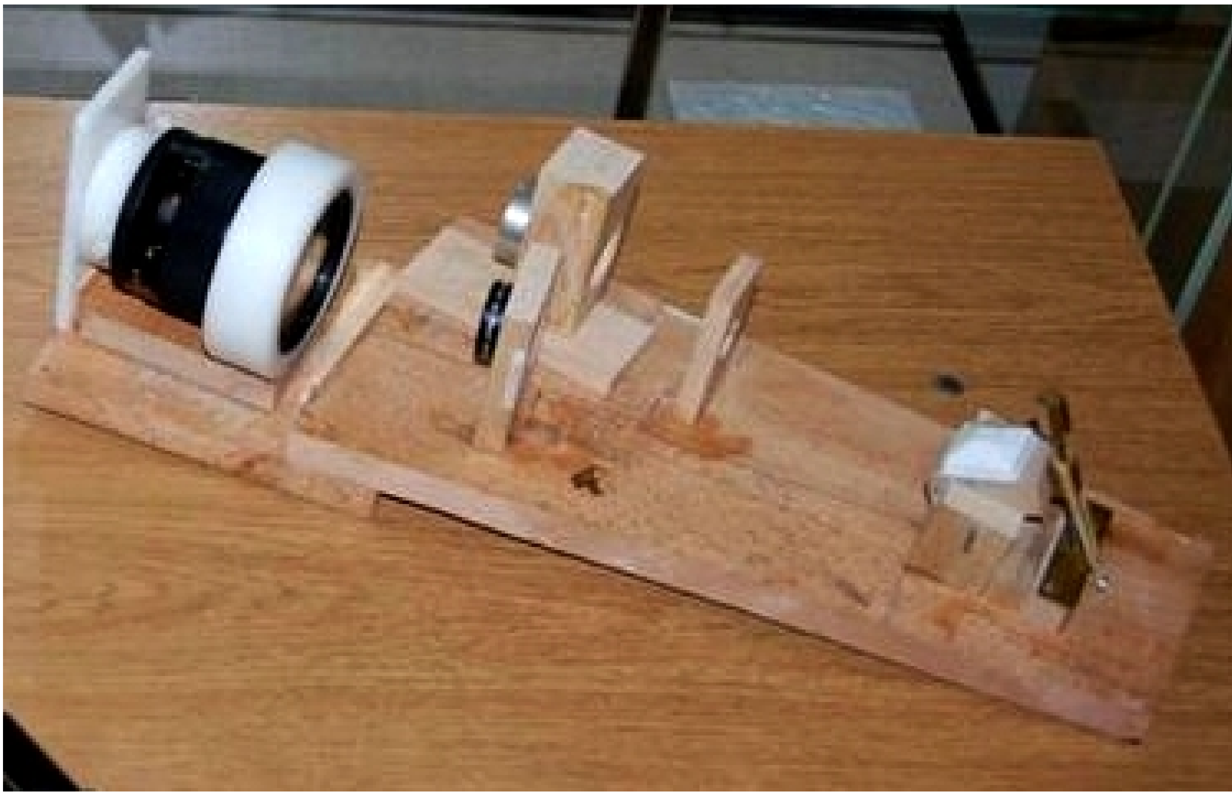
SPEKTRUM

Mitteilungsblatt der Fachgruppe Spektroskopie
in der Vereinigung der Sternfreunde e.V.

NR. 38 INTERNETAUSGABE 1 / 2010



TAGUNGSRÜCKBLICK RECKLINGHAUSEN

RADIALGESCHWINDIGKEITSMESSUNGEN AN MIZAR A

ROTATION FEATURES OF O AND B STARS

Impressum

Spektrum – Mitteilungsblatt der Fachgruppe Spektroskopie in der Vereinigung der Sternfreunde wird herausgegeben von der Fachgruppe Spektroskopie in der Vereinigung der Sternfreunde e.V. Es erscheint halbjährlich als PDF-Ausgabe oder auf Wunsch als Druckversion. Das Journal dient dem überregionalem als auch dem internationalen Erfahrungsaustausch auf dem Gebiet der Astrospektroskopie besonders für Amateure. Dazu können Beiträge in Deutsch oder English publiziert werden. Senden Sie Ihre Beiträge, Auswertungen, Erfahrungen und Kritiken an **Spektrum** zur Veröffentlichung ein, damit andere Spektroskopiefreunde an Ihren Erkenntnissen teilhaben und davon lernen können.

Spektrum – Mitteilungsblatt der Fachgruppe Spektroskopie in der Vereinigung der Sternfreunde is issued twice a year by Fachgruppe Spektroskopie of Vereinigung der Sternfreunde e.V. (The spectroscopy section of the German society for amateur astronomy). The journal is published as a PDF or as a printed version on special request. The aim of the journal is to be a national and international communication especially for amateurs, on topics related to astronomical spectrocopy. Contributions are welcome in German or English. Please send your papers, results, experiences and reviews to **Spektrum** for publication. The community can then benefit from your experience.

Die Fachgruppe Spektroskopie im Internet:	spektroskopie.fg-vds.de
Die Vereinigung der Sternfreunde e.V. im Internet:	www.vds-astro.de

Kontaktadresse (Redaktion, Bestellung gedruckter Ausgaben, Manuskripte)

Dr. Thomas Hunger
Normannenweg 39
59519 Möhnesee-Körbecke
fg-spektroskopie@vds-astro.de

Hinweise für Autoren:

Nur durch Ihre Artikel wird Spektrum gefüllt. Die Redaktion behält sich vor, in Rücksprache mit den Autoren Beiträge zu kürzen, anzupassen oder zu ändern. Für die Inhalte der Artikel ist aber allein der Autor verantwortlich.
Reichen sie Ihren Beitrag bitte elektronisch unter Berücksichtigung folgender Regeln ein:
Form des Textes: Senden sie vorzugsweise als unformatierten ASCII-Text. Tabellen mit Tabulatoren getrennt. Ein zusätzliches PDF des formatierten Gesamttextes ist anzuraten.
Aufbau der Artikel: Die Artikel benötigen einen Titel, eine vollständige Adressangabe des Autors / der Autoren, eine Kurzzusammenfassung, den klar gegliederten Artikel mit Einleitung und Zusammenfassung sowie eine vollständige Literaturangabe.
Abbildungen: Bitte getrennt vom Text senden. Empfehlenswert sind hochauflösende JPG, PNG und TIFF.

Hints for authors:
Your article will be edited to fit the style of Spektrum. The editor is responsible for editing the article in close collaboration with the author. The author is in charge of the content in all cases, however. Please send your contribution via electronic mail considering the following rules:
Text: Prepare it as unformated text (preferably ASCII). Tables: columns separated by tabs. A PDF printout of the whole document is highly recommended.
Article structure: Each article should include a title, an address line of the author(s), an abstract, a clear text body with introduction and conclusion and complete references.
Figures: Please send them separate from text. High resolution JPG, PNG or TIFF files are recommended.

(Special thanks to Robin Leadbeater for English translations.)

Umschlagfoto: Echelle-Spektrograph aus Holz von Berthold Stober.

Inhaltsverzeichnis / Content

Editorial

Liebe Leser des Spektrums,
liebe Spektroskopiker,

bedingt durch die Neustrukturierungen in der Fachgruppe, die Ihnen sicher nicht verborgen geblieben sind, hat sich die kontinuierliche Herausgabe unseres Fachgruppenorgans verzögert. Der langjährige Herausgeber und Gründer hat sich aus persönlichen Gründen zurückgezogen, so dass die Weiterführung erst geregelt werden musste. An dieser Stelle möchte ich aber Herrn Ernst Pollmann für seine langjährige und engagierte Arbeit im Dienste der Fachgruppe danken.

Mit dieser Ausgabe von Spektrum führe ich die Arbeit weiter. Die Zeitschrift ist aber nichts als eine Hülle, wenn keine Artikel aus dem Kreis der Aktiven sowie an den Themen der Astrospektroskopie Interessierten veröffentlicht vorliegen. Trauen Sie sich zu veröffentlichen, eine große Leserschaft wird es Ihnen danken.

Wie Sie bemerken, hat Spektrum ein neues Layout bekommen. Es war der allgemeine Tenor in der Gruppe, die Aufmachung neu zu gestalten. Ich hoffe, es spricht Sie an.

Mit sternfreundlichen Grüßen,
Thomas Hunger

Dear reader of Spektrum,
dear spectroscopist,

Due to changes in the structure of the Section, which you may be aware of, the publication of the latest edition of our section’s journal has been delayed. The long-time editor and founder has retired for personal reasons. The priority then was to find a new editor. I would like to thank Mr Ernst Pollmann for his many years of dedicated work in the service of the section.

With this issue of Spektrum I carry forward the work. The magazine is nothing but a shell without contributions from active spectroscopists and readers who are interested in the topic. I encourage you to publish your work to a wider audience that will thank you for it.

As you can see, Spektrum has a new look. It was the general feeling of the group that it should be redesigned. I hope it appeals to you.

Best regards and clear skies,
Thomas Hunger

Artikel

The website of the VdS spectroscopy section http://spektroskopie.fg-vds.de/

Thomas Eversberg
Schnörringen Telescope Science Institute – www.stsci.de

Introduction

Some years ago we established our section webpage. It was designed to be a portal for astronomical spectroscopy and all respective necessities. Our guideline was the regular request for information about how to make this field available for everybody, especially from those who have no education in physics. Until that, all available information about, e.g., how to build a spectrograph and the respective needs, the technique how to obtain and reduce spectra, the physics of stars and our sun had to be found somewhere hidden in the World Wide Web.

After some input from various colleagues our web page contains all basic information for the beginner as well as the advanced spectroscopist. This includes

- how to build a spectrograph, including automated Excel tools to estimate the respective optical parameters without mathematical knowledge,
- various publications from amateur and professional observers, fundamental literature and all previous journal editions,
- a virtual library,
- sorted external links,
- information out of the group (meetings, announcements, a database, a glossary, a wiki, etc.),
- a regularly updates news ticker and
- the link to our discussion forum.

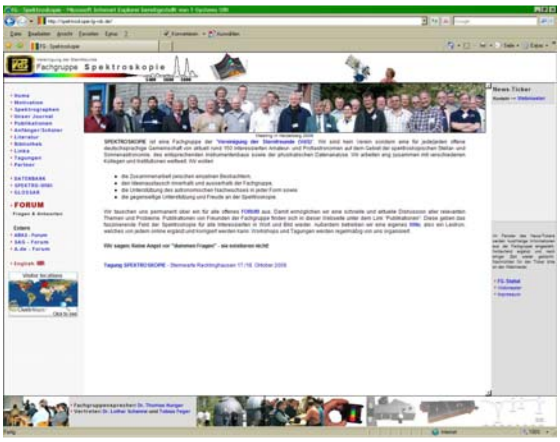
Information in our website

The site design focuses on a possibly easy and fast access to all information necessary. For this reason, the page is designed as a framed website. We tried to avoid scrolling where possible, although this is not always possible due to the large number of links and publications.

The site completely depends on the input of all interested people and luckily this works very well. Meanwhile we collected some hundred articles (mainly as optimized PDF for proper download) and important links to, e.g., other groups, manufacturers and pages about scientific methods and procedures. Some highlights are

- a public wiki to develop a spectroscopic encyclopaedia,
- a glossary for the explanation of spectroscopic expressions (Urs Flükiger),
- a database for stellar spectra in professional fits format (Otmar Stahl on his private server) and
- two Excel sheets for the easy and complete calculation of standard and Echelle spectrographs (Christian Buil and Klaus Vollmann).

All necessary tools for the interested user can



be found in the web page. The only investment is time to sort out data for the respective needs. The author (webmaster) wants to encourage all users to contribute new information for our site.

Visits from all over the world

In June 2006 we implemented a visitor counter (including respective visitor locations). In 2006/07 we got about 7.500 visits. This number jumped to more than 11.000 in 2007/08 and felt to 5.500 in 2008/09. When writing this article (Sept. 2009) the page got 1.300 visits since June 2009 and, hence, about 5.000 visits are expected for the year 2009/10.

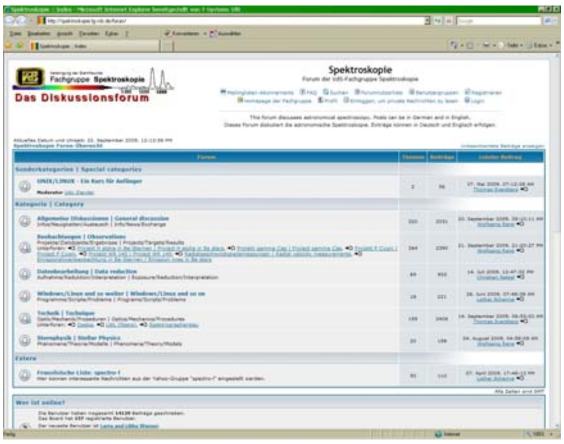
The visitor location has a prominent peak in Europe, especially in Germany. This is no surprise. Today, however, the visitors do not only come from the "hot spots" in spectroscopy (Germany, France) but from all over the world.

Fig. 2: Visitors location for our webpage (Sept. 2009).

A pleasant development can be observed in parts of eastern Europe (Czech Republic, Slovakia) and the USA where the number of visitors significantly increased during the last three years.

The webpage content increased dramatically after some time and the Vereinigung der Sternfreunde (VdS) offered web space for the section on their server. This generous offer as been accepted by the group and we migrated to their server.

Our discussion forum



In July 2006 we implemented a discussion forum for the group and all other interested people. After about half a year, all well known protagonists (~40) out of the group have been registered. Interestingly, the number of users permanently increased during the following years (Fig. 1).

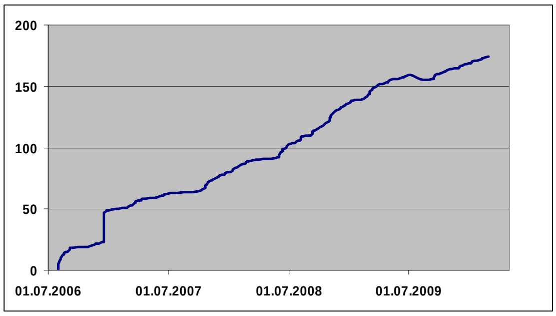


Fig. 4: Registered forum users until 2010-03-01.

One might believe that more and more people decide for spectroscopy. However, a more reasonable explanation for the trend is the increased popularity of our Website and the forum

As one also can see from figure 1, we also lost some users. However, the number remains on a high level and the overall trend remains positive. Just a few days ago the first two active colleagues from Illinois (USA) registered and they made an announcement about their interest to establish a spectroscopy group in the USA. If this becomes successful, the forum participation could jump dramatically.

The number of contributions to the forum strongly vary with time. Neglecting seasonal reasons (e.g., holidays) the average number of contributions is about 500 per month or about 17 per day (although this recently dropped to about 220 per month for a limited time). It is remarkable that so many people participate in our discussions (mainly of scientific contents) and it can well be considered as a big success for the world wide community. However, one should not neglect the fact that the German group uses a sophisticated and comfortable discussion tool. Easy access to information encourages for participation. This is confirmed by statistics of our group mailing list some years ago and the French ARAS forum. Both tools make conversation somewhat inconvenient, due to their reduced level of comfort for the user. Hence, it is strongly recommended to other groups to use tools as comfortable as possible to make beginners excited. On the other hand, we strongly invite users from all over the world to use our forum. The World Wide Web makes the geographical placement of a forum somewhat negligible, although the language problem should not be neglected (see below).

Further prospects

After some discussions about the internal section structure the group is presently on its way to increase the participation of others and especially of beginners in spectroscopy. This is reflected by the willingness to contribute into our virtual library and other parts of the page like articles and project announcements in the forum. In addition, the journal SPEKTRUM will continue and has been made available as PDF for free from our website. All our media are on a level of being usable tools for the community and the website is on the way to become one of the most important portals in the specific field of astrospectroscopy.

An important issue is the contribution of articles. Everybody should write down projects, results and experiences to pass on knowledge to others. Of course, that means work but enriches other colleagues as well as our web page.

Another open issue is the language of our information exchange. The web page itself is already bilingual and the forum can become bilingual, as well. However, one has to consider the tremendous scepticism by a number of participants. English makes it difficult for some out of the group and a hobby should not become hard work. In addition, translating tools are already available in the web and successfully used in the community. At this point we can only invite all interested astronomers to participate also in English. International users will appreciate all respective efforts.

Acknowledgment: Thanks to Robin Leadbeater for English proof reading.

Professionals und Amateurs in Dialogue – A meeting of the VdS Spectroscopy section

Thomas Eversberg
Schnörringen Telescope Science Institute – www.stsci.de

Zusammenfassung

Die VdS-Fachgruppe SPEKTROSKOPIE veranstaltet etwa alle zwei Jahre eine große Tagung in Deutschland. Ziel ist der gemeinsame Austausch, die gegenseitige Motivation und die generelle Freude an der spektroskopischen Astronomie. In diesem Jahr konnten wir uns in der Sternwarte Recklinghausen treffen, einem für solche Zwecke hervorragend geeigneten Ort. Kolleginnen und Kollegen aus verschiedenen Ländern reisten an, um gemeinschaftlich ihrer Leidenschaft zu folgen.

Fig. 1: The meeting begins.

Attending symposia covering a specific field of interest are no walk in the park. Long distance travel, concentration during the presentations as well as discussions through a long evening can test one's physical constitution – however, the soul revives! This was the case again during our section conference October 16 – 18, now at Recklinghausen Observatory. With a lecture and a seminar room plus a foyer for exhibitions, it was perfectly equipped for our meeting, which included a lecture program and a poster and instrument session. As usual, the early birds already met on Friday evening at the Residenzhotel about 200m away from the observatory. It is equipped with a health club including a pool but "unfortunately" we were too busy with our conversations about equipment and new experiences. Discussions about physics, instrumentation and the question if the local or the Bavarian beer is the best, occupied the group into the night.

Over the past years the group has developed into an international amateur and professional community and this time we welcomed Pro's and Am's from Germany, Austria, Belgium and Denmark.

First the schoolboy Benedikt Gröber (Düsseldorf) presented a project for "Youth Research" about spectroscopy of the Crab Nebula and asked for help to define the content. This idea was developed technically during a short discussion.

The presentations began with practical applications. Bernd Marquardt (Dormagen) introduced his development of a standard spectrograph and brought the instrument with him. A handy light weight apparatus with the data analyzed using self-written software.

Our physician Berthold Stober (Glan-Münchweiler) impressed the audience with a specific highlight, an Echelle spectrograph constructed from wood. The assembly is surprisingly simple but the respective adjustment is of high complexity. A tremendous achievement with high quality spectra of very high resolution as the result.

Sebastian Hess (Darmstadt) introduced his work with the commercial spectrograph DADOS. He has used the acquired data for stellar classification and the associated physics. We were quite impressed by the results delivered by such a low resolution instrument.

Restored by coffee and cake we continued with stellar physics. Our professional colleagues Gregor Rauw and Thierry Morel from the astrophysical institute Liège in Belgium presented talks describing the prominent stellar wind effects in massive stars and the associated observation techniques used (see page 14 in this issue). I want to highlight a specific remark by Gregor: „*Professional astronomy is caught in a self-constructed trap. The telescopes become larger and larger and the number of small instruments decreases. But one can only acquire extended observing time for long term campaigns at small telescopes. For this reason professional stellar astronomers now need the amateurs.*“

Udo Zlender (Linz) has a new computer and he wanted to see what this machine could do. Hence, he developed a program for the simulation of Be star disks and compared the result with real spectra. This attempt can be considered as a first step in the complex calculations needed for stellar physics.

Fig. 2: Thierry Morel

Recklinghausen Observatory has its own planetarium and the institute head Burkhard Steinrücken provided some light relief in the form of a “private” show after the demanding talks. The rest of the evening in the hotel was again filled with discussions, a nice dinner and the local brew.

Sunday morning started early at 9 o’clock and some of the „night owls“ were somewhat bleary eyed. Everybody quickly became very excited however. Most amateurs know the famous Zeiss APQ 110 and 150 lenses which are worth their weight in gold. But who knows the designer of probably the best lenses in the world? It is Wolfgang Holota, who currently develops the infrared spectrograph NIRSPEC, on board the James Webb Space Telescope, at Astrium in Ottobrunn. The resulting spectacular presentation of a state-of-the-art system with parameters at the technical forefront deeply astonished the audience.

Thomas Eversberg (Köln) then presented the ProAm WR140 campaign about stellar winds. Section members (from schoolboy to pensioner) and professionals from seven countries measured stellar winds for about 3.5 months from a world-class observing site. This campaign showed that amateurs can play a significant role in the professional league.

Richard Gierlinger (Schärding - Austria) came to Recklinghausen with a specific problem. He works with a telescope of 0.7m aperture and is now interested in the search for exoplanets. To send him back with as much input as possible we introduced a new and somewhat risky format – a round table discussion. Richard presented all the important technical input parameters and all participants discussed various considerations and approaches. There was a risk of a silent audience, afraid to ask “stupid questions”. But far from it. An intense exchange of ideas popped up and after about two hours we were able to deliver an initial technical proposal to Richard.

The poster and instrument session – A market of possibilities

Fig. 3: The poster and instrument session.

Participants often bring their own equipment to our meetings and posters to present. This time we wanted to support such presentations by including an extra two hour session. We started on Saturday afternoon in the observatory foyer right after lunch. A highlight was the self-developed laboratory spectrograph of Hans-Herrmann Müller (Dillenburg).

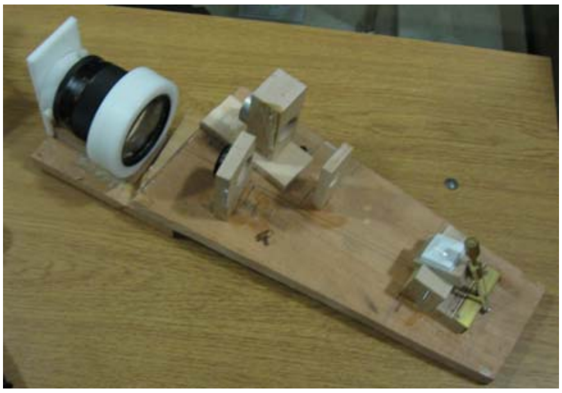


Fig. 4: The wooden Echelle by Berthold Stober.

This instrument as well as the wooden Echelle from Berthold Stober was permanently besieged by a crowd of people.
Klaus Vollmann (Waldbröl) demonstrated the two Excel programs SIMSPEC and SIMECHELLE on the computer. These programs calculate all necessary parameters for the construction of a spectrograph without any mathematical knowledge. A wonderful construction tool for the less mathematically minded.

Fig. 5: A curious crowd around the spectrograph of Hans-Hermann Müller (front). F.l.t.r.: Olaf Simon, Richard Gierlinger, Udo Zlender, Andreas Nimphius (covered), Bernd Marquardt.

Lessons Learned

Of course, we had not enough time again. Eight talks are the absolute maximum. Time runs out when not only the presentations but also the questions and discussion are included (originally, we had planned nine talks). From my point of view however, it is better to plan only seven contributions.

Fig. 6: Hans-Herrmann Müller and Rainer Sparenberg.

On the other hand, the poster and instrument session was a complete success. Nothing is better than the personal discussion. It is simply fun to walk around the results with a cup of coffee in the hand, reflecting on the interests and personality of the respective people. That is not only informative but also exciting and a kind of group support. The group approach to organizing the meeting also stood the test. First, the necessary preparation work was done by different people and second, various ideas improved the quality of such a meeting. It was very lucky that Rainer Borchmann, living close to the meeting place, was in our organizing team. Hence, he could discuss and solve various open issues with the hotel team and the observatory. There was some concern that a large team would not be as efficient as a single person. However, that was not confirmed. Quite the opposite: New paths and sometimes unusual ideas could be realized.

Résumé

Our next meeting will take place 2011 in Jena. A new team will be established next year to organize it . It is especially planned that beginners will get the opportunity to introduce new ideas. This can only be favourable for the group. So, help will be appreciated from everybody interested in organizing Jena 2011. Until then everybody is invited to visit our website http://spektroskopie.fg-vds.de and especially our discussion forum. All questions are very welcome.

Some personal impressions: The main strength of the group is the motivation of all participants to do scientifically oriented work at a possibly a high level and to be open to critical discussions. This is confirmed by the professionals who are continuously impressed by the quality of work and technical skills of amateurs. Of course, the relatively small numbers of amateur spectroscopists in Europe enforces our team spirit. We were very happy to meet Knud Strandbaek from Denmark. Following the meeting he will now try to encourage other colleagues in Denmark to do some spectroscopy. Similarly our newcomer Andreas Nimphius from Ahaus who enthusiastically absorbed all information. It is the personal contacts and the common enjoyment which bring spectroscopic beginners like Richard Gierlinger and David Voglsam (both Austria) or Rainer Sparenberg to us (all three with access to 1m class telescopes). Those guys in particular motivate „old stagers“ to invest their knowledge in the group. For this reason I want to finally thank all participants for their kind willingness to contribute their knowledge, to carry on the group discussions and for their good humour. My special gratitude goes to Rainer Borchmann and Burkhard Steinrücken, head of Recklinghausen Observatory. We could not have been so successful without their intensive preparations and their lasting and uncomplicated support.

Acknowledgment: Thanks to Robin Leadbeater for English proof reading.

Fig. 7: The participants of the Recklinghausen conference

Messung von Doppelstern-Orbitalelementen mit dem spaltlosen Spektrographen

Lothar Schanne
Hohlstrasse 19, 66333 Völklingen (www.astrospectroscopy.eu)

Zusammenfassung

„Für die Messung des Orbits von Doppelsternen über Radialgeschwindigkeitsmessungen benötigt man Spaltspektrographen“. Das ist die gängige Meinung. Dass ein Teil der Orbitalelemente an Doppelsternsystemen des Typs SB2 auch mit spaltlosen Spektrographen gemessen werden kann ist weitgehend unbekannt. Nachfolgend wird die Auswertung entsprechender Spektren und Ergebnisse am Beispiel des bekanntesten Doppelsterns „Mizar“ A vorgestellt.

Fortsetzung des Artikels aus Spektrum Nr. 35 (2008)

Abstract

„For determining orbital elements of binaries via radial velocity measurements one needs slit spectrographs“. This is a common opinion. Mostly unknown is the fact that a part of this elements for type SB2 binaries is accessible by slit less spectrographs. The article describes the treatment of the spectra and some results gained on the well known binary „Mizar A“.

Einführung

Mit einem spaltlosen Spektrographen kann man keine absoluten Radialgeschwindigkeiten messen. Die auf elliptischen Bahnen umlaufenden Komponenten von Doppelsternsystemen werden aber üblicherweise (durch die professionelle Astronomie) mit hochauflösenden Spaltspektrographen vermessen, die über ausgeklügelte Kalibriersysteme verfügen. Weshalb man in Amateurkreisen automatisch - aber fälschlicherweise - davon ausgeht, dass mit spaltlosen Spektrographen auf diesem Gebiet „nichts zu holen ist“.

Nachfolgend wird gezeigt, dass im Falle von Doppelsternen des Typs SB2 (das Spektrum beider Komponenten ist im Spektrum zu erkennen) auch mit einem spaltlosen Spektrographen bei Auflösungen um die 10000 einige Orbitalelemente recht genau gemessen werden können. Hier ergibt sich ein spezieller Vorteil: Die Spektren müssen nicht einmal kalibriert werden, weshalb Kalibrierfehler vermieden werden. Die erzielbaren Messgenauigkeiten brauchen sich deshalb nicht hinter professionellen Ergebnissen zu verstecken.

Linienaufspaltungen in den Spektren

Mit Ausnahme des Falles, dass die Bahnebene des Doppelsterns genau in der Himmelsebene liegt, wird bei einer vorhandenen Bahnneigung ein Stern eine Geschwindigkeitskomponente auf uns zu haben, und der andere Stern von uns weg[1]. Die Bewegung und damit auch die Radialgeschwindigkeiten unterliegen einer periodischen Änderung. Bei Mizar A beträgt diese Periode 21,53 d, sie ist also während einer Schönwetterperiode mit einer Beobachtungserie abzudecken[2]. Die Radialgeschwindigkeiten bewirken eine Dopplerverschiebung der Spektrallinien der beiden Sterne, sie wandern in entgegengesetzten Richtungen nach links und rechts um ihre Ruhewellenlänge im Spektrum. Beobachtbare Aufspaltungen der Linien sind die Folge.
Ein schönes Beispiel ist in Abb. 2 wiedergegeben, die Aufspaltung der Hα-Linie von Mizar A.

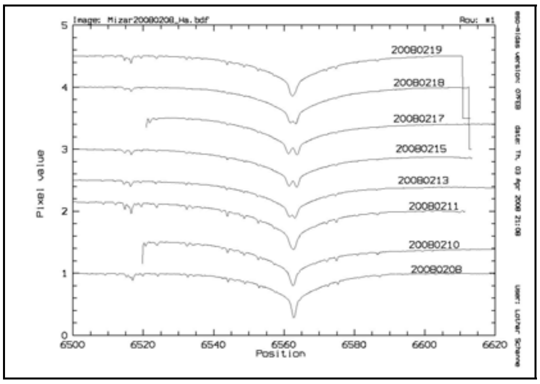


Abb. 1: Zeitserie der Hα-Linie von Mizar A

Etwas Theorie

[1] Stehen beide Sterne in Opposition bzgl. der Sichtlinie des Beobachters, sind ebenfalls keine radialen Geschwindigkeitskomponenten vorhanden.
[2] Wegen der strengen Periodizität der Umläufe sind aber auch durchaus Beobachtungen über Jahre hinweg kombinierbar.

Die Bahn einer jeden Komponente um den gemeinsamen Schwerpunkt wird durch 7 Bahnelemente („Orbitalelemente") im Raum definiert.

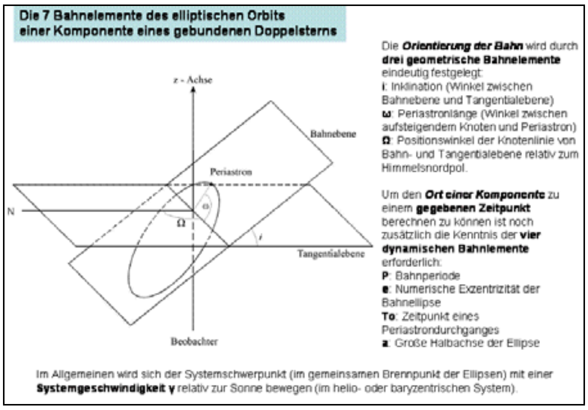


Abb. 2: Bahnelemente des Orbits einer Komponente des Doppelsterns

Die relativ komplexe mathematische Aufgabe, den Bezug zu den beobachtbaren Größen herzustellen, führt zu folgenden Gleichungen. Ihre Ableitung wollen wir uns hier ersparen.

Die Differenz der Radialgeschwindigkeiten der beiden Stern-Komponenten, also die Aufspaltung der Spektrallinien, ausgedrückt in km/s, ist wie folgt berechenbar.

$$\Delta v_r = (K_1 + K_2) \cdot [e \cdot \cos\omega + \cos(\omega + v)] \quad \textbf{(1)}$$

Die einzige zeitabhängige Größe ist die wahre Anomalie *v*, alles andere sind Konstanten (Bahnelemente). Es sind 3 Parameter (die Amplitudensumme[3] (*K1 + K2*), die Exzentrizität *e* und die Periastronlänge ω).

Um zu einem Beobachtungszeitpunkt *t* die korrespondierende wahre Anomalie *v* berechnen zu können, sind weitere Parameter zu wissen: Ein Bezugspunkt T_0 (z.B. der Zeitpunkt eines Periastrons), die Umlaufperiode *P* sowie die Exzentrische Anomalie *E(t)*.

$$\tan(E/2) = [(1-e)/(1+e)] \cdot \frac{1}{2} \tan\left(\frac{v}{2}\right) \quad \textbf{(2)}$$
$$E - e \cdot \sin E = (2\pi / P)(t - T_0)$$

Kennt man *v(t)* kann man nach Gl. (1) Δv_r berechnen. Leider ist der Zusammenhang zwischen *E* und *v* mathematisch transzendent, weshalb eine analytische Lösung nicht eindeutig ist und deshalb die Parameter numerisch an die Messwerte $\Delta v_r(t)$ zu fitten sind. Dies lässt man am besten ein iterierendes Computerprogramm erledigen, das die Parameter so wählt, dass der Verlauf der gemessenen rv – Differenzen die möglichst geringsten Abweichungen vom berechneten aufweist.

Praktische Vorgehensweise

Man nimmt möglichst oft das Spektrum des Doppelsterns auf und misst die Aufspaltung geeigneter (ungestörter) Absorptionslinien aus. Dazu müssen die Spektren nicht einmal kalibriert werden. Es genügt, die Minima der getrennten Absorptionslinien der beiden Komponenten subpixelgenau auszumessen (am besten durch ein Gauss-fitting der Linien mit MIDAS oder VSpec) und die Wellenlängendifferenz mit der aus anderen Messungen bekannten Dispersion des Spektrographen zu multiplizieren, um Δv_r in Wellenlängeneinheiten oder Geschwindigkeitseinheiten zu erhalten. Die so erhaltene Datentabelle der Linienaufspaltungen $\Delta v_r(t)$ wird dann ausgewertet.

In Abb. 3 sind die ausgemessenen Doppleraufspaltungen gegen das Julianische Datum der Messung aufgetragen. In diesem Diagramm sind keine Periodizitäten zu erkennen.

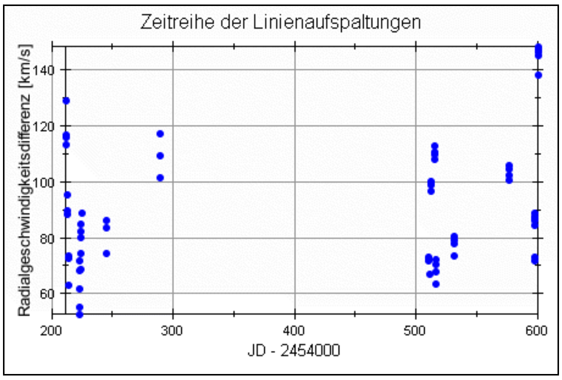


Abb. 3: Auftragung der Doppleraufspaltung der ausgemessenen Linien gegen das Jul. Datum der Messungen (Linien H6563, Fe6455, Si6370, Si6348, Messungen aus 2007 und 2008)

Möchte man die Bahnparameter herausbekommen ohne auf Literaturwerte zurück zu greifen, ist es ratsam zuerst die Periode *P* zu bestimmen, damit die Messwerte in ein Phasendiagramm eingezeichnet werden können.

[3] Aus K_1 und K_2 lassen sich die projizierten großen Halbachsen $a_1 \sin i$ und $a_2 \sin i$ berechnen. Aus der mit dem spaltlosen Spektrographen gemessenen Summe $K_1 + K_2$ ergibt sich also der projizierte Abstand der beiden Sterne im Apastron.

$(a_1 + a_2) \cdot \sin i = 13750 \cdot (K_1 + K_2) \cdot P \cdot \sqrt{1 - e^2}$

Ich habe dazu das Programm Peranso[4] verwendet, das automatisch mittels verschiedener mathematischer Standardroutinen Perioden in Zeitreihen von Messwerten ermittelt.

Mit dem eigenen Datensatz (Aufspaltungen der Linien H6563, Fe6455, Si6370, Si6348 aus 2007 und 2008) ergibt sich die Periode vorläufig zu 20,54 d (Methode ANOVA, vgl. Abb. 4).

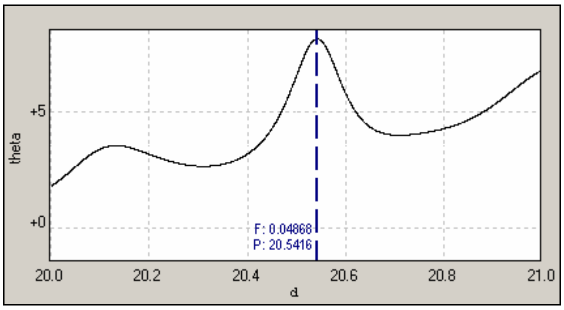


Abb. 4: ANOVA-Datenanalyse

Nach (beliebiger) Wahl eines Bezugszeitpunktes T_0 können die gemessenen Linienaufspaltungen in ein Phasendiagramm eingezeichnet werden, nachdem die Messzeitpunkte *t* mit der ermittelten vorläufigen Periode *P* in die Phase ϕ umgerechnet wurden[5]:

$$\phi = \frac{t - T_0}{P} \qquad \textbf{(3)}$$

Der Phasenplot der Messwerte ist in Abb. 5 gezeigt.

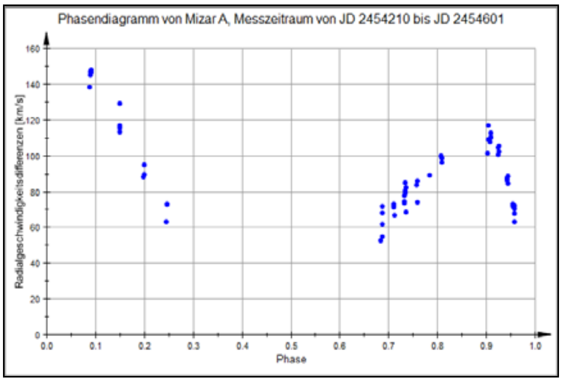


Abb. 5: Phasendiagramm der gemessenen Doppleraufspaltungen (Linien H6563, Fe6455, Si6370, Si6348 aus 2007 und 2008)

An diesen Datenpunkten sind jetzt die Bahnelemente zu optimieren (data fitting). Dazu habe ich eine selbst geschriebene Routine in MATLAB/MuPAD verwendet. In meinem Programm muss ich die Parameter selbst variieren und an Hand der Abweichungen zwischen theoretischen Werten und gemessenen Aufspaltungen optimieren (durch Minimierung der Summe der Abweichungsquadrate). In Abb. 6 ist das Ergebnis des Datenfittings dargestellt. Der optimierte Satz der Bahnelemente, das Endergebnis, ist in Tabelle 1 mit Literaturwerten von 1961 verglichen.

Bahnparameter	eigenes Ergebnis	Literaturwerte (Fehrenbach 1961)
K1+K2 [km/s]	128.1	136,50 ± 1.70
P [d]	20.53745	20.53860
e	0.528	0.537 ± 0.04
ω [°]	103.1	104,16 ± 1.13
T [JD]	2454208.32[6]	2436997.212 ± 0.032
$(a_1 + a_2) \cdot \sin i$ [km]	35.2 * 10^6	32.7 * 10^6

Tab. 1: Die „gemessenen“ Bahnparameter im Vergleich zu Literaturwerten

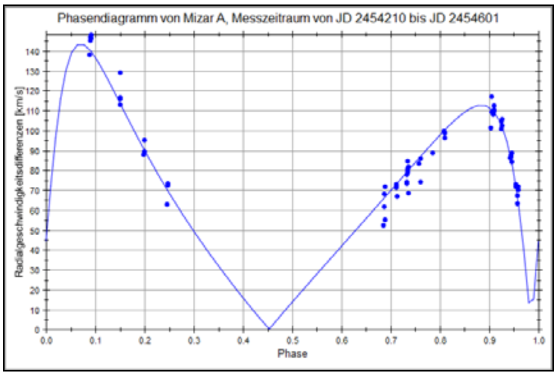


Abb. 6: Phasendiagramm mit eingezeichnetem berechnetem Verlauf (optimierte Bahnelemente)

Offensichtlich ist es möglich, auch mit spaltlosen Spektrographen anspruchsvolle und recht genaue Messungen von Bahnelementen durchzuführen. Damit ist dem Amateurspektroskopiker, der über einen ausreichend hoch auflösenden spaltlosen Spektrographen verfügt, ein zusätzliches Arbeitsfeld erschlossen.

---

[4] http://www.peranso.com/

[5] Vgl. meinen Artikel im Spektrum 35, Seite 16 unten.

[6] Der Bezugszeitpunkt (Periastrondurchgang) T_0 der Literaturwerte (1960 gemessen) und meinen Messwerten (2007) unterscheidet sich um 17211.11 d = 838.00 Perioden (etwa 47 Jahre).

Rotation features of O and B stars, I. General properties of massive stars

Gregor Rauw
Institute for Astrophysics and Geophysics, Liège University, Allée du 6 Août, 17, 4000, Liège, Belgium

Abstract
Stars of spectral type O play a key role in many processes in our Galaxy and beyond. However, there are still a number of open issues about these massive and luminous objects that need to be addressed. Several of these questions require (long-term) spectroscopic monitoring that is difficult to achieve with the highly-demanded equipment on modern professional instruments. However, these kinds of studies offer an opportunity for collaborations between amateur spectroscopists and professional astrophysicists.

Zusammenfassung
Sterne der Spektralklasse O spielen eine herausragende Rolle in unserer Galaxis und auch darüber hinaus. Es gibt aber noch ungeklärter Fragestellungen zu diesen massiven und leuchtkräftigen Objekten, die es zu behandeln gilt. Einige dieser Fragen bedürfen einer spektroskopischen (Langzeit-) Überwachung, welche durch die starke Nachfrage bei den modernen professionellen Geräten kaum durchgeführt werden kann. Diese Art von Studien laden aber zur Zusammenarbeit zwischen Amateur-spektroskopikern und Astrophysikern ein.

Dieser Artikel wird in Spektrum Nr. 39 fortgesetzt.

1. Introduction

O-type stars are hot (more than 30000 K), luminous (between 30000 and 3000000 times the solar luminosity) and massive (more than 10 solar masses) objects. With these extreme properties, O-type stars and massive stars in general, play a key role in the processes that shape the Universe (see e.g. the review by Nazé 2006). For instance, because of their high temperatures and extreme luminosities, O-type stars produce a large amount of UV radiation that ionizes the interstellar material in their vicinity, thus creating the well-known H II regions (emission nebulae containing ionized hydrogen such as the Rosette Nebula). The large luminosity is also responsible for the acceleration of their stellar wind (see Sect. 4).

Because of their high luminosities, these massive stars have rather short lifetimes (for astronomical standards) of order 10 million years (see Sect. 2 & 3). At the end of their life, they explode as supernovae, ejecting large amounts of material and energy into the interstellar medium.

At low spectral resolution, O-type stars can be identified thanks to their relatively low number of spectral lines and their blue colours. At higher spectral resolution, their spectral type, which reflects directly the surface temperature of the star, can be determined thanks to the ratio between the strengths of two helium lines: the neutral helium line He I λ 4471 and the singly ionized helium line He II λ 4542 lines (see e.g. Gray 2000). Hotter O-stars, i.e., stars with "earlier" spectral types (O2 – O6.5), have an atmosphere that is more ionized and display hence a stronger He II line. "Later" spectral types (O7.5 – B0), on the contrary, display weaker He II features in their spectra. The two lines have equal strength at spectral type O7.

In this contribution, we review the general properties of these stars and discuss how these properties are determined. Special emphasis is put on the powerful stellar winds which are unique features of these massive

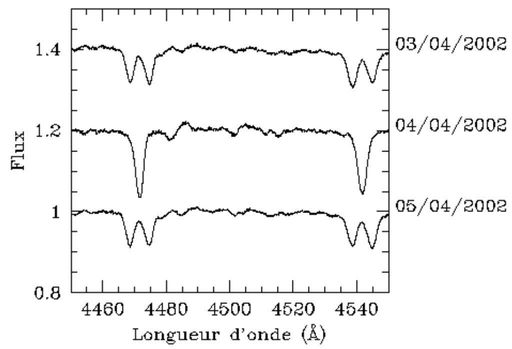


Fig. 1: Spectroscopic observations of the O-type binary HD165052 for three different dates illustrating the shift in wavelength of the lines of both stars as they move around each other (Linder et al. 2007).

stars. Finally, we introduce some peculiar classes of O-type stars that display spectral variability and we highlight some aspects where amateur astronomers can make important contributions and help their professional colleagues achieve a deeper understanding of these stars.

2. The determination of the stellar mass

There are several techniques that allow determining the mass of a star. By far the most accurate and least model-dependent approach is based on the study of binary systems. Indeed, in a binary system, the radial velocity, i.e., the velocity component along the line of sight towards the observer, of each star changes periodically as the stars move around their centre of mass. As a result of the Doppler effect, these changes of the radial velocity translate into a change of the wavelength of the spectral lines (see Fig. 1) with an amplitude that is directly proportional to the product of the stellar mass times the third power of the sine of the inclination angle between the orbital plane and the line of sight

$$M \sin^3 i$$

(i = 90° standing for the line of sight being actually inside the orbital plane, i.e., edge-on eclipsing systems).

The determination of absolute masses requires the knowledge of the orbital inclination angle i. The latter can be determined if the binary system displays photometric eclipses, i.e., for values of i not too far away from 90°, by fitting a geometrical model of the binary system to its observed light-curve (see Fig. 2).

Currently, the most massive stars that have been reliably weighed in this way have masses around 80 solar masses (Rauw et al. 2005). There are a few candidates of even more massive objects (up to 150 solar masses, De Becker et al. 2006, Schnurr et al. 2008), but these values are more uncertain.

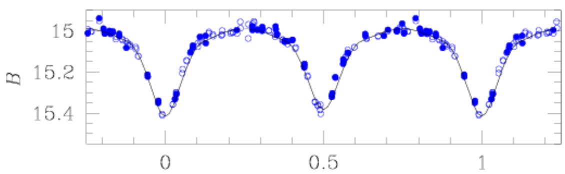


Fig. 2: Photometric light-curve of the very massive eclipsing binary system WR 20a in the B filter, along with the best fit model that allows to determine the inclination of the orbital plane with respect to the line of sight and to show that this system consists of two stars of about 82 solar masses each (Rauw et al. 2007).

A second technique, that allows estimating the mass of a star, is the mass-luminosity relation. The latter is an empirical relation that was established based on the results from the study of a large sample of eclipsing binary systems. For massive main-sequence stars, such as the O-type stars considered here, this relation is approximately given by

$$L \propto M^{\alpha}$$

where α ≈ 3 for stars between about 1 and 10 solar masses, whilst α ≈ 2 for stars more massive than 10 solar masses. It is the latter relation, implying that the luminosity increases with a large power of the mass, which explains the short lifetimes of the most massive stars. Indeed, to produce their huge luminosity, these objects need to "consume" their nuclear fuel at a much faster rate than the Sun.

The mass-luminosity relation can be used to get a rough estimate of the mass of a star, based on its observed luminosity. However, this technique is rather crude, especially for very distant objects, and fails completely if we are actually observing an unresolved multiple system, where the luminosity is not produced by a single star, but rather by a binary star or even a compact stellar cluster (see e.g. Maíz Apellániz et al. 2007). Moreover, because massive star are rather rare objects and because only a few percent of the spectroscopic binary systems display eclipses, there are only a handful massive eclipsing binaries and the empirical mass-luminosity relation is thus rather poorly constrained in the higher-mass range.

The third method, frequently used to estimate the mass of a star, is the spectral analysis with a model-atmosphere code (e.g. Marcolino et al. 2009). This approach consists in computing synthetic spectra accounting for the physical processes inside the stellar atmosphere and adjusting this model to the observed spectrum. Among the model parameters, one finds the surface effective temperature T_{eff}, the stellar luminosity L and the surface gravity g. The former two parameters are related through the simple relation

$$L = \sigma \; R^2 T_{eff}^4 \, ,$$

where σ is the Stefan-Boltzmann constant (5.67 10^{-8} W m^{-2} K^{-4}), whilst the surface gravity is given by

$$g = \frac{G \cdot M}{R^2} \, ,$$

where G is the gravitational constant (6.67 10^{-11} m^3 kg^{-1} s^{-2}).

Therefore, if we know the distance of a star, hence its luminosity, we can use its best-fit effective temperature to derive its radius and from the best-fit value of the surface gravity, we eventually infer the stellar mass. This method is however dependent on the stellar atmosphere model and is also often hampered by a poor knowledge of the distance of the star.

3. The evolution of massive stars

Stars, whether massive or low-mass, produce their energy through nuclear reactions in their core. During the so-called main-sequence lifetime, these reactions transform hydrogen into helium. In massive stars, the evolution is also influenced by the stellar wind that progressively removes the outer layers of the star. As a reaction to this mass-loss, the stellar core shrinks and material that was initially part of the convective core reaches the stellar surface. At this stage, the stellar atmosphere hence contains the chemical elements that are products (helium) and/or by-products (nitrogen) of the nuclear reactions that once occurred in the

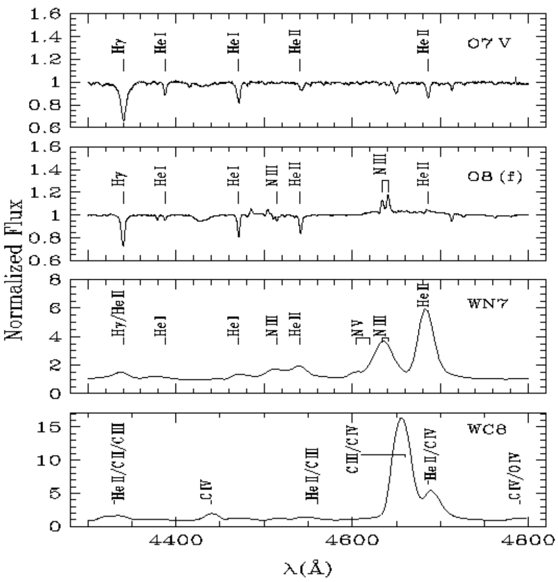


Fig. 3: A sequence of spectra of massive stars showing the evolution from a main-sequence O-star to an Of supergiant and subsequent Wolf-Rayet stages (respectively the nitrogen-rich WN and the carbon-rich WC stages).

stellar interior. In parallel, the nuclear reactions in the core shift towards the production of increasingly heavier elements. First, helium is “burned” to produce carbon and oxygen. Then, carbon is consumed to produce neon and magnesium, etc. As the processed material arrives at the stellar surface, the changes in the composition of the stellar atmosphere leave their signature in the stellar spectrum and the enhanced metal content of the atmosphere leads to a stronger stellar wind. The star thus progressively evolves from a main-sequence O-star into an Of supergiant, displaying some (usually) weak emission lines in its spectrum, and eventually becomes a Wolf-Rayet star, first of spectral type WN, then WC (see Fig. 3).

Finally, once the nucleosynthesis in the stellar core has produced an iron core, there is no possibility to produce energy by further nuclear reactions. At this level, the stellar core collapses and the star explodes as a supernova, leaving a neutron star or black hole behind. Let us stress that the above scenario applies to single massive stars. In massive binary systems, the stellar evolution is a lot more complex because of the possibility for the two stars to exchange mass and/or angular momentum.

4. Stellar winds and their consequences

In the previous sections, we have frequently mentioned the effects of stellar winds. It is now time to state more explicitly what this is all about. Stellar winds in hot massive stars are driven by radiation pressure, i.e., it is the exchange of momentum between the photons from the stellar surface and the atoms in the stellar atmosphere that produces the acceleration of these atoms and leads to the formation of the stellar wind (see Fig. 4).

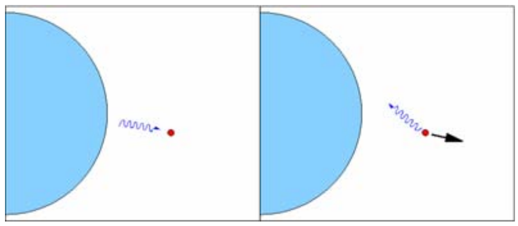


Fig. 4: Schematic illustration of the interaction between a stellar photon and an atom in the atmosphere of the star leading to the formation of a stellar wind. The atom absorbs a photon coming from the photosphere (left) and re-emits it in an arbitrary direction (right). The net result is an outwards acceleration of the atom along the radial direction.

The stellar wind of a massive star carries substantial amounts of material at high velocity. The typical mass-loss rates of O-type stars are of order 10^{-6} solar masses per year and can reach 10^{-4} solar masses per year in the most extreme massive stars. The material in the stellar wind moves at a velocity of order 1000 to 5000 km/s (see e.g. Nazé 2006 for a review). Hence, the stellar winds of massive stars carry a huge amount of kinetic power and have therefore an important impact on the surroundings of these stars, leading for instance to the formation of circumstellar bubbles or to the triggering of new generations of lower mass stars.

The existence of an outwards expanding spherical stellar wind can be inferred from the spectra (especially in the ultraviolet domain) of massive stars through the presence of P-Cygni type profiles (see Fig. 5) or strong emission lines (see Fig. 3).

The above picture is however too simplistic. Over recent years it has been shown that the winds of massive stars are usually not homogeneous, but have structures that are either large scale structures or small-scale clumps (see Fig. 6), or both. This situation has various consequences: (1) the effective mass-loss rate of a clumpy wind is lower than for a homogeneous one (e.g. Martins 2009) and (2) the existence of structures can lead to substantial temporal variability of the lines that are formed inside the stellar wind (Eversberg et al. 1998, Howarth et al. 1998, see also the contribution by Thierry Morel in this volume).

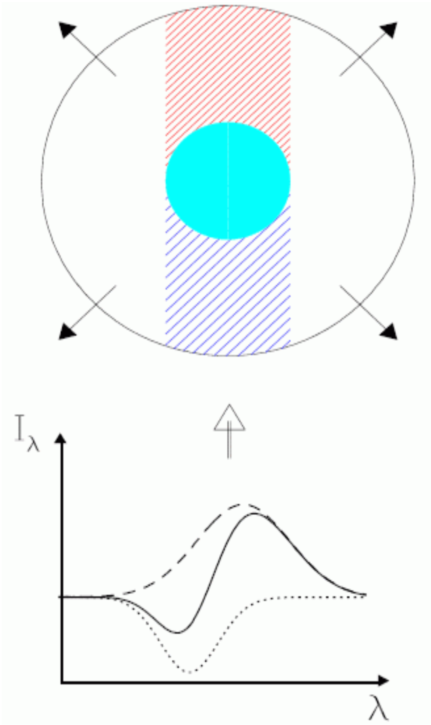


Fig. 5: Schematic view of the formation of a P-Cygni type line profile. The observer is looking at a spherically expanding wind from below in this figure (direction of the white arrow). Everywhere in the wind, the material absorbs photons from the photosphere beneath and re-emits them into an arbitrary direction. The blue-shaded material is moving towards the observer (hence producing a blue-shifted absorption) whilst the red-shaded material is hidden by the stellar body and the side lobes of the stellar wind have on average zero velocity and produce thus an un-shifted emission line. The combination of these features eventually leads to the P-Cygni type profile.

An important consequence of the existence of stellar winds associated with massive stars is the collision of these winds in massive binaries. In fact, when two massive stars form a binary, their winds interact somewhere in between the two stars, and this interaction produces a wealth of observational signatures over a wide range of wavelengths (from the gamma-rays and X-rays to the radio domain). Describing all these effects in detail is clearly beyond the scope of this contribution[7]. Nevertheless, let us stress that this phenomenon is intensively studied by astrophysicists and that the most efficient approach is through multi-wavelength studies. Amateur astronomers can make important contributions in this field, as is nicely illustrated by the MONS spectroscopic monitoring campaign orchestrated by Thomas Eversberg and friends. This campaign allowed collecting unique data for the long-period (7.94 years) colliding-wind system WR 140 (WC7 + O4-5) around its periastron passage in early 2009.

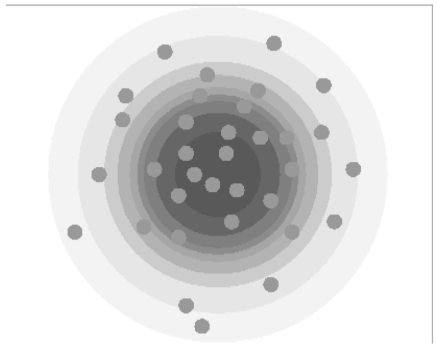


Fig. 6: Schematic representation of a clumpy stellar wind.

5. Some peculiar O-type stars and how amateurs can help us understand these objects

Massive stars are rare objects and as such, one could consider that they are all peculiar objects. Still, among the massive stars, there are some categories that deserve a particular interest, because they exhibit some special features in their spectrum and/or because their spectrum is variable. In this section, we briefly review two such categories, the Oe and the Of?p stars. We subsequently discuss the possible contributions of amateur spectroscopists to this research and we provide a non-exhaustive list of stars in the northern hemisphere that are of interest in the context of a collaboration between amateurs and professionals.

In the previous section, we have seen that the winds of massive stars are nowadays understood to harbour considerable structures. These structures can be either small (compared to the dimensions of the star) or large. In the case of so-called Oe stars, the structure is

[7] For more details see e.g. http://www.gaphe.ulg.ac.be/col_e.html

most probably a large-scale one. There are only eight such stars known in our Galaxy and their distinctive feature is that their spectra exhibit a large number of double-peaked emission lines (Negueruela et al. 2004, see also Fig. 8). The Oe stars are usually considered to form an extension of the Be stars (for the latter, see the contribution by Udo Zlender in this volume) towards somewhat more massive and hotter stars. In Be stars, the double-peaked emissions are attributed to the stellar wind being concentrated near the stellar equator in a rotating disk-like structure. By analogy, the same situation is likely to apply to Oe stars (see Fig. 7).

However, the mere existence or absence of an equatorial disk in the case of Oe stars is still a matter of controversy. Important clues can be obtained from the temporal behaviour of the emission lines in the spectra of Oe stars. In fact, in Be stars, these lines are highly variable, often as a result of the existence of moving density waves in the disk itself. Similar variations of the equivalent width of the Balmer emission lines and the ratio of the violet emission peak over the red emission peak have been observed at least in two Oe stars: HD45314 and HD60848 (Rauw et al. 2007b, see Fig. 9). However, the long-term behaviour of these stars still needs to be explored in much more detail. Important steps towards such a study were taken during the MONS campaign mentioned above, when these two stars were more or less regularly monitored during 3 months.

The Of?p category is even more scarce than the Oe class, since only three objects of this kind are known within our Galaxy (Nazé et al. 2008). These are HD108, HD148937 and HD191612. This class was originally defined by an unusual strength of some carbon emission lines compared to neighbouring nitrogen emissions. However, over recent years, spectroscopic monitoring revealed that these objects display substantial spectroscopic variability as illustrated in the case of HD191612 by Fig. 10. Not only are these stars variable, apparently changing between a low and high-emission state, but most of all, this variability was found to be cyclic with periods of about seven days in the case of HD148937, 538

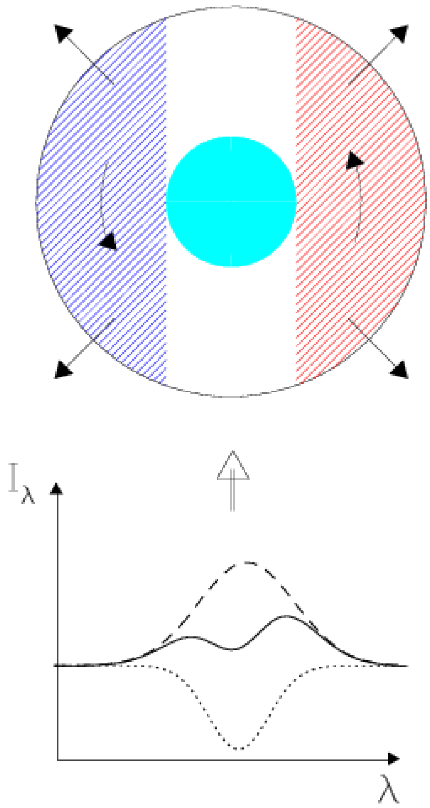


Fig. 7: Illustration of the formation of a double-peaked emission line in the spectrum of a star surrounded by a co-rotating equatorial wind.

days for HD191612 and 55 years (!) for HD108 (see Nazé et al. 2008). The interest in these objects was even more stimulated by the discovery of a rather strong magnetic field in HD191612 (Donati et al. 2006). Magnetic fields are difficult to measure in massive stars and only a few cases are known with certainty. However, the impact of a magnetic field on the

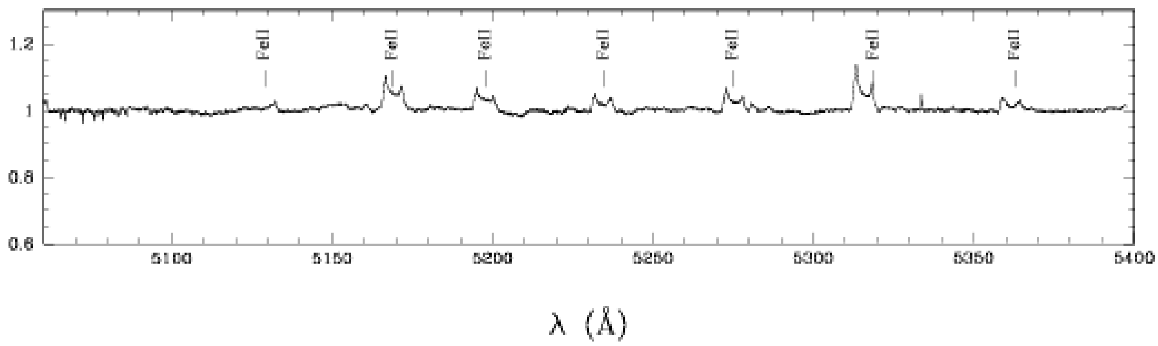


Fig. 8: Small part of the optical spectrum of the Oe star HD45314 displaying a large number of double-peaked emission lines. The lines in this spectral domain are due to singly ionized iron.

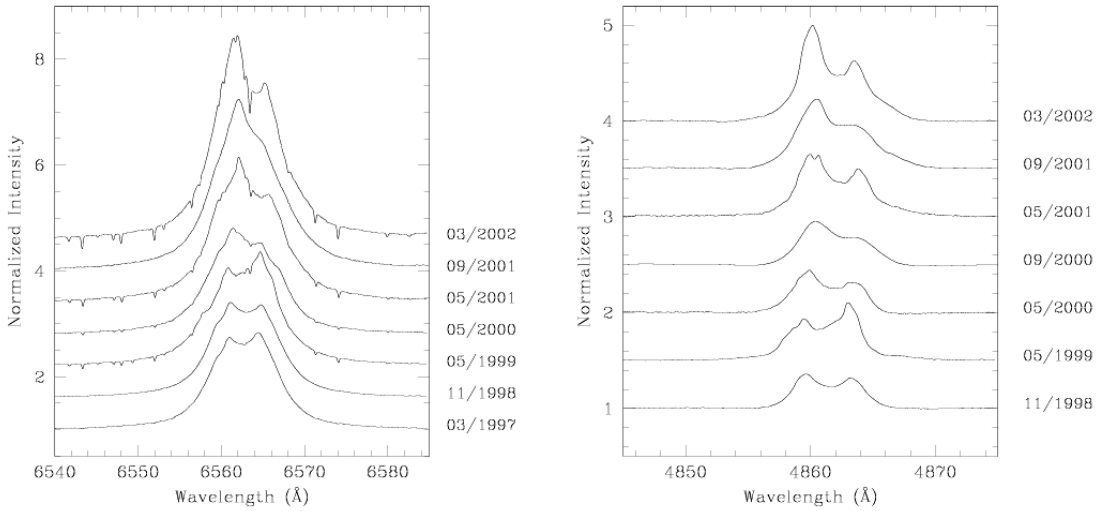


Fig. 9: Illustration of the changing Hα (left) and Hβ (right) line in the spectrum of the O9.5Ve star HD45314 as observed with snap-shot observations between 1997 and 2002 (from Rauw et al. 2007b).

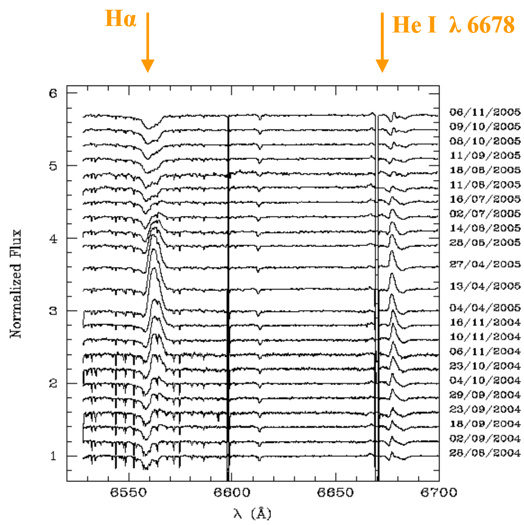


Fig. 10: The changes in the red spectrum of the Of?p star HD191612. Note especially the Hα and He I λ 6678 lines that vary between an absorption dominated profile and a P-Cygni type morphology.

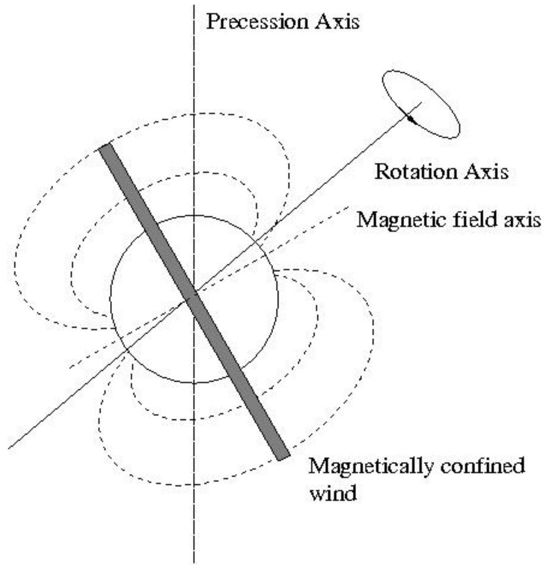


Fig. 11: Sketch of a possible interpretation of the variations of Of?p stars. The precession of the rotation axis of a star with a magnetically confined wind changes the orientation of the confined wind with respect to the direction towards the observer.

stellar wind can be quite substantial. In fact, such a field can potentially control the flow of the wind material leading to a stellar wind compressed near the magnetic equator. Such a feature is likely responsible for the variability of the very young O-star θ^1 Ori C (Stahl et al. 1996). If the magnetic axis is inclined with respect to the rotation axis and/or if the rotation axis is precessing (see Fig. 11), the compressed high-density part of the wind will be seen by the observer under a changing inclination and this could possibly explain the spectacular spectral variations observed in these stars. However, only a continuous monitoring of their variability over a long time-scale (especially for HD108) will allow us to eventually establish the origin of the variations of these objects.

Many of these peculiar objects are relatively bright (often brighter than magnitude 8) and usually, a spectral resolution of order 10000 is sufficient for our purpose. Monitoring the spectra of these stars is important since the temporal information provides complementary clues to understand the physics behind their peculiarities. Whilst this kind of monitoring is potentially very rewarding, it is quite difficult to organize in practice for professional astronomers. The reasons are multiple:

- Professional astronomers rarely have permanent access to a telescope.
- The time scales over which the stars must be investigated are often rather long (several months, sometimes even years) and are incompatible with (typically) short observing runs lasting for only a few nights.

- Over the recent decades most efforts in the field of professional astrophysics have been invested to (1) the developments of very big telescopes which are ideally suited for the study of very faint (often extragalactic) sources and (2) the design of very specialized instrumentations devoted to a specific research field such as the search and investigation of extra-solar planets.

For all these reasons, the spectroscopic monitoring of massive stars offers an interesting opportunity for a fruitful collaboration between amateur spectroscopists and professionals.

- More and more amateurs nowadays have medium-resolution spectrographs mounted on their own private telescopes. This equipment is suited for many long-term studies that do not require an access to very big facilities.
- Amateurs with their own equipment are not constrained by the schedule of a professional observatory. They can observe whenever the weather permits and whenever they like.
- Amateur spectrocopists, by their nature, are very patient people. They are more willing to support long-term campaigns than are the time allocation committees of professional observatories…

The most obvious targets in the northern hemisphere for a collaboration between amateurs and professionals are HD108 (V = 7.4), HD45314 (V = 6.6) and HD60848 (V = 6.9). However, other objects such as λ Cep (V = 5.1), HD192639 (V = 7.1) or λ Ori (V=3.3) are also of interest. Ideally, the observations should focus on a specific wavelength domain (Hα is obviously an interesting line to monitor) and should be taken with the same set-up all the time. For professional astronomers studying massive stars, this can open up brand new avenues to obtain unique data on their favourite objects, and for amateurs, it can be great fun to contribute to the scientific research.

Acknowledgment: I wish to thank the organizers of the Recklinghausen meeting for their invitation to this nice workshop. My heartiest thanks go to my colleague and wife Yaël Nazé for comments that helped to improve this manuscript. This work is supported by the Belgian Fonds de la Recherche Scientifique and a PRODEX contract (Belspo).

References

De Becker, M., Rauw, G., Manfroid, J., & Eenens, P., 2006, Astronomy & Astrophysics, 456, 1121

Donati, J.-F., Howarth, I.D., Bouret, J.-C., Petit, P., Catala, C., & Landstreet, J., 2006, Monthly Notices of the Royal Astronomical Society, 365, L6

Eversberg, T., Lepine, S., & Moffat, A.F.J., 1998, Astrophysical Journal, 494, 799

Gray, R.O., 2000, *A digital spectral classification atlas,* http://nedwww.ipac.caltech.edu/level5/Gray/frames.html

Howarth, I.D., Townsend, R.H.D., Clayton, M.J., Fullerton, A.W., Gies, D.R., Massa, D., Prinja, R.K., & Reid, A.H.N., 1998, Monthly Notices of the Royal Astronomical Society, 296, 949

Linder, N., Rauw, G., Sana, H., De Becker, M., & Gosset, E., 2007, Astronomy & Astrophysics, 474, 193

Maíz Apellániz, J., Walborn, N.R., Morrell, N.I., Niemela, V.S., & Nelan, E.P., 2007, Astrophysical Journal, 660, 1480

Marcolino, W.L.F., Bouret, J.-C., Martins, F., Hillier, D.J., Lanz, T., & Escolano, C., 2009, Astronomy & Astrophysics, 498, 837

Martins, F., 2009, Communications in Asteroseismology, 158, 106

Nazé, Y., 2006, Astronomy, 34, 40

Nazé, Y., Walborn, N.R., & Martins, F., 2008, Revista Mexicana de Astronomía y Astrofísica, 44, 331

Negueruela, I., Steele, I.A., & Bernabeu, G., 2004, Astronomische Nachrichten, 325, 749

Rauw, G., Crowther, P.A., De Becker, M., Gosset, E., Nazé, Y., Sana, H., van der Hucht, K.A., Vreux, J.-M., & Williams, P.M., 2005, Astronomy & Astrophysics, 432, 985

Rauw, G., Manfroid, J., Gosset, E., Nazé, Y., Sana, H., De Becker, M., Foellmi, C., & Moffat, A.F.J., 2007a, Astronomy & Astrophysics, 463, 981

Rauw, G., Nazé, Y., Marique, P.X., De Becker, M., Sana, H., & Vreux, J.-M., 2007b, Information Bulletin on Variable Stars, 5773

Schnurr, O., Casoli, J., Chené, A.-N., Moffat, A.F.J., & St-Louis, N., 2008, Monthly Notices of the Royal Astronomical Society, 389, 806

Stahl, O., Kaufer, A., Rivinius, T., Szeifert, T., Wolf, B., Gäng, T., Gummersbach, C.A., Jankovics, I., Kovacs, J., Mandel, H., Pakull, M.W., & Peitz, J., 1996, Astronomy & Astrophysics, 312, 539

Terminvorschau

Spektroskopie-Vortrag auf ATT

Die Fachgruppe gestaltet auf der diesjährigen **ATT** in **Essen** einen einstündigen Einsteigervortrag zum Thema Astrospektroskopie für Amateure. Vortragende werden Lothar Schanne und Thomas Hunger sein.

Workshop Heppenheim

Am ***10. – 12. September 2010*** veranstaltet die Fachgruppe Spektroskopie ihren **4. Praxis- und Anfängerworkshop** an der **Sternwarte Heppenheim**.
Mit dem Kurs wollen wir Interessierte in die Lage versetzen, die Grundlagen spektroskopischer Techniken zu verstehen und nachzuvollziehen. Dazu gehören unter anderem der Umgang mit Geräten (Selbstbau oder aus dem Handel), ihre Anwendungen, die Datenauswertung und die Physik. Die genauen Wünsche und Ziele für diesen Kurs werden wie bisher nicht vorgegeben sondern vor Ort zu Beginn zusammen mit allen Teilnehmern diskutiert und abgestimmt. Kompetente und erfahrene Mentoren werden die Teilnehmerinnen und Teilnehmer durch die Materie begleiten und gemeinsame Messungen sowie deren Auswertung durchführen.
Weitere aktuelle Informationen und die Anmeldeformalitäten finden Sie unter spektroskopie.fg-vds.de.

Langenselbold Treffen

Am ***30. Oktober 2010*** findet das diesjährige informelle Treffen der FG Spektroskopie in **Langenselbold** bei Frankfurt/Main statt.
Die Zusammenkunft dient wie immer dem Austausch zu verschiedenen Themen der Spektroskopie in lockerer Atmosphäre. Ein festes Programm gibt es nicht, besondere Themenwünsche können jedoch geäußert werden.
Weitere Informationen finden Sie unter spektroskopie.fg-vds.de.

ASpekt 2011
Jahrestagung der Fachgruppe Spektroskopie

Zum Vormerken: Die große Jahrestagung der Fachgruppe Spektroskopie ist für ***Mai 2011*** in **Jena** geplant. Nähere Informationen erfolgen im nächsten Spektrum und auf spektrokopie.fg-vds.de

---

In der nächsten Ausgabe von Spektrum lesen Sie

T. Morel: Rotation features of O and B stars, II. Wind structures of massive stars

R. Borchmann: Erste Erfahrungen mit dem Staranalyser 100