but they can hardly publish some actual information in the printed version in time, if they have not enough papers to complete an issue.

Let me use this opportunity to wish you all a lot of strength and brilliant ideas in solving both the mysteries of distant stars and common problems of close people in the starting New Year as well as the starting Millennium.

Stanislav Štefl
WG Chairman

3. CONTRIBUTIONS

3.1. Optical and Hα Outburst of δ Scorpii

J. Fabregat[1], P. Reig[2,3], and A. Tarasov[4]
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[2] Foundation for Research and Technology-Hellas, 711 10 Heraklion, Crete, Greece
[3] Physics Department, University of Crete, 710 03 Heraklion, Crete, Greece
[4] Crimean Astrophysical Observatory, 334413 Nauchny, Crimea, Ukraine
Received: August 9, 2000

The bright star δ Scorpii (HD 143275, HR 5953, $V = 2.32$, MK B0.3IV, $v \sin i = 145$ km s^{-1}) is a member of the Upper Scorpius region of the Sco-Cen association. It is a visual and spectroscopic binary, with $P = 10.583$ years, $e = 0.92$ and $T_0 = 1979.41$ (Hartkopf et al. 1996). These parameters imply that a periastron passage is occurring at July 2000. It is also known to be a non-radial pulsator (Smith 1986, Telting & Schrijvers 1998).

Delta Sco is currently undergoing a bright optical and Hα outburst. The optical brightening was first detected by the visual observer Sebastian Otero (Liga Ibero-Americana de Astronomia), who, at the end of June 2000, noticed the star 0.1 mag brighter than its quiescient $V = 2.32$ magnitude. Ever since the brightening has continued, reaching $V = 1.9$ mag by the end of July. The light curve displaying Otero's visual estimates during the period 30 June–2 August is presented in Figure 1.

Follow-up spectroscopic observations were obtained with the 1.3 m telescope at Skinakas Observatory (Crete, Greece), with spectral resolution of 0.3 nm in the range 580–760 nm. The spectra reveal the Hα line clearly in emission, confirming the Be star nature of δ Sco. Two spectra obtained on 19 and 20 July are presented in Figure 2. Measured equivalent widths are -0.34 ± 0.02 nm and -0.33 ± 0.02 nm ($fwhm$ 0.69 ± 0.01 nm) respectively.

A further high-resolution spectrum is presented in Figure 3. It was obtained on July 28 with the 2.6 m Shain Telescope at the Crimean Astrophysical Observatory, Ukraine. The Hα emission line shows a double peaked structure with a peak separation of about 150 km s^{-1}.

Emission features in δ Sco were first detected in 1990 by Cote & van Kerkwijk (1993), who observed weak emission on the flanks of the Hα line core in absorption, and proposed its classification as a Be star. During the last five years emission lines have been frequently observed, although the spectra showing them are not yet published (Harmanec et al., in preparation). Hence, the observations of Cote & van Kerkwijk might represent the onset of the current Be phase, which would have been active during the last ten years.

The optical outburst starts around the end of June 2000. Surprisingly, there is not apparent line variability associated to the optical brightening. The three Hα lines

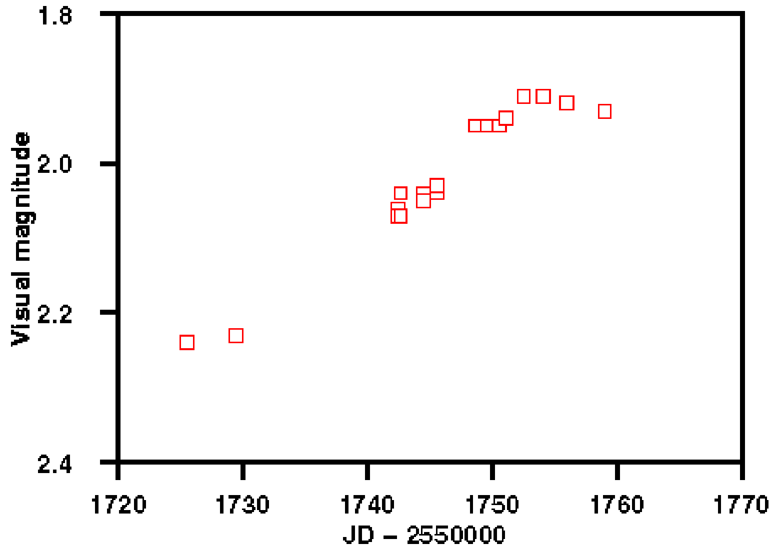

Figure 1. Visual light curve from June 30 to August 2, 2000.

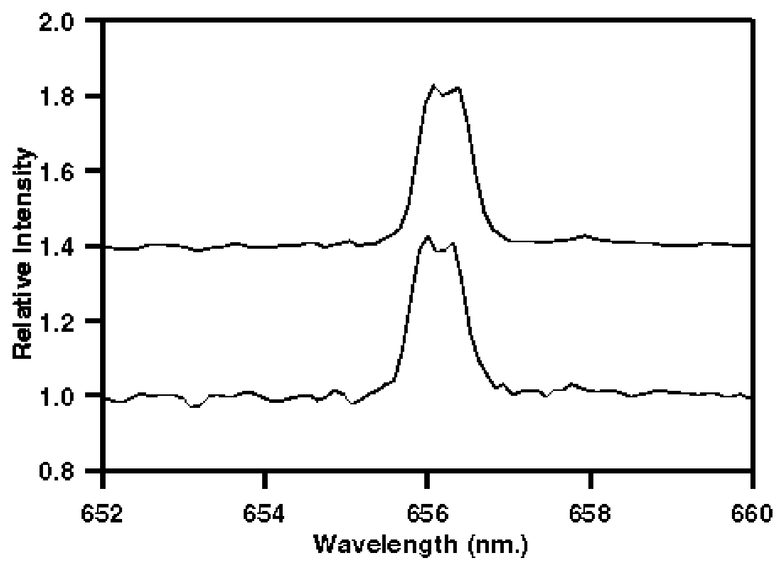

Figure 2. Hα line low resolution spectra. The bottom spectrum was obtained on July 19, and the top one on July 20, 2000.

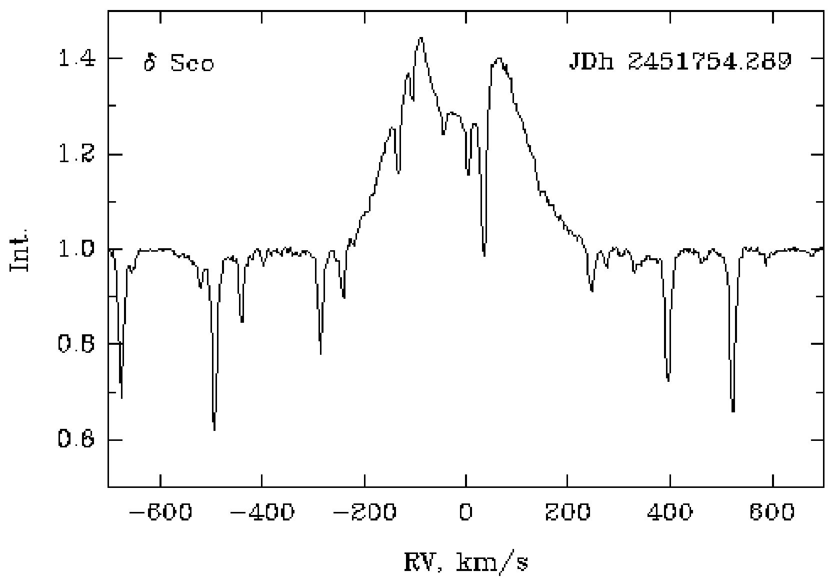

Figure 3. Hα line high resolution spectrum, obtained on July 28, 2000.

presented in this paper, obtained about 9 days apart, show similar shape and equivalent width. Spectra obtained within the Be Star Spectrographic Survey Project by the Aude Association (Buil 2000) cover a longer baseline. Their first spectrum was obtained on June 3, prior to the beginning of the optical outburst, when the star was at its quiescent $V = 2.3$ magnitude. The last one corresponds to July 30, when δ Sco had brightened more than 0.4 mag. With the exception of the different resolution, both Hα lines appear identical. These spectra can be found at http://astroccd.com/terre/buil/us/catalog/7sco.htm.

Since its announcement in *IAU Circ. 7461*, the outburst of δ Sco is attracting the interest of many observers and researchers. There are currently several open discussion forums in Internet. Interested readers can find some of them at the Be-Stars Mailing List (Townsend 2000, http://www.mailbase.ac.uk/lists/be-stars), and the VSNET (international mailing list on variable stars, http://www.kusastro.kyoto-u.ac.jp/vsnet).

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Hartkopf, W.I., Mason, B.D., & McAlister, H.A. 1996, AJ, 111, 370

Smith, M.A. 1986, ApJ, 304, 728

Telting, J. & Schrijvers, C. 1998, ASP-CS, 135, 149

Townsend, R. 2000, Be Star News, 34, 43

3.2. Hα Monitoring of Be Stars

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Received: August 9, 2000

Since their discovery Be stars have been systematically examined in long-term observing programs. It is now clear that these stars exhibit obvious changes in their spectra on timescales of a few years to decades. In particular, Hα and Hβ emission lines can unpredictably and dramatically change in strength and appearance. In addition, no connection has been found between variations in emission lines and changes in brightness as shown by light curves.

Phase transitions from B to Be and from Be to B can be relatively easily observed by amateurs. This can be done by following the intensity of hydrogen emission. The author has measured Hα emission strength of different Be stars with an objective prism spectrograph for several years. The goal is to get a sense of the long-term behavior of some well known stars. This is a desirable project because professional astronomers have limited observation time which causes gaps in coverage and loss of continuity in the measurements. Many Be stars are incompletely observed. The plots show how the program stars changed over time as observed by the author and others.

The positive response of professional astronomers to observational results from amateur astronomers who do spectroscopy shows that the possibility of scientific contributions by amateurs is growing. This motivated the author to build a spectrograph for the specific purpose of observing line profiles in Be-stars. High spectral resolving power and high signal to noise are called for. The spectrograph is attached to a 20 cm Schmidt-Cassegrain (1:3,8) telescope. Here are details of the instrument.

- Mounting: Schmidt-Cassegrain focus
- Slit: None
- Collimator optics: $f = 50$ mm, 1:3,5, Pentacon photographic lens
- Reflection grating: 1200 g mm^{-1}
- Grating position: Fixed and centered at 6563 Å
- Imaging optics: $f = 135$ mm, 1:3,5, Soligor photographic lens
- CCD pixel size: 9×9 μm
- Total weight: 1300 g
- Dispersion: 43 Å mm^{-1} (0.391126 Å pixel^{-1})
- Resolving power: 16000

Following are Hα emission line profiles for some popular Be stars as observed with this instrument.

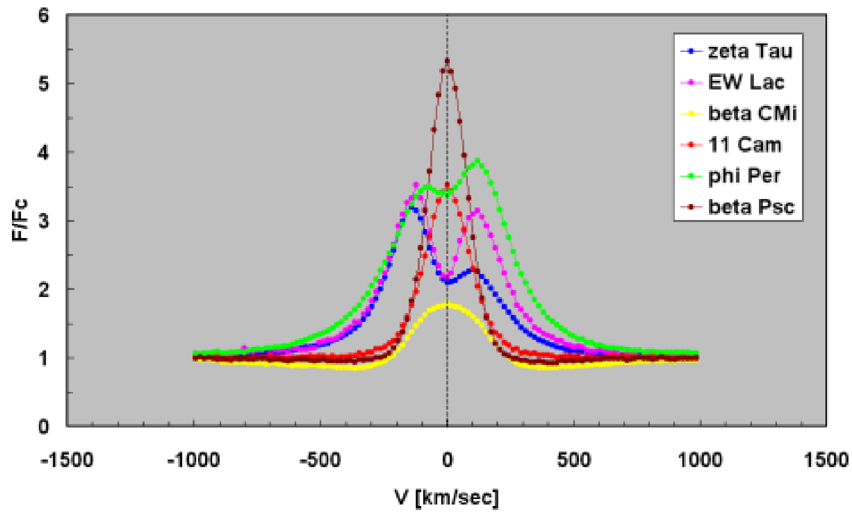

Figure 1. Hα emission line profiles for some popular Be stars.

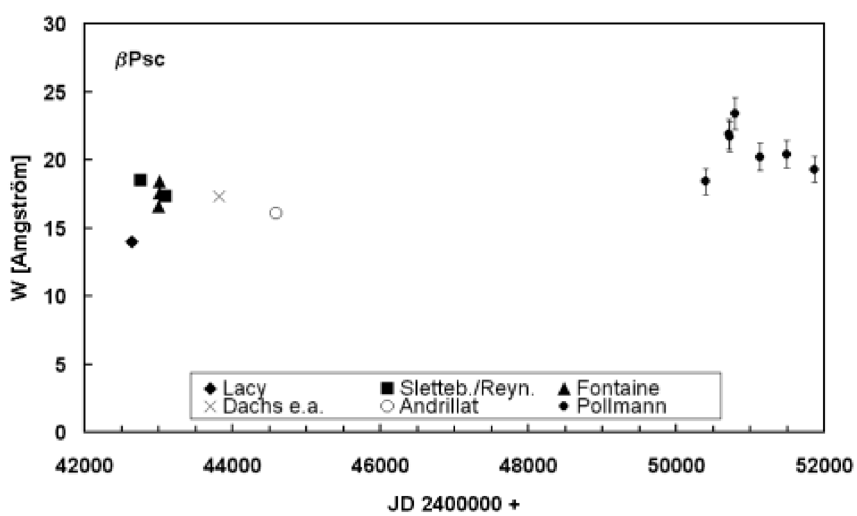

Figure 2. β Psc: Without being able to fill a 17-year gap in observations of β Psc all that can be concluded from this figure is that the mean Hα equivalent width was about 3 Å larger at the end of the period than it was at the beginning.

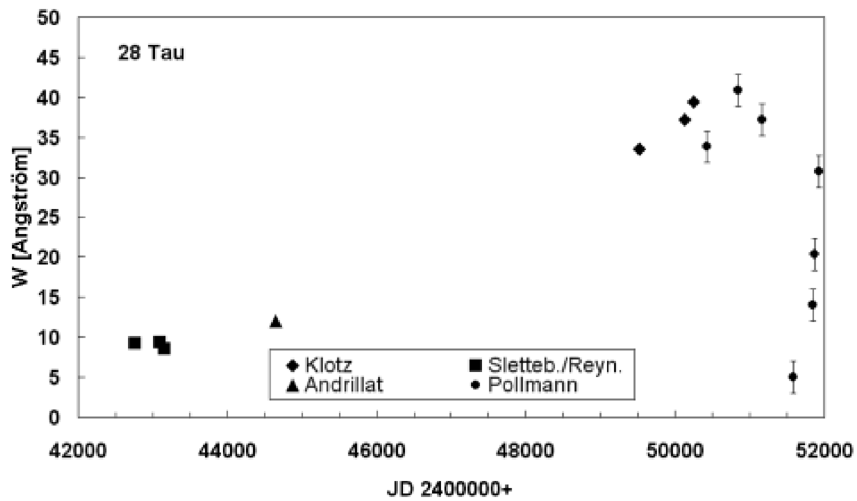

Figure 3. 28 Tau: Equivalent widths through JD 2444651 were fairly stable. Subsequently they rose and fell through a range of 36 Å. At JD 2451586 28 Tau was at the close of a B phase.

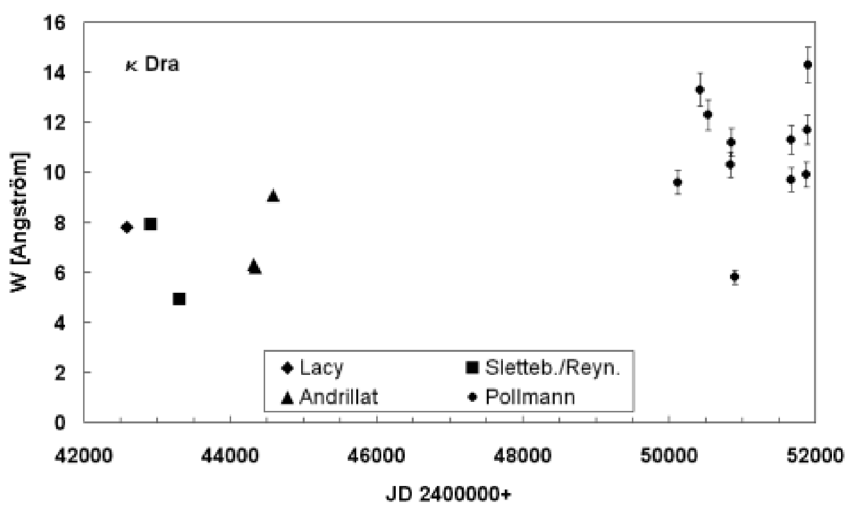

Figure 4. κ Dra: Prior to JD 2450123 there are not enough observations to show cyclical behavior in κ Dra. Coverage after that date may indicate its presence.

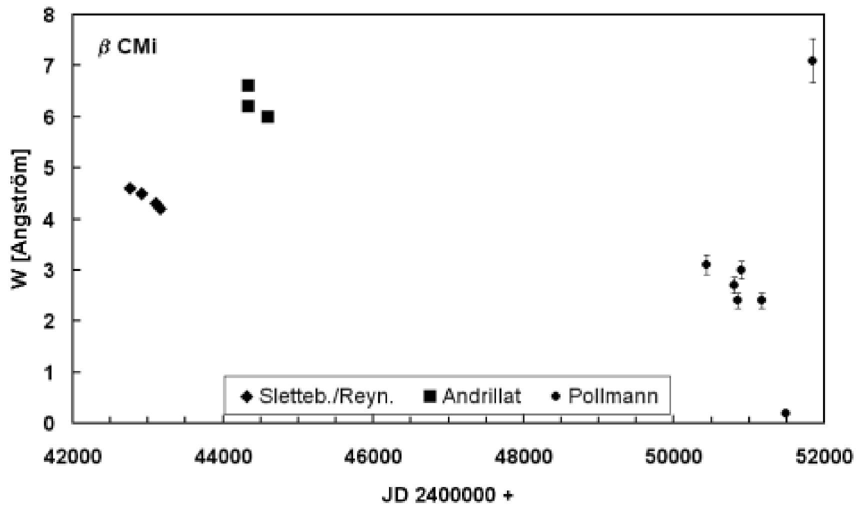

Figure 5. β CMi: At JD 2451495 β CMi was probably in the B phase. The Be phase may have been reached when the equivalent width rose to 7 Å (JD 2451849). The transformation appears to have taken about a year.

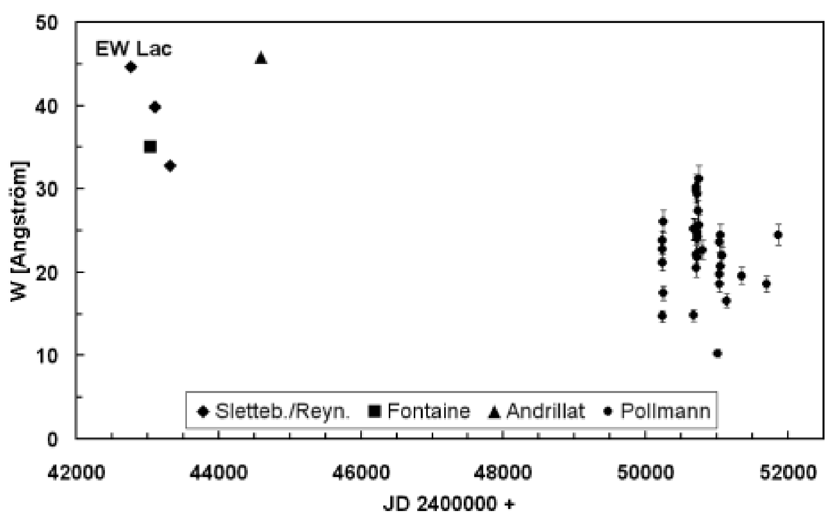

Figure 6. EW Lac: Equivalent widths from JD 2442761 to 2444588 were greater by a mean of about 20 Å over those in the period JD 2450240 to 2451705. The author's measurements starting JD 2450240 reveal variability in EW Lac of about 0.3 Å day^{-1}.

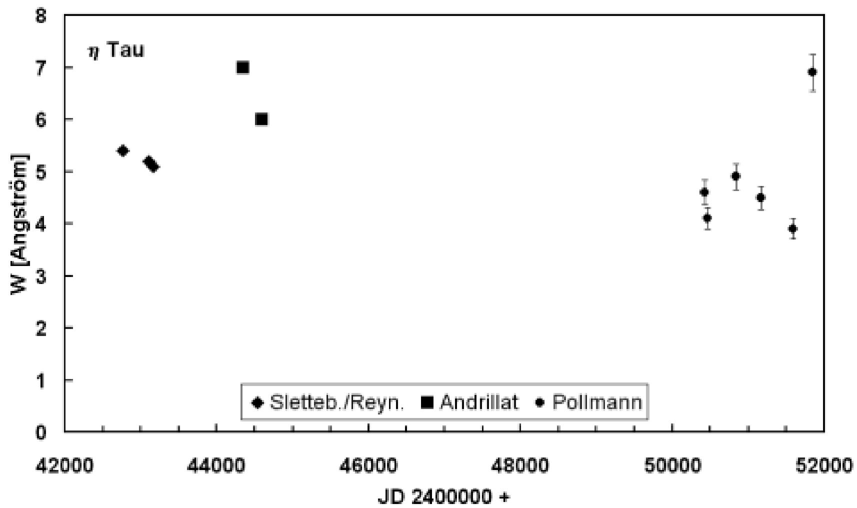

Figure 7. Current equivalent widths for η Tau agree with those of Slettebak & Reynolds and Andrillat.

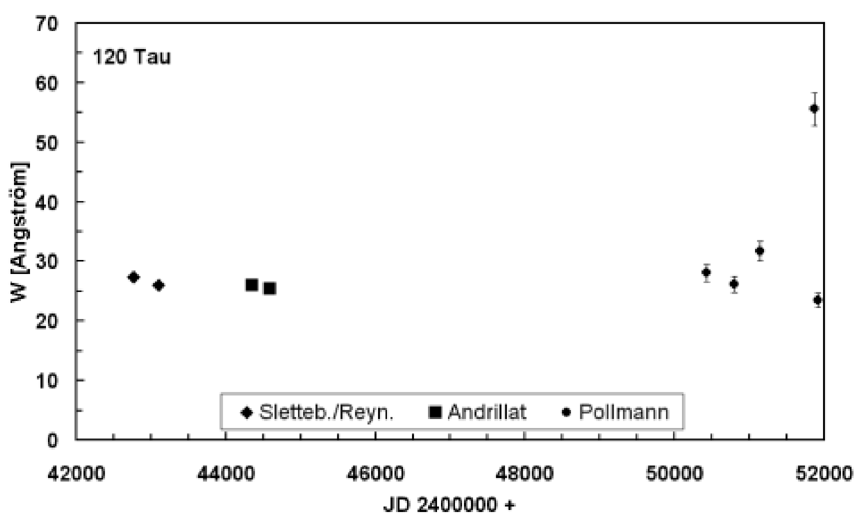

Figure 8. The author's measurements for 120 Tau agree with those of Slettebak & Reynolds and Andrillat.

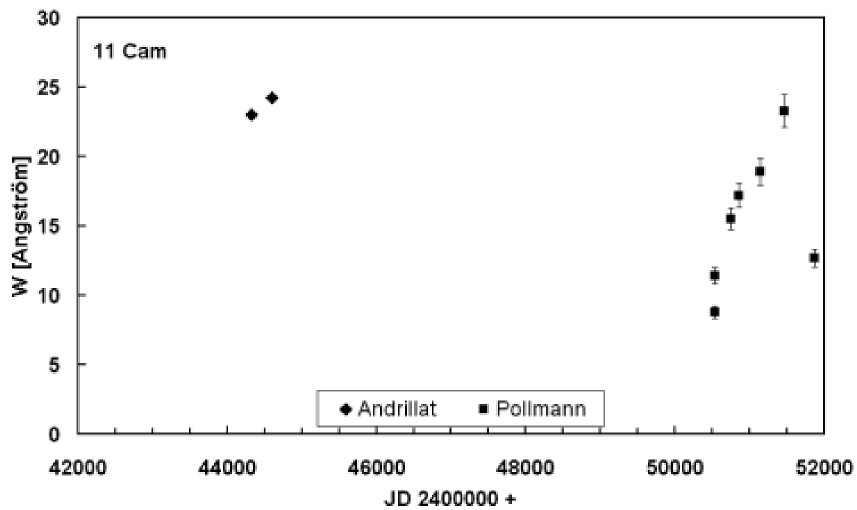

Figure 9. Only Andrillat's much earlier measurements of 11 Cam were available to the author. At about 24 Å, the last equivalent width peak (JD 2451468) seems to indicate the Be phase. Future measurements may show the Be to B transformation.

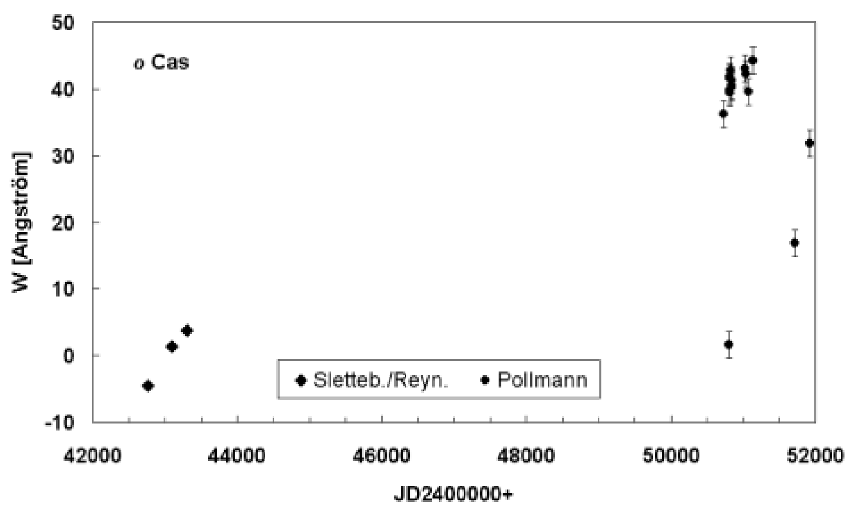

Figure 10. o Cas: The equivalent width measurements of Slettebak and Reynolds probably coincide with the B phase of o Cas. The author observed transformation to the Be phase in which Hα equivalent width reached 44 Å. It appears that this phase lasted for about 330 days.

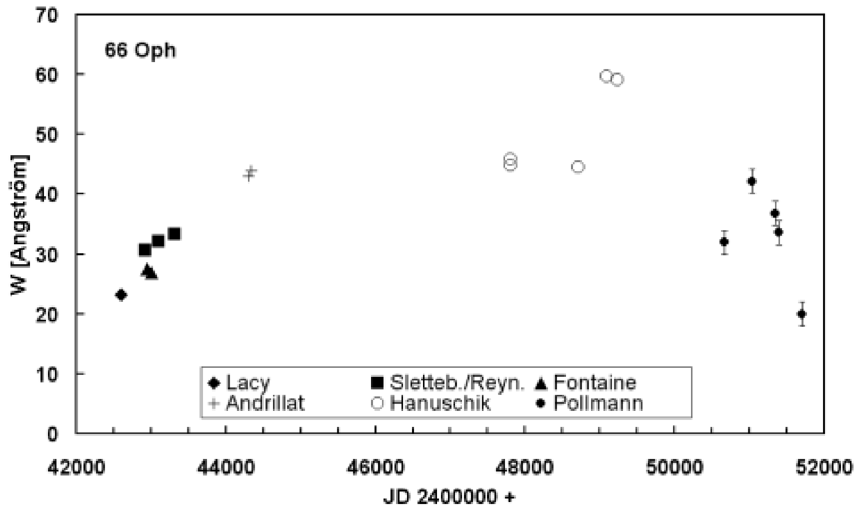

Figure 11. 66 Oph: Over about 30 years 66 Oph underwent a long cycle with a range of almost 40 Å. The coverage is not good enough to permit conclusions about short time variations.

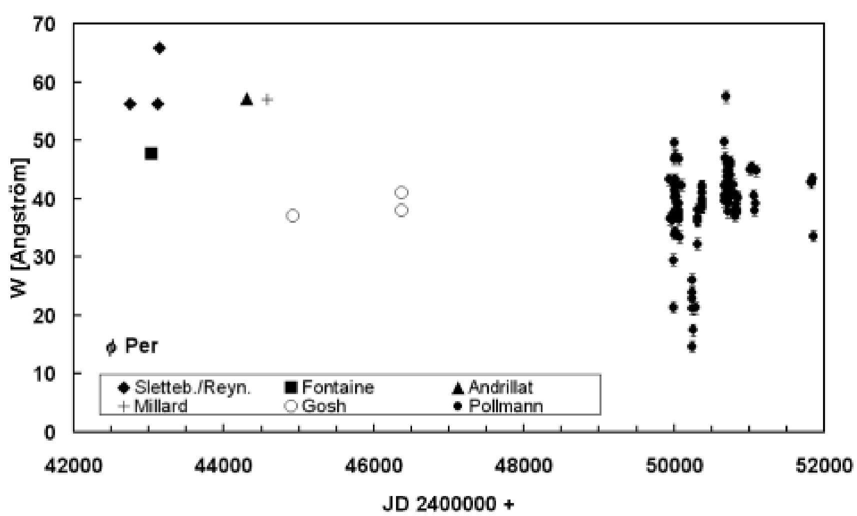

Figure 12. ϕ Per: In this plot the extreme range for Hα equivalent widths in ϕ Per is about 50 Å. Frequent observations after JD 2450000 reveal much short-term activity. Considering these facts, it is no surprise that significant differences exist between the results of different observers. At the suggestion of Dr. R. Hanuschik, the author is using a new grating spectrograph (R=16000) to search for V/R variations on a timescale of minutes. A similar effort is being made with ζ Tau.

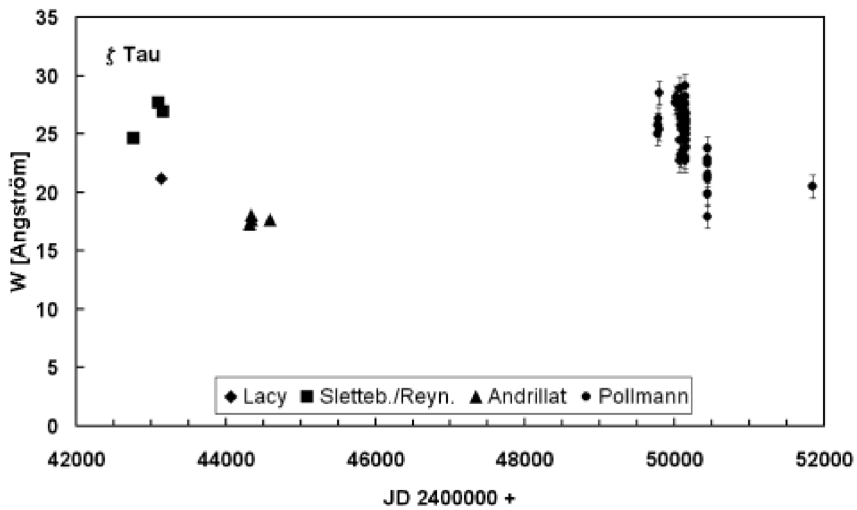

Figure 13. ζ Tau: The author's results are similar to those of Slettebak & Reynolds, Andrillat, and Lacy. His more frequent observations show interesting short time period variations. As with ϕ Per, he is attempting to detect V/R variations on a timescale of minutes.

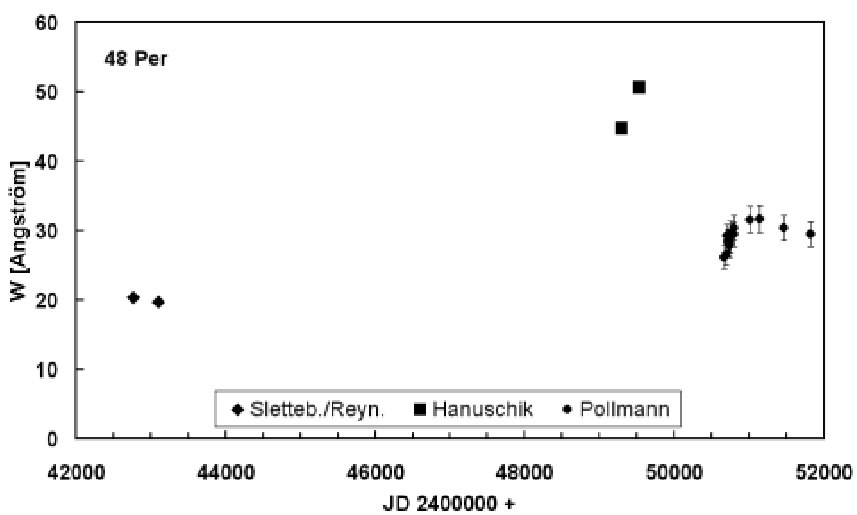

Figure 14. 48 Per: Although the author has followed 48 Per for about four years, the sketchy picture that emerges when his observations are combined with others makes it difficult to draw any conclusion about activity in this object.

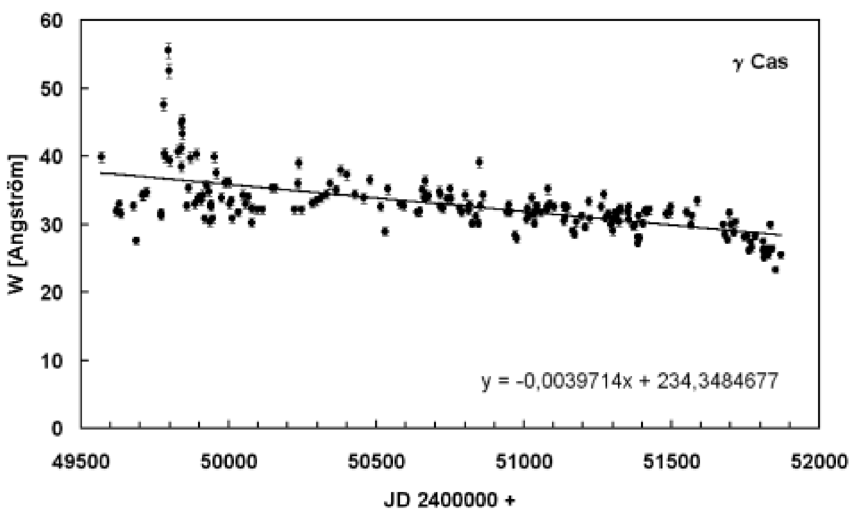

Figure 15. γ Cas: Excluding the outburst around JD 2449800, the Hα equivalent width in γ Cas showed a steady linear decline over 2300 days. Equivalent width decreased by an average of 9.13 Å for the period.

3.3. Line Forces in Keplerian Circumstellar Disks and Precession of Nearly Circular Orbits

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Received: April 13, 2001

ABSTRACT: We reexamine the role of radiative forces in an orbiting disk. A previous conceptual bias toward radially streaming radiation has caused the potential for strong optically thick line forces in such disks to be overlooked. We discuss possible consequences of including such forces in disk models. Although substantial uncertainty remains because appropriate line opacity distributions have not yet been determined, we conclude that line forces may play a fundamental role in ablation from the disk surface and in long-term disk variability.

1. Introduction

Despite recent advances, many due to readers of this newsletter, the overall dynamics of Be disks remain an enigma. We don't fundamentally understand the processes that lead to either their (often recurrent) formation or destruction, nor do we understand the complex forms of variation they exhibit in between. A proper dynamical understanding requires knowledge of the role of forces associated with, e.g., gravity, viscosity, inertia, magnetic fields, and radiation. Here we focus on the last of these, specifically the radiative forces that arise from line scattering of a star's continuum radiation. Such line forces are well known to be important in driving the wind outflow in a broad range of luminous, early-type stars. But thus far, their consideration in Be stars has been mostly confined to modeling high-speed winds from higher latitudes (e.g., Bjorkman & Cassinelli 1993).

Attempts have been made to include parametrized optically *thin* line forces (e.g. Chen & Marlborough 1994) in disk dynamics (Okazaki 1997), but in winds, it is the marginally optically *thick* lines that dominate. We present arguments, in the main article summarized here, that the same should be expected in disks. When treated similarly to the CAK approach so successfully applied in winds, the signature of such forces is a unique sensitivity to the gas dynamics, accompanied by rich and surprising phenomena.

At first glance, it may seem strange to apply CAK formalism to gas that is not radially expanding. This would indeed be inappropriate if the central source were a *point star*. But if one takes account of the *nonradial* radiation streams from a finite-size star, the Keplerian shear of a steady, orbiting disk can desaturate lines in much the same way as a radially accelerating outflow does. This leads to surprisingly effective optically thick line acceleration within a disk.

We stress two potentially important consequences of such line forces. First, the self-consistent structure of the disk is no longer Keplerian. Although this may require only minor corrections in the densest portions of the disk, in the low-density surface layers it may lead to changes in the disk structure that alter or enhance the inexorable erosion by disk winds, and this may be a key factor in what appears to be the occasional complete disappearance of disks in many Be stars. Second, even in the denser regions, the perturbative effect of line forces can lead to a precession of elliptical orbits, and this may be an important factor for understanding long-term V/R variations and the precession of global disk oscillation modes. In both these cases, the actual computation of relevant timescales for disk destruction or mode precession may depend on various details and subtleties not yet accounted for. Nonetheless, our analysis shows how the basis for such further work can be built upon existing line-driven wind theory, with appropriate geometric corrections.

2. CAK-Type Line Driving for an Orbiting Disk Geometry

One requirement for strong line driving is large line-of-sight velocity gradients. To understand how a Keplerian disk generates such gradients, consider the schematic in Figure 1. A central point is that the finite size of the star allows for nonradial radiation streams, including the tangential stream from the limb depicted in the figure. These streams encounter the disk at oblique angles that sample the Keplerian velocity gradient, even in the absence of any radial motions. Since Keplerian speeds are of the same order as wind speeds, and they vary over the same radial scale, the line-of-sight gradients can also be of the same order. Thus the justification for applying CAK-type line forces in winds is not as distinct from disks as has been assumed in the past.

When standard CAK theory is applied, the radiative acceleration $\mathbf{g}$ is proportional to the flux-weighted average of the line-shadowing correction factor $\tilde{t}^{-\alpha}$, integrated over direction $\hat{\mathbf{n}}$. This factor in turn obeys

$$\tilde{t}(\hat{\mathbf{n}})^{-\alpha} \;\propto\; \rho^{-\alpha} \left(\frac{dv}{dl} \right)^{\alpha} \;, \qquad (1)$$

and accounts for all optical depth effects within the line distribution,
where $dv/dl \;=\; (\hat{\mathbf{n}} \cdot \nabla)\,(\hat{\mathbf{n}} \cdot \mathbf{v})$ is the line-of-sight velocity gradient. For such a power-law line list, $\tilde{t}$ is of order the cumulative Sobolev optical depth along $\hat{\mathbf{n}}$ summed over all lines (Gayley 1995; see Cranmer & Owocki 1995 for a derivation of the detailed geometrical terms).

The essential point of equation (1) is that the radiative acceleration weakens as density is increased or as line-of-sight velocity gradient is decreased. Since Figure 1 shows that the latter is comparable in winds and disks, it is really the former, the density, that represents the key factor distinguishing the forces in Be disks from those in winds of hot stars.

3. Radial Forces on Circular Orbits

For strictly circular orbits, the expressions for the line force become quite simple, and the result is that both the Keplerian velocity shear and the orbital curvature serve to *augment* the velocity gradient for nonradial radiation streams. Relative to the inverse-square falloff of gravity, it then follows that the radiative acceleration varies as

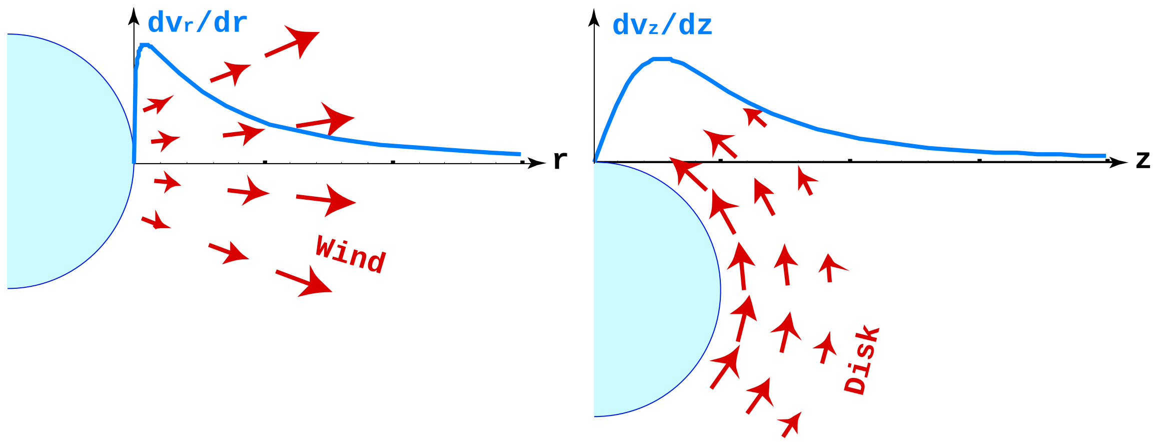

Figure 1. Comparison of the radial velocity gradient, dv_r/dr, of a radial stellar wind outflow with the line-of-sight gradient, dv_z/dz, along a ray direction z that is *tangent* to the stellar limb and passing through an orbiting Keplerian disk. The units of the gradient are arbitary, but the relative scaling is accurate for the case in which the terminal velocity of the wind is the same as the near-surface orbital velocity of the disk.

$$\frac{g_{rad}}{g_{grav}} \propto \rho^{-\alpha} r^{-5\alpha/2} . \tag{2}$$

The overall scale of this ratio is order unity when the density is windlike, and the steepness of the reduction in a disk due to the density enhancement is controlled by the α power-index. The appropriate value of this parameter in a disk is a matter for future study, but we note that wind models (Puls, Springmann, & Lennon 2000) suggest a low value, in the vicinity of $\alpha \sim 0.3$, may be relevant at B-star temperatures.

If the radiation field is azimuthally symmetric, the force points radially outward. Since strictly Keplerian orbits do not include such an additional force, the overall results are not self consistent, and can only be used to test when the magnitude of the radiative force will represent a *small* perturbation. A key point is that this should not hold near the disk boundaries, and so future models of the seat of disk winds should include a self-consistent structure calculation that includes the effect of Keplerian shear on the line force. How this could alter our view of disk winds is not yet known, including the ramifications for accretion disks.

4. Precession of Slightly Elliptical Orbits Due to Radiative Forces

Even when the radiative force is small, it can have an important cumulative effect on the long-term disk dynamics. For example, the apparent precession of global disk modes (e.g., Telting et al. 1994; Hummel & Hanuschik 1997) requires of order 10^3 orbits, which implies a force perturbation that is roughly only 10^{-3} times gravity. Calculating radiative global modes is beyond our scope, so we simply attempt to guide expectations by considering slightly elliptical orbits embedded in such a mode, and show in the full paper that line driving does cause such orbits to precess. Indeed, there are two separate types of precession induced, and they often have similar magnitude but opposite sign.

The first is the more obvious, and is caused by the force gradient given in equation (2). If the eccentricity is not rapidly increasing, we argue that ρ over a *single* elliptical orbit (not adjacent orbits) will fall off less rapidly than $r^{-5/2}$, and so the radiative force falls off more rapidly than inverse-square. This induces precession in a way similar to the steeply falling quadrupole gravity term. The key difference is that the radiative force is *outward*, and so the induced precession is *retrograde*, not prograde. This creates difficulty when compared with observations that currently favor a prograde interpretation.

There is, however, a second effect of radiative forces that is considerably more subtle, and may contribute to prograde precession. That is the radiative *torque* imposed by the line driving, which would peak when the radial and azimuthal speeds are of the same order. This torque was first postulated for winds by Grinin (1978), and was recently examined more fully by Gayley & Owocki (2000) under the assumption that the radial speed is much greater than the azimuthal speed. Here we consider the opposite limit, for which weak ellipticities yield weak torques that become apparent only after many orbits. Such torques are symmetric over an orbit, so changes in the overall angular momentum average out. However, the orbit ceases to be closed, and the resulting precession will be prograde whenever the torque is positive on the outbound leg.

A self-consistent calculation of the impact of these effects on an actual one-arm mode remains to be carried out. Our results are applied only to gas parcels in elliptical orbits of constant eccentricity, and suggest in this case that the gradient effect dominates and the net precession will be retrograde. But considerable further work is needed before these effects can be confronted with observations. Self-consistent mode calculations are required, which must likely be followed into the nonlinear regime. Our current objectives are merely to call attention in the Be-star community to the potential importance of line forces for Be disks, to stimulate interest in including them in disk models, and to outline how familiar CAK concepts may be utilized with a minimum of additional effort. Of particular importance would be future calculations of the ionization conditions and the appropriate line lists, and inclusion of line driving into nonlinear hydrodynamic simulations of disk formation, destruction, and precession.

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4. WHAT'S HAPPENING?

4.1. Be-Stars Mailing List

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Received: May 9,2000

In order to promote discussion of possible mass-ejection and disk-formation processes in Be stars, I have created a mailing list devoted to the topic on Mailbase, the UK Higher Education list-server.

The list is open to all members of the Be star community (and related communities, where relevant), both observers and theoreticians. Subscribers can post messages to the list, and will receive a copy of every message sent to the list.

To subscribe to the list, send a message to mailbase@mailbase.ac.uk (a program), with the BODY as follows (the subject line is ignored):

join be-stars firstname lastname

stop

(fill in your own personal names instead of "firstname" and "lastname").

After you send a join command, you'll get an automatic message from the Mailbase computer, containing a unique code. You'll have to confirm your membership by sending a message like this to mailbase@mailbase.ac.uk:

accept xxxxxx

where xxxxxx is the code sent to you. This allows the Mailbase computer to check your email address. Full instructions for use of the list will then follow, including how to unsubscribe at a later date.

Members of the community who wish to monitor the discussion on the list, but who do not want to subscribe, may review all messages sent to the list by browsing the web-archive at

http://www.mailbase.ac.uk/lists/be-stars/ .

I look forward to fruitful discussion!

Regards,
Rich Townsend

4.2. Outburst of μ Cen

D. Baade[1], Th. Rivinius[1], and S. Štefl[2]
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Received: July 5, 2001

Visual observations made by S. Otero (Liga Iberoamericana de Astronomía, Buenos Aires) and communicated on June 21 imply that the Be star μ Cen (= HR 5193 = HD 120321) brightened between June 7 and June 21 by about 0.2 mag from its previous level of 3.5 mag. An echelle spectrogram taken on June 21.95 by X. Liu (University College, London) with the ESO 1.5 m telescope (+*FEROS*) at the La Silla Observatory shows broad emission wings in Hα and numerous emission lines from singly ionized metals; the peak separations of the Si II line at 634.7 nm and the Fe II lines at 516.9 and 531.7 nm are 285, 280, and 290 km s^{-1}, respectively. Comparison with earlier observations of the same star (Rivinius et al. 1998, A&A, 333, 125) suggests that the outburst proper took place about 10 $\pm$ 10 days earlier. The ephemeris of Rivinius et al. (1998, ASP Conf. Ser., 135, 343), which is based on the beating of several nonradial pulsation modes, predicts an outburst on June 18 $\pm$ 7 days.

4.3. Alert on ω CMa

Sebastian Otero
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Received: October 25, 2001

The bright Be star ω Canis Majoris is in a bright and long outburst that started at the end of March 2001. By that time the star rose slowly and steadily from 4.1, reaching 3.8 in early June when it got very low to be observed. Now it is at 3.7, half a magnitude brighter than in its quiescence state. The lightcurve of this outburst mimics the one caught by *Hipparcos* in 1992. It would be important to take spectra of this star now that is at maximum and to compare them with the visual behaviour. Omega (28) CMa is located at: RA = 07h 14m 48.65s, Dec = -26° 46' 21.6" (2000.0). The range given in the GCVS is 3.60 – 4.18 in V.

5. ABSTRACTS

One Hundred Years of Observations of the Be Star HDE 245770 (the X-ray Binary A0535+26/V725 Tau): The End of an Active Phase?

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UBV observations of the X-ray binary system A0535+26/V725 Tau at the Crimean Station of the Sternberg Astronomical Institute in 1980–1998 are presented. Based on our and published data, we analyze the photometric history of the star from 1898. Over a period of 100 years, the star apparently showed all three activity phases (B, Be, Be-shell) of Be stars. We conclude that the X-ray activity of the object is attributable to the 1970–1997 outburst of the Be star due to envelope ejection. The star's colors during the minimum light of 1998 and its 1953–1956 colors (before the outburst) correspond to the spectral type B0-B1 at the color excesses $E_{B-V} = 0.74$ and $E_{U-B} = 0.48$, in agreement with the current spectral type O9.7. The minimum light of 1998 and the color excesses are used to determine the colors of the additional radiation, analyze their evolution during the 1973–1997 outburst, and refine the distance to the object (3 kpc). The colors of the additional radiation at maximum light of the star (1973–1980) match the colors of a hydrogen plasma with $T_e = 1.5 \times 10^4$ K which is optically thick in the Balmer continuum. The brightness decline corresponds to a decrease in the optical depth of the plasma; at $V = 9.1$ mag, it becomes optically thin in the Balmer continuum with $T_e = 10^4$ K and $N_e = 10^{10}$–10^{12} cm^{-3}. This conclusion is consistent with the model of a circumstellar envelope but is inconsistent with the existence of an accretion disk around the neutron star. All the additional radiation responsible for the optical variability is produced by a single source. The intensity of the Hα emission line at maximum light (1975–1980) is triple its intensity in 1987–1997, when quasi-periodic light fluctuations with $P = 1400^{\rm d}$ were observed. At this time, the line intensity correlated with brightness. The Hα line was in absorption at the minimum of 1998, and, at present, the star's active phase appears to have ended.

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New theoretical mass-loss rates of O and B Stars

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We have calculated mass-loss rates for a grid of wind models covering a wide range of stellar parameters and have derived a mass-loss recipe for two ranges of effective temperature at either side of the bi-stability jump around spectral type B1. For a large sample of O stars, it is shown that there is now good agreement between these new theoretical mass-loss rates that take *multiple scattering* into account and observations. Agreement between the observed and new theoretical wind momenta increases confidence in the possibility to derive distances to luminous stars in distant stellar systems using the Wind momentum Luminosity Relation. For the winds of the B stars there is an inconsistency in the literature between various mass-loss rate determinations from observations by different methods. One group of $\dot{M}$ determinations of B stars *does* follow the new theoretical relation, while another group does not. The lack of agreement between the observed mass-loss rates derived by different methods may point to systematic errors in mass-loss determinations from observations for B stars. We show that our theoretical mass-loss recipe is reliable and recommend it be used in evolutionary calculations.

2001, A&A, 369, 574

A Search for High Velocity Be Stars

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We present an analysis of the kinematics of Be stars based on *Hipparcos* proper motions and published radial velocities. We find approximately 23 of the 344 stars in our sample have peculiar space motions greater than 40 km s^{-1}, and a similar number are found at large distances from the galactic plane ($|z| > 1200$ pc). We argue that these high velocity stars are either the result of a supernova that disrupted a binary or they were ejected by close encounters of binaries in young clusters. Be stars spun up by binary mass transfer will only appear as high velocity objects if there was significant mass loss during the supernova explosion of the initially more massive star, but the moderate peculiar velocities of Be X-ray binaries indicate that the progenitors lost most of their mass prior to the supernova (in accordance with model predictions). Whether all Be stars were spun up by binary mass transfer remains unknown, since the post-mass transfer companions are difficult to observe.

2001, ApJ, 555, 364

Stellar and circumstellar activity in the Be star EW Lac from the 1993 multi-site campaign

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A multi-site, multi-technique campaign on the Be star EW Lac was held for about 9 days in August–September 1993. We present results of the analysis of visual, high S/N spectroscopic data (He I 6678 Å and Hα). Search for short-term variability was carried out on He I 6678 (line profiles, radial velocity (RV), equivalent width (EW), full width at half-maximum ($fwhm$) on the absorption part of the line profile and on violet (V) and red (R) emission peaks) and on Hα emission line (line profiles, EW, V, R, and V/R ratio). The presence of multi-periodicity is confirmed and we detected the frequencies found in 1989 by Floquet et al. (1992) during an 8-day mono-site campaign. Possible non-radial pulsation solutions for the main frequencies detected are $\ell \approx 2-3$, $|m| \approx 2-3$. We found evidence on the He I 6678 line of episodic matter outflows through the presence of relatively broad, variable absorption line-profile variations. At least one sharp absorption feature was also observed slowly crossing the stellar disc. It is attributed to a blob of matter temporarily orbiting the star. A brief account is given of broad-band polarimetric observations, performed over 6 nights. A correlation is found between the variation in intrinsic polarization level in the B-band and He I 6678 Å strength. Finally, we present a simple model that reproduces rather well the additional "pseudo-photosphere" contribution in 1993 as opposed to 1989.

2000, A&A, 362, 1020

Viscous Transonic Decretion in Disks of Be Stars

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We study the characteristics of the outflow in disks of Be stars, based on the viscous decretion disk scenario. In this scenario, the matter ejected from the equatorial surface of the star drifts outward because of the effect of viscosity, and forms the disk. For simplicity, we adopt the α-prescription for the viscous stress, and assume the disk to be isothermal. Solving the resulting wind equations, we find that a transonic solution exists for any value of α. The sonic point is located at $r > 100R$ for plausible values of parameters, where R is the stellar radius. The sonic radius is smaller for higher temperature and/or larger radiative force. We also find that the topology of the sonic point is nodal for $\alpha \gtrsim 0.95$, while it is of saddle type for $\alpha \lesssim 0.9$. We expect that the sonic point in the former case is unstable, whereas that in the latter case is stable. The outflow is highly subsonic in the inner part of the disk. Roughly, the outflow velocity increases linearly with r and the surface density decreases as r^{-2}. Interestingly, the disk is near Keplerian in the inner subsonic region, while it is angular momentum conserving in the outer subsonic region and in the supersonic region. Our results, together with the observed range of the base density for Be star disks, suggest that the mass loss rate in the equatorial region is at most comparable with that in the polar region.

2001, PASJ, 53, 119

Properties and nature of Be stars XX. Binary nature and orbital elements of γ Cas

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An analysis of accurate radial velocities (RVs) of the Be star γ Cas from 295 Reticon spectrograms secured between October 1993 and May 2000 allowed us to prewhiten the RVs for the long-term changes and to obtain the first orbital RV curve of this star. The orbital period is 203.59 days and the orbit has an eccentricity of 0.26. The orbital motion is detectable even in the published velocities, based on photographic spectra. This implies that γ Cas is a primary component of a spectroscopic binary. The secondary has a mass of about 1 solar mass, appropriate for a white dwarf or a neutron star, but it could also be a normal late-type dwarf. The ultimate solution of the dispute whether the observed X-ray emission is associated with the secondary or with the primary will need further dedicated studies.

2000, A&A, 364, 85

Near-IR and visible interferometry of Be stars: constraints from wind models

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We report theoretical H I visible and near-IR line profiles, i.e. Hα (6562 Å), Hβ (4861 Å) and Brγ (21656 Å), and intensity maps for a large set of parameters (density, temperature, envelope geometry, inclination angle), representative of early to late Be spectral types. We have computed the size of the emitting region in the Brγ line and its nearby continuum which both originate from a very extended region, i.e. at least 40 stellar radii which is twice the size of the Hα emitting region. We predict the relative fluxes from the central star, the envelope contribution in the given lines and in the continuum for a wide range of parameters characterizing the disk models. For a density $\rho = 5 \times 10^{-13}$ g cm^{-3} at the base of the stellar photosphere, we obtain the largest probability of H I IR lines in emission, which is a factor of 100 lower than typical values found for Be stars. We have also studied the effect of changing the spectral type on our results and we obtain a clear correlation between the luminosity in Hα and in the infrared. We found that for a density $\rho = 5 \times 10^{-12}$ g cm^{-3}, the probability of detecting H I IR lines in emission must be stronger for late-B spectral type stars. If no IR lines are detected for late types, it may indicate that the density in the disc is very high ($\sim 10^{-11}$ g cm^{-3}). On the other hand, we found that around $\rho = 5 \times 10^{-13}$ g cm^{-3}, it is possible to have a large envelope contribution in the Brγ line and a similar or even smaller emission in the Balmer lines. Even if Brγ is formed in an extended region, it is possible to obtain a $fwhm$ and a V/R that agree well with observed profiles. Finally, it seems that the contribution in the Brγ line increases when the envelope becomes more and more "disk-like", contrary to the Hα and Hβ lines.

2001, A&A, 367, 532

Far Ultraviolet Spectra of B Stars near the Ecliptic

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Spectra of B stars in the wavelength range of 911–1100 Å have been obtained with the *EURD* spectrograph onboard the Spanish satellite *MINISAT-01* with $\sim$ 5 Å spectral resolution. *IUE* spectra of the same stars have been used to normalize Kurucz models to the distance, reddening and spectral type of the corresponding star. The comparison of 8 main-sequence stars studied in detail (α Vir, ϵ Tau, λ Tau, τ Tau, α Leo, ζ Lib, θ Oph, and σ Sgr) shows agreement with Kurucz models, but observed fluxes are 10–40% higher than the models in most cases. The difference in flux between observations and models is higher in the wavelength range between Lyman α and Lyman β. We suggest that Kurucz models underestimate the FUV

flux of main-sequence B stars between these two Lyman lines. Computation of flux distributions of line-blanketed model atmospheres including non-LTE effects suggests that this flux underestimate could be due to departures from LTE, although other causes cannot be ruled out. We found the common assumption of solar metallicity for young disk stars should be made with care, since small deviations can have a significant impact on FUV model fluxes. Two peculiar stars (ρ Leo and ϵ Aqr), and two emission line stars (ϵ Cap and π Aqr) were also studied. Of these, only ϵ Aqr has a flux in agreement with the models. The rest have strong variability in the IUE range and/or uncertain reddening, which makes the comparison with models difficult.

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Comparison of the Hα circumstellar disks in Be/X-ray binaries and Be stars

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We present a comparative study of the circumstellar disks in Be/X-ray binaries and isolated Be stars based upon the Hα emission line. ¿From this comparison it follows that the overall structure of the disks in the Be/X-ray binaries is similar to the disks of other Be stars, i.e. they are axisymmetric and rotationally supported. The factors for the line broadening (rotation and temperature) in the disks of the Be stars and the Be/X-ray binaries seem to be identical. However, we do detect some intriguing differences between the envelopes. On average, the circumstellar disks of the Be/X-ray binaries are twice as dense as the disks of the isolated Be stars. The different distribution of the Be/X-ray binaries and the Be stars seen in the full width half maximum versus peak separation diagram indicates that the disks in Be/X-ray binaries have on average a smaller size, probably truncated by the compact object.

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The circumstellar structure of the Be shell star ϕ Per: I. Data analysis

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We present new phase resolved observations of emission lines of the Be binary ϕ Per. Analyzing the orbital phase variations in the He I emission features we find strong arguments that the feature as a whole originates in the outer parts of the disk around the primary star. In addition to the He I 6678 and 5876 lines, the emission features with orbital phase variations were detected in three more He I lines. The observations are in agreement with the scenario of Poeckert and others, in which the outer parts of an axisymmetric disk are illuminated by the radiation of the secondary. The observations after 1996 are consistent with a growing global density inhomogeneity in the circumprimary disk as it occurs in disks of single Be stars. The combination of the illumination effect and the increasing density inhomogeneity make ϕ Per an ideal laboratory to study density perturbations of circumstellar disks of Be stars in more detail.

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The circumstellar structure of the Be shell star ϕ Per: II. Modeling

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We model Fe II 5317 emission lines and phase resolved He I 6678 and 5876 emission lines of the bright B2e+sdO shell binary ϕ Per to find the size and shape of the excitation region inside the circumprimary disk. We find the Fe II 5317 emission to originate within 9 stellar radii in an axisymmetric disk around the primary. Orbital phase variations of He I 6678 are fit in terms of a disk sector with disk radius of 10 stellar radii and opening angle of $\simeq 120°$ facing the secondary. This region can be alternatively described by an intersection of a sphere around the secondary and the circumprimary disk with a penetration depth of about 7 R_*. Similar fit values are found for He I 5876. The enigmatic orbital phase precedence of shell occurrence in the He I emission features is discussed. We favor a model in which the inner He I shell is deformed because of differential rotation in combination with a finite recombination time.

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Be stars: Single and Binary Components

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There is growing evidence that a significant number of the rapidly rotating Be stars were spun up through mass transfer in massive close binary stars. We observe Be stars in several kinds of binaries predicted by theory: (1) Be + a cool, Roche-filling companion (so-called "hot Algols"), (2) Be + He star (the stripped down core of the mass donor), and (3) Be + neutron star (Be X-ray binaries). There are no known examples of Be + white dwarf binaries (although EUVE observations of the system λ Sco may have revealed the first rapidly rotating B star + white dwarf binary). Here I review the observational data on Be stars in binaries for comparison with model predictions. Because the detection of hot, faint (He star and white dwarf) companions is so difficult, we still cannot estimate accurately the fraction of such systems among the Be star population. Thus, the actual percentage of Be stars formed by binary mass transfer processes remains unknown.

In the proceedings of "The influence of binaries on stellar population studies", ed. D. Vanbeveren (Dordrecht: Kluwer)

The Algol-Type Binaries

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The nature of the circumstellar material in interacting binaries of the Algol-type, including the accretion disk, gas stream, high temperature plasma, and domains of outflow is reviewed. Mass transfer is compared in six similar systems with early B primaries and short-moderate periods that approximately represent a series of snapshots of such binaries during their slow evolutionary phase. Evidence for moderate systemic mass loss during the current and earlier stages is presented.

In the proceedings of "The influence of binaries on stellar population studies", ed. D. Vanbeveren (Dordrecht: Kluwer)

A Representative Sample of Be Stars IV: Infrared Photometry and the Continuum Excess

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We present infrared (JHK) photometry of 52 isolated Be stars of spectral types O9–B9 and luminosity classes III–V. We describe a new method of reduction, enabling

separation of interstellar reddening and circumstellar excess. Using this technique we find that the disc emission makes a maximum contribution to the optical ($B-V$) colour of a few tenths of a magnitude. We find strong correlations between a range of emission lines (Hα, Brγ, Br11, and Br18) from the Be stars' discs, and the circumstellar continuum excesses. We also find that stellar rotation and disc excess are correlated.

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The Be/X-ray transient 4U 0115+63/V635 Cas: I. A consistent model

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We present photometry and high SNR spectroscopy in the classification region of V635 Cas, the optical counterpart to the transient X-ray pulsator 4U 0115+63, taken at a time when the circumstellar envelope had disappeared. V635 Cas is classified as a B0.2Ve star at a distance of 7–8 kpc. We use the physical parameters derived from these observations and the orbit derived from X-ray observations to elaborate a model of the system based on the theory of decretion discs around Be stars. We show that the disc surrounding the Be star must be truncated by the tidal/resonant interaction with the neutron star and cannot be in a steady state. This explains many of the observed properties of 4U 0115+63. In particular, because of this effect, under normal circumstances, the neutron star cannot accrete from the disc, which explains the lack of regular Type I outbursts from the source.

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The Be/X-ray transient 4U 0115+63/V635 Cas: II. Outburst mechanisms

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We present multi-wavelength long-term monitoring observations of V635 Cas, the optical counterpart to the transient X-ray pulsar 4U 0115+63. The evolution of emission lines and photometric magnitudes indicates that the Be star undergoes relatively fast ($\sim 3-5$ yr) quasi-cyclic activity, losing and reforming its circumstellar disc. We show that the general optical, infrared and X-ray behaviour can be explained by the dynamical evolution of the viscous circumstellar disc around the Be star. After each disc-loss episode, the disc starts reforming and grows until it reaches the radius at which the resonant interaction of the neutron star truncates it. At some point, the disc becomes unstable to (presumably radiative) warping and then tilts and starts precessing. The tilting is very large and disc precession leads to a succession of single-peaked and shell profiles in the emission lines. Type II X-ray outbursts take place after the disc has been strongly disturbed and we speculate that the distortion of the disc leads to interaction with the orbiting neutron star. We discuss the implications of these correlated optical/X-ray variations for the different models proposed to explain the occurrence of X-ray outbursts in Be/X-ray binaries. We show that the hypothesis of mass ejection events as the cause of the spectacular variability and X-ray outbursts is unlikely to be meaningful for any Be/X-ray binary.

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Stellar and circumstellar activity of the Be star μ Centauri III: Multiline nonradial pulsation modeling

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After the description and time series analysis of the variability of the circumstellar and stellar lines, respectively, in Papers I and II of this series, this paper sets out to model the stellar variability in terms of multi-mode nonradial pulsation (*nrp*), but also adds another 109 echelle spectra to the database, obtained in 1999. While the near-circumstellar emission has faded further, the six periods and the associated line profile variabilities (*lpv*) have remained unchanged. For the modeling, $\mathcal{P}_1$ of the periods $\mathcal{P}_1$-$\mathcal{P}_4$ close to 0.5 day, and $\mathcal{P}_5$ of the two periods $\mathcal{P}_5$ and $\mathcal{P}_6$ near 0.28 day were selected, because they have the largest amplitude in their respective groups, which are characterized by their own distinct phase-propagation pattern. Permissible

ranges of mass, radius, effective temperature, projected equatorial rotation velocity, and inclination angle were derived from calibrations and observations available in the literature. A total of 648 different combinations of these parameters were used to compute a number of trial series of line profiles for comparison with the observations. Next to reproducing the observed variability, the primary constraint on all models was that the two finally adopted solutions for $\mathcal{P}_1$ and $\mathcal{P}_5$ had to be based on only one common set of values of these quantities. This was, in fact, accomplished. Townsend's 1997 code Bruce was deployed to model the pulsational perturbations of the rotationally distorted stellar surface. With the help of Kylie, from the same author, these perturbations were converted into observable quantities. The local flux and the atmosphere structure were obtained from a grid of Atlas9 models with solar metallicity, while the formation of 5967 spectral lines was calculated with the LTE code of Bachek et al. (1966). An initial coarse grid of models using all these ingredients was computed for all 12 *nrp* modes with $\ell \leq 3$ and $m \neq 0$. Comparison with the observed variability of C II 4267, which is the best compromise between contamination by circumstellar emission and significance of the variability, yielded ($\ell = 2$, $m = +2$) for $\mathcal{P}_1$ (and, by implication, $\mathcal{P}_2$-$\mathcal{P}_4$) and ($\ell = 3$, $m = +3$) for $\mathcal{P}_5$ (and $\mathcal{P}_6$) as the best matching *nrp* modes. At 9 $M_\odot$ / 3.4 $R_\odot$ and 440 km s^{-1}, respectively, the mass-to-radius ratio and the equatorial velocity are on the high side, but not in fundamental conflict with established knowledge. The photometric variations of all six modes combine at most to a maximal peak-to-peak amplitude of 0.015 mag, consistent with the non-detection of any of the spectroscopic periods by photometry. Without inclusion of additional physical processes, present-day linear *nrp* models are fundamentally unable to explain major red-blue asymmetries in the power distribution, which however seem to be limited to only some lines and the modes with the highest amplitudes. Nevertheless, the model reproduces very well a wide range of observed details. Most notable among them are: (i) Although all modeling was done on the *residuals from the mean profiles only*, the mean spectrum *predicted* by the model closely fits the observed one. (ii) Dense series of high-quality spectra obtained as early as 1987 and as recently as 1999, published independently but not included in the modeling efforts of this paper, are matched in great detail by the multiperiodic *nrp* model. As in ω CMa, the inferred modes are retrograde in the corotating frame and in the observer's frame appear prograde only because of the rapid rotation. This has implications for models of the ejection of matter during line emission outbursts, which in μ Cen are correlated with the beating of modes in the 0.5 d group of periods. The length of the corotating periods as well as the horizontal-to-vertical velocity amplitude ratios suggest a g-mode character.

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A Useful Approximation for Computing the Continuum Polarization of Be Stars

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2002, Be Star Newsletter, **35** *– 38*

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This paper describes a practical model for the polarization of Be stars which can be used to estimate roughly the physical parameters for optically thin circumstellar envelopes from broadband *UBVRI* photopolarimetry data. Analysis of long-term variability in terms of these parameters is a promising approach toward understanding the Be phenomenon. An interesting result from fitting the model to observations of eight Be stars is that all of them may have geometrically thin disks, with opening half-angles on the order of ten degrees or less. This contributes to the growing evidence that most Be disks are geometrically thin.

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Statistical analysis of intrinsic polarization, IR excess, and projected rotational velocity distributions of classical Be stars

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We present the results of statistical analyses of a sample of 627 Be stars. The parameters of intrinsic polarization (p_*), projected rotational velocity ($v \sin i$), and near IR excesses have been investigated. The values of p_* have been estimated for a much larger and more representative sample of Be stars ($\approx$ 490 objects) than previously.

We have confirmed that most Be stars of early spectral type have statistically larger values of polarization and IR excesses in comparison with the late spectral type stars. It is found that the distributions of p_* diverge considerably for the different spectral subgroups. In contrast to late spectral types (B5–B9.5), the distribution of p_* for B0–B2 stars does not peak at the value $p_* = 0\%$. Statistically significant differences in the mean projected rotational velocities ($\overline{v \sin i}$) are found for different spectral subgroups of Be stars in the sense that late spectral type stars (V luminosity class) generally rotate faster than early types, in agreement with previously published results. This behaviour is, however, not obvious for the III–IV luminosity class stars. Nevertheless, the calculated values of the ratio v_t/v_c of the true rotational velocity, v_t, to the critical velocity for break-up, v_c, is larger for late spectral type stars of all luminosity classes. Thus, late spectral type stars appear to rotate closer to their break–up rotational velocity.

The distribution of near IR excesses for early spectral subgroups is bimodal, the position of the second peak displaying a maximum value $E(V-L) \approx 1\overset{\rm m}{.}3$ for O–B1.5 stars, decreasing to $E(V-L) \approx 0\overset{\rm m}{.}8$ for intermediate spectral types (B3–B5). It is shown that bimodality disappears for late spectral types (B6–B9.5).

No correlations were found between p_* and near IR excesses and between $E(V-L)$ and $v \sin i$ for the different subgroups of Be stars. In contrast to near IR excesses, a relation between p_* and far IR excesses at 12μm is clearly seen.

2002, Be Star Newsletter, **35** – *39*

A clear relation between p_* and $v \sin i$ (as well as between p_* and $\overline{v \sin i}/v_c$) is found by the fact that plots of these parameters are bounded by a "triangular" distribution of p_*: $v \sin i$, with a decrease of p_* towards very small and very large $v \sin i$ (and $\overline{v \sin i}/v_c$) values. The latter behaviour can be understood in the context of a larger oblateness of circumstellar disks for the stars with a rapid rotation.

From the analysis of correlations between different observational parameters we conclude that circumstellar envelopes for the majority of Be stars are optically thin disks with the range of the half-opening angle of $10° < \Theta < 40°$.

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Population Synthesis of Be/White Dwarf Binaries in the Galaxy

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Using the "Scenario Machine" (a numerical code that models the evolution of large ensembles of binary systems) we study the number and physical properties of binary Be stars with white dwarfs taking account of the compact object cooling and we discuss the ways of their formation. In our calculations we take into account the influence of tidal synchronization on the evolution of stars in a close binary. The synchronization time scale may be less than the life-time of a Be star on the main sequence after the first mass transfer. It has strong effects on the resulting number distribution of binary Be stars over orbital periods. In particular, it can explain the lack of short period Be binaries. According to our calculations the number of binary systems containing a Be star paired with a white dwarf in the Galaxy is very large — 70% of all Be stars formed as a result of binary evolution must have a white dwarf as a companion. Based on our calculations we conclude that the compact companion in these systems must have a high surface temperature. The number distribution over the surface temperature peaks at 2×10^4 K for all white dwarfs and at 4×10^4 K for white dwarfs paired with early-type Be stars (between B0 and B2). The registration of white dwarfs in such systems is hampered by the fact that the entire orbit of a white dwarf is embedded in the dense circumstellar envelope of the primary star (our calculations show that the majority of Be/WD systems have orbital periods less than one year) and all extreme-UV and soft X-ray photons of a compact companion are absorbed by the Be star envelope. The detection of a white dwarf is possible during the period when the Be star disc-like envelope is lacking by the detection of white dwarf extreme-UV and soft X-ray emission. This method of registration appears to be particularly promising for "single" early-type Be stars because in these systems the white dwarfs must have a very high surface temperature. However, the loss of the Be disc-like envelope does not often occur and it is a rather rare event for many Be stars. The best possibility of white dwarf detection is given by the study of helium spectral lines found in emission from several Be stars. The ultraviolet continuum energy of these Be stars is found to be not enough to produce the observed helium emission. Besides, we also discuss the orbital properties of binary Be star systems with other evolved companions such as helium stars and neutron stars and give a possible explanation for the lack of Be/black hole binaries.

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Zeeman Detection of Magnetic Fields in Hot Stars

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No confirmed detection of a surface magnetic field exists for any nondegenerate star earlier than about spectral type B2. On the other hand, the existence of intense fields in main sequence A and B type stars, along with the cyclic variability commonly observed in the winds and envelopes of many O and Be stars, provide strong indications that magnetic fields are indeed present in hot stars. In this paper I discuss the observational and theoretical bases for suspecting that many hot stars host surface magnetic fields of order 10-1000 G. I describe the difficulties involved in using conventional Zeeman magnetic diagnostic techniques to detect such fields, and review the various attempts to date. I conclude by describing the recent "success stories" of β Cep and θ^1 Ori C, and describe possible future strategies and the outlook for exploitation of large telescopes.

In the proceedings of "Magnetic Fields Across the H-R Diagram", ed. G. Mathys, S.K. Solanki, & D.T. Wickramasinghe (San Francisco: PASP)

Hα emission line spectroscopy in NGC 330: On the hybrid model for global oscillations in Be star circumstellar disks

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We perform an observational test on global oscillations in Be star circumstellar disks in the metal deficient environment of the SMC. According to the hybrid model of disk oscillations early-type Be stars require an optically thin line force to establish a density wave. The low metallicity in the SMC should therefore diminish or prevent the formation of disk oscillations in early-type Be stars. We present short wavelength range spectra around Hα of 48 Be stars in the young open cluster NGC 330 in the SMC. We find that the fraction of early-type Be stars in NGC 330 which host a global disk oscillation does not differ from the known fraction of Galactic field Be stars. This observational result is in contradiction to the theoretical prediction. We discuss several interpretations and propose a further observational test.

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UBVI and Hα Photometry of the h & χ Persei Cluster

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UBVI and Hα photometry is presented for 17319 stars in the vicinity of the young double cluster h & χ Persei. Our photometry extends over a $37' \times 1^\circ$ field centered on the association. We construct reddening contours within the imaged field. We find that the two clusters share a common distance modulus of 11.75$\pm$0.05 and ages of $\log \mathrm{age(yr)} = 7.1 \pm 0.1$. From the $V-$Hα colour, a measure of the Hα emission strength, we conduct a survey for emission line objects within the association. We detect a sample of 33 Be stars, 8 of which are new detections. We present a scenario of evolutionary enhancement of the Be phenomenon to account for the peak in Be fraction towards the top of the main-sequence in the population of h & χ Persei and similar young clusters.

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The magnetic field and wind confinement of β Cephei: new clues for interpreting the Be phenomenon?

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In this paper, we use the very recent spectropolarimetric observations of β Cep collected by Henrichs et al. (2001) and propose for this star a consistent model of the large scale magnetic field and of the associated magnetically confined wind and circumstellar environment. A re-examination of the fundamental parameters of β Cep in the light of the Hipparcos parallax indicates that this star is most likely a 12 $M_\odot$ star with a radius of 7 $R_\odot$, effective temperature of 26000 K and age of 12 Myr, viewed with an inclination of the rotation axis of about 60°. Using two different modelling strategies, we obtain that the magnetic field of β Cep can be approximately described as a dipole with a polar strength of 360 ± 30 G, whose axis of symmetry is tilted with respect to the rotation axis by about $85° \pm 10°$.

Although one of the weakest detected to date, this magnetic field is strong enough to confine magnetically the wind of β Cep up to a distance of about 8 to 9 R_*. We find that both the X-ray luminosity and variability of β Cep can be explained within the framework of the magnetically confined wind shock model of Babel & Montmerle (1997a), in which the stellar wind streams from both magnetic hemispheres collide with each other in the magnetic equatorial plane, producing a strong shock, an extended postshock region and a high density cooling disc.

By studying the stability of the cooling disc, we obtain that field lines can support the increasing disc weight for no more than a month before they become significantly elongated to equilibrate the gravitational plus centrifugal force, thereby generating strong field gradients across the disc. The associated current sheet eventually tears, forcing the field to reconnect through resistive diffusion and the disc plasma to collapse towards the star. We propose that this collapse is the cause for the recurrent Be episodes of β Cep, and finally discuss the applicability of this model to He peculiar, classical Be, and normal non-supergiant B stars.

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Hot Emission-Line Stars After 134 Years of Study: A personal view of current problems

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A brief review of current problems in the research of hot emission-line stars is presented. Special attention is paid to problems of reliable determination of basic physical properties of underlying stars and to possible role of duplicity in the whole phenomenon. A preliminary catalogue of OBA emission-line stars in binaries is also included.

In the proceedings of 2000, "Interacting Astronomers: A Symposium on Mirek Plavec's Favourite Stars", Publications of the Astronomical Insti-

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Spectroscopic Observations of the Delta Scorpii Binary during Its Recent Periastron Passage

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The bright star δ Sco has been considered a typical B0-type object for many years. Spectra of the star published prior to 1990 showed no evidence of emission, but only of short-term line profile variations attributed to nonradial pulsations. Speckle interferometric observations show that δ Sco is a binary system with a highly-eccentric orbit and a period of $\sim$10.6 years. Weak emission in the Hα line was detected in its spectrum for the first time during a periastron passage in 1990. Shortly before the next periastron passage in the summer of 2000, the binary entered a strong Hα emission and enhanced mass loss phase. We monitored the spectroscopic development of the Be outburst from July 2000 through March 2001. In this paper we present results from our spectroscopy, refine elements of the binary orbit, and discuss possible mechanisms for the mass loss.

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Ultraviolet Spectrophotometry of Variable Early-Type Be and B stars Derived from High-Resolution IUE Data

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High-dispersion *IUE* data encode significant information about aggregate line absorptions that cannot be conveniently extracted from individual stellar spectra. Herein we apply a new technique in which fluxes from each echelle order of a short-wavelength *IUE* spectrum are binned together to construct low-resolution spectra of a rapidly varying B or Be star. The division of binned spectra obtained during a "bright-star"

phase by spectra from a "faint-star" phase leads to a ratioed spectrum which contains information about the mechanism responsible for a star's variability. The most likely candidate mechanisms are either the periodic or episodic occultations of the star by ejected matter or a change in photospheric structure, e.g. from pulsation. We model the variations caused by these mechanism by means of model atmosphere and absorbing-slab codes. Line absorptions strength changes are rather sensitive to physical conditions in circumstellar shells and "clouds" at temperatures of 8,000–13,000 K, which is the regime expected for circumstellar structures of early B stars.

To demonstrate proofs of concept, we construct spectral ratios for circumstellar structures associated with flux variability in various Be stars: (1) Vela X-1 has a bow-shock wind trailing its neutron star companion; at successive phases and hence in different sectors, the wind exhibits spectrophotometric signatures of a 13,000 K or 26,000 K medium (2) 88 Her undergoes episodic "outbursts" during which its UV flux fades, followed a year later by a dimming at visible wavelengths as well; the ratioed spectrum indicates the "phase lag" is a result of a nearly gray opacity that dominates all wavelengths as the shell expands from the star and cools, permitting the absorptions in the visible to "catch up" to those in the UV, and (3) ζ Tau and 60 Cyg exhibit periodic spectrum and flux changes, which match model absorptions for occulting clouds but are actually most easily seen from selective variations of various resonance lines. In addition, ratioed UV spectra of radial and large-amplitude nonradial pulsating stars show unique spectrophotometric signatures which can be simulated with model atmospheres. An analysis of ratioed spectra obtained for a representative sample of 18 classical Be stars known to have rapid periodic flux variations indicates that 13 of them have ratioed spectra which are relatively featureless or have signatures of pulsation. Ratioed spectra of three others in the sample exhibit signatures that are consistent with the presence of co-rotating clouds.

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A natural explanation for periodic X-ray outbursts in Be/X-ray binaries

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When applied to Be/X-ray binaries, the viscous decretion disc model, which can successfully account for most properties of Be stars, naturally predicts the truncation of the circumstellar disc. The distance at which the circumstellar disc is truncated depends mainly on the orbital parameters and the viscosity. In systems with low eccentricity, the disc is expected to be truncated at the 3:1 resonance radius, for which the gap between the disc outer radius and the critical lobe radius of the Be star is so wide that, under normal conditions, the neutron star cannot accrete enough gas at periastron passage to show periodic X-ray outbursts (Type I outbursts). These

systems will display only occasional giant X-ray outbursts (Type II outbursts). On the other hand, in systems with high orbital eccentricity, the disc truncation occurs at a much higher resonance radius, which is very close to or slightly beyond the critical lobe radius at periastron unless the viscosity is very low. In these systems, disc truncation cannot be efficient, allowing the neutron star to capture gas from the disc at every periastron passage and display Type I outbursts regularly. In contrast to the rather robust results for systems with low eccentricity and high eccentricity, the result for systems with moderate eccentricity depends on rather subtle details. Systems in which the disc is truncated in the vicinity of the critical lobe will regularly display Type I outbursts, whereas those with the disc significantly smaller than the critical lobe will show only Type II outbursts under normal conditions and temporary Type I outbursts when the disc is strongly disturbed. In Be/X-ray binaries, material will be accreted via the first Lagrangian point with low velocities relative to the neutron star and carrying high angular momentum. This may result in the temporary formation of accretion discs during Type I outbursts, something that seems to be confirmed by observations.

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BeppoSAX survey of Be/X-ray binary candidates

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We present a BeppoSAX survey of five Be/X-ray binary candidates. We report on the identification of two of them, HD 110432 and HD 141926, as low luminosity Be/X-ray binaries. For HD 110432 we report on the detection of a pulsation period of ~14 ks. Because the luminosity of these sources is low and their spectra do not require non-thermal emission models, these systems are good Be+White Dwarf candidates. If the pulsation period for HD 110432 is confirmed, this system would be the most firm Be+WD candidate found up to date. The other three objects HD 65663, HD 249179 and BD+53 2262 did not show detectable X-ray emission. We argue that, while the properties of BD+53 2262 are still consistent with a quiescent Be+Neutron Star scenario, the lack of detection for the other two objects implies that they are most probably not X-ray binaries.

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High angular resolution observations in the near infrared and modeling of the peculiar envelope of HD 62623

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We report new observations of the peculiar star HD 62623 obtained with aperture masking interferometry performed on the Keck I telescope at $\lambda = 1.24$, 1.65, 2.26 and 3.08 μm. The envelope around this star appears partially resolved in the near infrared except at 1.65 μm. Radiative transfer modeling of the dust shell of this star has been performed in spherical geometry. This modeling has two goals: it provides a framework for understanding the partially resolved object shown by the visibility curves, and it allows investigation of the envelope of HD 62623 by discrimination between proposed models.
We show that reasonable fits to photometric observations can be obtained with a simple spherically symmetric silicate dust shell. Nevertheless, our high angular resolution measurements bring some important constraints on the modeling of the circumstellar environment of HD 62623. More realistic model involving the presence of a non spherically distributed dust envelope including the gas component in the circumstellar environment is required.

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HR 2142, Thirty Years After it was Hypothesized to be an Interacting Binary

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The current status of our knowledge of the HR 2142 system is reviewed. The mass flow in the system and its long-term behavior are currently being studied using *IUE* HIRES data obtained between 1979–95 and archival *Copernicus* observations acquired in the late 1970s. Some recent results are summarized here. The strength and velocity behavior of the infall components to the Si II, IV lines seen during the *primary* shell

phase from $\phi \sim$0.70–0.98 resemble that observed in conventional Algol systems. The inferred mass infall rate of $\sim 10^{-7}$ $M_\odot$ yr^{-1}, however, is too small to account for the massive Hα-emitting disk about the primary. The cause for the mass outflow observed during the *secondary* shell phase is still unknown. The nature of the secondary star, which remains undetected, is discussed. The small amount of residual flux in the UV that might be attributed to the secondary weakens the assumption that it must be an O subdwarf as in the ϕ Per system, but further studies are warranted.

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Evolution if circumstellar envelopes of Be stars: from disks to rings?

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New series of echelle spectra were obtained to study the medium- and long-term evolution of the disks of several Be stars. Subtle variations in the wings of optically thin and thick emission lines suggest that the conventional, static picture of the disk being in quasi-contact with the central star is justified primarily (only?) after an outburst event. Some weeks to months later, a low-density region seems to develop above the star and slowly grows outwards. A subsequent new outburst may later replenish this cavity. In fact, in two stars this more ring-like structure is apparently at times detached far enough from the star to allow for the formation of a secondary inner disk from the ejecta of a later outburst. This behaviour is not necessarily representative of Be stars in general because in the later spectral sub-types discrete mass loss events have not so far been observed to play a major role.

In the light of the apparent life cycle of such disks, a brief discussion is given of the differences in strength and variability between the winds of Be and normal B stars. It seems possible to attribute these differences to matter, that was initially in the disk and therefore largely shielded against the stellar radiation, but during the course of the inner excavation (or even complete destruction) of the disk becomes exposed.

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Astero-oscillometry: Gauging stars with oscillations

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Astero-oscillometry is presented as a new method for deriving stellar parameters on the basis of a physical modeling of line profile variability (*lpv*) caused by nonradial pulsation (*nrp*). First applications to rapidly rotating B-type stars show that the method is able to yield reasonable stellar parameters. The radii are systematically smaller compared to those derived by conventional methods. This could be attributed to possible effects of rapid rotation on stellar evolution. Since the method requires only one or a few pulsation modes to be excited, it is ideally suited to investigate early-type stars.

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Unified nrp-modelling of Be stars

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Recently, the line profile variability (*lpv*) of two low $v \sin i$ Be stars μ Cen and ω (28) CMa was successfully modelled as nonradial pulsation (*nrp*) of rapidly rotating stars seen pole-on. In this work, it is shown that the *lpv* of low $v \sin i$ early-type Be stars in general closely resembles these two cases, and is therefore explainable by the same mechanism. The *lpv* of intermediate to high $v \sin i$ Be stars can be explained by the very same model if only the inclination angle of the model is increased. Consequently, early-type Be stars form a distinct, fairly homogeneous class of non-radial low-order g-mode pulsators.

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HR 4074: an emission-free NRP twin of the Be star 28 CMa

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Identical line-profile variabilities in HR 4074 and 28 CMa imply a uniform physical mechanism in both stars. The long-term absence of line emission in HR 4074 rules out all circumstellar models.

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Photometric modeling of slowly-pulsating B stars

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Highlights are presented from a theoretical study of the photometric characteristics of slowly-pulsating B stars. One outstanding result is the discovery, for $\ell \geq 2$ modes, of cancellation between the flux variations originating from surface temperature perturbations, and those arising from radius perturbations. In addition to reducing greatly the variability generated by such modes, the cancellation introduces significant phase differences between the flux changes in each passband. On the grounds that similarly-large phase differences are not seen in observational data, it is suggested that the light variations of slowly-pulsating B stars might be due primarily to $\ell = 1$ modes.

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High and intermediate-resolution spectroscopy of Be stars: An atlas of Hγ, He I 4471 and Mg II 4481 lines

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We present an atlas of Hγ, He I λ 4471 and Mg II λ 4481 line profiles obtained in a 10 year observation period of 116 Be stars, which enabled many of them to be observed at quite different emission epochs. From the best fit of the observed He I λ 4471 line profiles with non-LTE, uniform $(T_{\rm eff}, \log g)$ and full limb-darkened model line profiles, we determined the $V \sin i$ of the program stars. To account, to some degree, for the line formation peculiarities related to the rapid rotation-induced non-uniform distributions of temperature and gravity on the stellar surface, the fit was achieved by considering $(T_{\rm eff}, \log g)$ as free parameters. This method produced $V \sin i$ estimations that correlate with the rotational velocities determined by Slettebak (1982) within a dispersion $\sigma \leq 30$ km s^{-1} and without any systematic deviation. They can be considered as given in the new Slettebak's et al. (1975) system. Only 13 program stars have discrepant $V \sin i$ values. In some objects, this discrepancy could be attributed to binary effects. Using the newly determined $V \sin i$ parameters, we found that the ratio of true rotational velocities $V/V_{\rm c}$ of the program Be stars has a very low dispersion around the mean value. Assuming then that all the stars are rigid rotators with the same ratio $V(\overline{\omega})/V_{\rm c}$, we looked for the value of $\overline{\omega}$ that better represents the distribution of $V \sin i/V_{\rm c}$ for randomly oriented rotational axes. We obtained $\overline{\omega} = 0.795$. This value enabled us to determine the probable inclination angle of the stellar rotation axis of the program stars. In the observed line profiles of Hγ, He I λ 4471, Mg II λ 4481 and Fe II λ 4351 we measured several parameters related to the absorption and/or emission components, such as: equivalent width, residual emission and/or absorption intensity, FWHM, emission peak separations, etc. The parameters related to the Hγ line emission profiles were used to investigate the structure of the nearby environment of the central star. From the characteristics of the correlations between these quantities and the inferred inclination angle, we concluded that in most of cases the Hγ line emission forming regions may not be strongly flattened. Using a simple representation of the radiation flux emitted by the star+envelope system, we derived first order estimates of physical parameters characterizing the Hγ line emission formation region. Thus, we obtained that the total extent of the Hγ region is $R_{\rm f} \simeq 2.5 \pm 1.0 R_*$ and that the density distribution in these layers can be mimicked with a power law $\rho \sim R^{-\alpha}$, where $\alpha = 2.5^{+2.2}_{-0.6}$. The same approach enabled us to estimate the optical depth of the Hγ line emission formation region. From its dependence with the aspect angle, we concluded that these regions are characterized by a modest flattening and that the ρ(equator)/ρ(pole) density contrast of the circumstellar envelope near the star should be two orders of magnitude lower than predicted by models based on a priori disc-shaped circumstellar envelopes. We found that the separation between the emission peaks, $\Delta_{\rm p}$, and the full width at half maximum, $\Delta_{1/2}$, of the Hγ line emission are not only sensitive to kinematic effects, but to line optical depth as well. This finding agrees with previous theoretical predictions and confirms that Huang's (1972) relation overestimates the extent of the Hγ line emission formation region.

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Emission activity of the Be star 28 CMa: entering a new cycle?

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A new major emission phase of the southern Be star 28 CMa is reported. It manifests itself as a brightening by more than $0\overset{m}{.}4$ in the V band and a drop of the Balmer line emission. The spectroscopic behaviour fits the outburst scheme derived for μ Cen, but takes place on a much longer time scale, thereby making 28 CMa an ideal target for detailed studies of Be star outbursts. On this basis, some spectroscopic phenomena expected to appear within a few months are mentioned.

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Photometric modeling of Slowly-Pulsating B stars

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The photometric characteristics of slowly-pulsating B stars are investigated using a numerical approach. Stability calculations are performed for a set of stellar models representative of the mid-B type, using a nonradial nonadiabatic pulsation code. The results from these calculations are used to synthesize photometry, in several common systems, for unstable modes of harmonic degrees $\ell = 1 \ldots 4$. Focusing on the Geneva system for illustrative purposes, a variety of techniques are employed to analyze and visualize the synthetic data, including the use of multicolour-amplitudes (Heynderickx 1994) and amplitude-phase (Stamford & Watson 1981) diagnostic diagrams. One outstanding aspect of the analysis is the discovery, for the $\ell = 2 \ldots 4$ modes, of 'inter-term cancellation' (ITC) — the process of destructive interference between the flux

variations originating from surface temperature perturbations and those arising from radius perturbations.

The ITC can be severe enough that a mode may be excited to a significant amplitude, and yet exhibit levels of photometric variability which fall below typical observational detection thresholds. Furthermore, it can affect not only the light variations in a given photometric passband, but also the variations of the bolometric flux. However, the cancellation is dependent on wavelength, and will not occur to the same degree in more than one passband. Therefore, simultaneous observation in a multitude of passbands represents the best approach to ensuring that no modes are overlooked during searches for variability in B-type stars.

A consequence of ITC is that ratios between the variability amplitude, in differing passbands, become very sensitive towards mode-to-mode changes in the pulsation. This increased sensitivity will tend to complicate any attempts at identifying the harmonic degrees of the modes responsible for observed variability. However, the cancellation also introduces significant phase differences between the light variations in each passband, especially for the $\ell = 3$ and $\ell = 4$ modes. On the grounds that correspondingly large phase differences are not seen in observational data, it is argued that the variability seen in slowly-pulsating B stars can tentatively be attributed to $\ell = 1$ and $\ell = 2$ modes.

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Multicomponent radiatively driven stellar winds II. Gayley-Owocki heating in multitemperature winds of OB stars

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We show that the so-called Gayley-Owocki (Doppler, GO) heating is important for the temperature structure of the wind of main sequence stars cooler than the spectral type O6. The formula for GO heating is derived directly from the Boltzmann equation as a direct consequence of the dependence of the driving force on the velocity gradient. Since GO heating deposits heat directly to the absorbing ions, we also investigated the possibility that individual components of the radiatively driven stellar wind have different temperatures. This effect is negligible in the wind of O stars, whereas a significant temperature difference takes place in the winds of main sequence B stars for stars cooler than B2. Typical temperature difference between absorbing ions and other flow components for such stars is of the order 10^3 K. However, in the case when passive component falls back onto the star the absorbing component reaches temperatures of order 10^6 K, which allows for emission of X-rays. Moreover, we compare our computed terminal velocities with the observed ones. We found quite

good agreement between predicted and observed terminal velocities. The systematic difference coming from the using of the so called "cooking formula" has been removed.

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New Spectroscopic Observations of the B[e]/K Binary System MWC 623
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Non-standard Abbreviations:

1. PAICR - Publications of the Astronomical Institute of the Academy of Sciences of the Czech Republic. These papers were part of the proceedings from the celebratory mini-symposium “Interacting Astronomers: A Symposium on Mirek Plavec’s Favorite Stars” held in honor of Prof. Plavec’s 75th birthday at UCLA on 2000 October 21.

2. EAA - Encyclopedia of Astronomy & Astrophysics, ed. P. Murdin (Bristol: Institute of Physics Publishing)

3. IBSPS - “The Influence of Binaries on Stellar Population Studies”, ed. D. Vanbeveren (Dordrecht: Kluwer)

7. MEETINGS

- 15–19 January 2001
  Magnetic Fields Across the Hertzsprung-Russell Diagram
  Santiago, Chile
  http://www.eso.org/gen-fac/meetings/magfields2001/

- 11–15 June 2001
  The First Eddington Workshop: Stellar-structure and Habitable Planet Finding
  Cordoba, Spain
  http://astro.esa.int/SA-general/Projects/Eddington/Eddi2001

- 26–31 July 2001
  IAU Colloquium No. 185: Radial and Nonradial Pulsations as Probes of Stellar Physics
  Leuven, Belgium
  http://www.ster.kuleuven.ac.be/~iau185

- 11–15 November 2002
  IAU Symposium No. 215: Stellar Rotation
  Cancun, Yucatan, Mexico
  http://www.astro.ugto.mx/~eenens/iau215/

See http://cadcwww.dao.nrc.ca/meetings/meetings.html for more.

8. LATEX TEMPLATE FOR ABSTRACTS

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}\end{center}
\centerline{\bf A. Author$^1$ and B. Author$^2$
}{\footnotesize $^1$   Institute One and Address
             \\ $^2$   Institute Two and Address
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