Bulletin de la Société Royale des Sciences de Liège, Vol. 80, 2011, p. 469 - 474

Spectroscopic madness - A golden age for amateurs

Thomas Eversberg

Schnörringen Telescope Science Institute (STScI), Am Kielshof 21a, 51105 Köln, Germany

Abstract: Today, professional instrumentation is dominated by heavily oversubscribed telescopes which focus mainly on a limited number of "fashionable" research topics. As a result, time acquisition for massive star research including extended observation campaigns, becomes more difficult. On the other hand, massive star investigations by amateur astronomers performing spectroscopic measurements are on a level which can fulfil professional needs. I describe the instrumentation available to the amateurs, their observational skills and the potential contribution they can make to the professional community.

1 Introduction

The so-called "Golden Age of Astronomy" not only influences professional scientific work but also the amateur domain. State-of-the-art instrumentation such as 1m class telescopes have reached the amateur domain and optics and CCD detectors are available off-the-shelf for relatively low prices. Today amateurs can accomplish extraordinary spectroscopic results, which would have been impossible a few decades ago.

2 State-of-the-art amateur astronomy

In the past few years, various spectrographs have been successfully designed and constructed by dedicated amateur astronomers using off-the-shelf optics and blazed gratings, and have been properly adapted to respective telescopes. The first generation of instruments delivering a spectral resolution of more than 10.000 are now also available commercially, and after the successful design and construction of various prototypes by some skilled amateurs (fig. 1) the first off-the-shelf Echelle spectrographs are also available, including a complete and tested software routine for a "plug-and-play" data reduction chain (fig. 2)[1]. Amateur and off-the-shelf Echelle spectrographs have the same performance but are often cheaper than similar professional prototypes for small telescopes. This is mainly due to commercial off-the-shelf serial production.

3 Long-term campaigns, surveys, monitoring

Amateur spectroscopic equipment can easily be used for scientific investigations of stellar physics, particularly the study of bright emission line stars where line profile analysis of their often fast varying

[1] www.shelyak.com

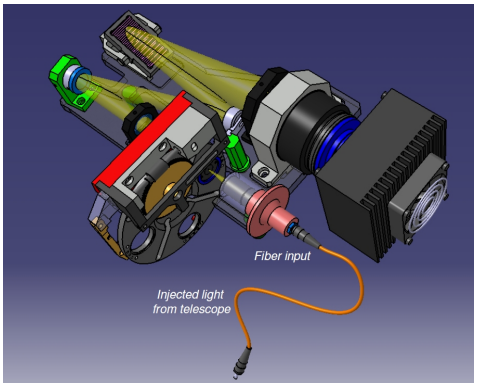

Figure 1: Prototype of an Echelle spectrograph with grating cross-disperser designed by the amateur Tobias Feger. The final device will be mounted in a solid casing.

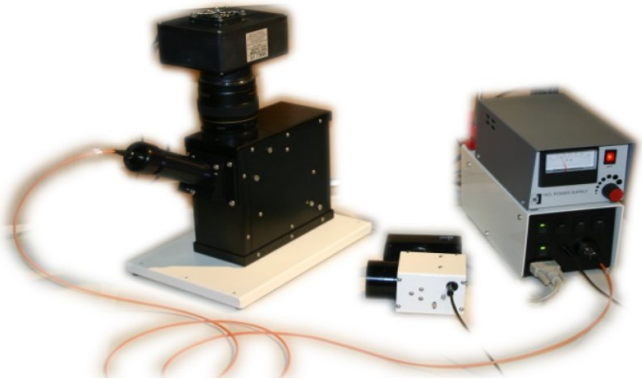

Figure 2: Off-the-shelf fiber-fed Echelle spectrograph with prism cross-disperser from Shelyak.

spectra can be performed. For instance, using a standard 10 inch telescope, a signal-to-noise ratio (S/N) of about 100 can be achieved within 30 minutes for a star of about 8 magnitudes in V and for a two pixel resolution of about 1 Å. Objects of the order of $V = 10$ and fainter are generally excluded due to limited amateur telescope apertures, although with longer exposure times and/or lower S/N this limit can be extended to even fainter stars. Hence, amateur spectroscopists can fill specific gaps for detailed investigations. These are **A) spectroscopic long-term campaigns** monitoring line profiles for periods of the order of months or even years, **B) surveys** to support detailed observations by large or space-based telescopes and **C) monitoring** of specific spectroscopic parameters over many years.

3.1 The long-term ϵ Aurigae campaign

A prominent example of a long-term amateur campaign is the eclipsing binary ϵ Aurigae (F0Ia + companion) with an orbital period of about 27 years[2]. Hα time series, obtained by Christian Buil from his balcony in Marseille using a Shelyak Echelle spectrograph (fig. 2) is shown in fig. 3.

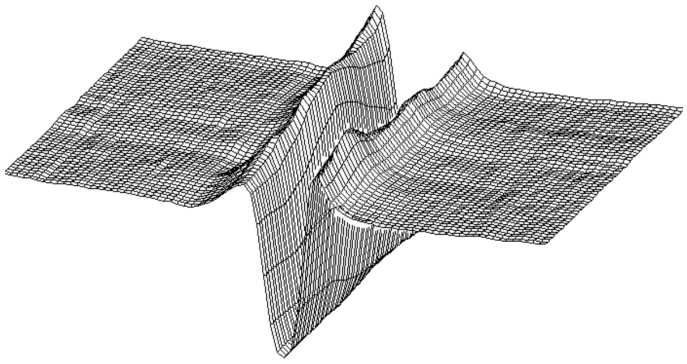

Figure 3: Hα time series for the eclipsing binary ϵ Aur between July 21, 2009 and March 10, 2010 with 3-days increment. Celestron C11, Shelyak Echelle spectrograph, average spectral resolving power R = 11000.

[2]http://www.threehillsobservatory.co.uk/epsaur_spectra.htm

3.2 The long-term MONS campaign

The archetype of colliding-wind binary systems is the 7.9-year period and highly eccentric WR+O binary system WR140 (HD193793, $V = 6.9$). Twenty-six amateurs and professionals from eight countries observed the prominent C III wind line and its excess during periastron passage from Tenerife and from various home observatory in Europe (fig. 4) to estimate the ephemerides of the system. All stations used the LHIRES III spectrograph. As part of this global campaign, Robin Leadbeater obtained spectra during periastron passage from his home observatory (fig. 4). Figure 5 shows his two spectra of C III/C IV before and during periastron passage obtained with his instrumentation. The inset shows the resulting excess emission due to the wind-wind interaction shock cone.

Figure 4: The private Three Hills Observatory of Robin Leadbeater in Cumbria / England consisting of a Vixen 20cm Cassegrain and an off-the-shelf LHIRES III Littrow slit spectrograph

.

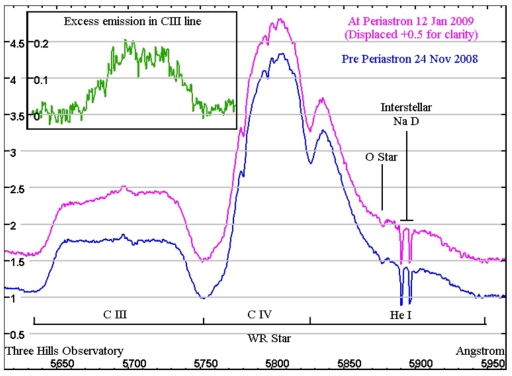

Figure 5: Spectral variability of WR 140 within seven weeks (Robin Leadbeater).

3.3 Surveys

A "classical" example for an astronomical survey, supported by amateur observers, has been the astrometrical High Precision Parallax Collecting Satellite (Hipparcos), launched in 1989. Amateur astrometry has been performed for centuries and dedicated amateurs had already the respective experience to obtain high precision data. As a result, many observers contributed their measurements to perform a successful satellite project. Such ProAm surveys are today possible in spectroscopy, as well. The presently most popular spectroscopic survey is the COROT Be Stars Survey[3] project for the astroseismology satellite COROT (COnvection, ROtation and planetary Transits). A respective amateur COROT survey of bright stars (e.g. Be stars), as performed under professional supervision can help understanding spectral variability like non-radial pulsations or oscillations in the respective Be star disks. An example spectrum, obtained by a French amateur group around C. Buil is shown in fig. 6.

3.4 Monitoring

The most problematic tasks for professional spectroscopy are probably extremely long-term monitoring of specific spectral parameters. Only snapshots within relatively short time-scales are usually

[3]http://www.astrosurf.org/buil/corot/data.htm

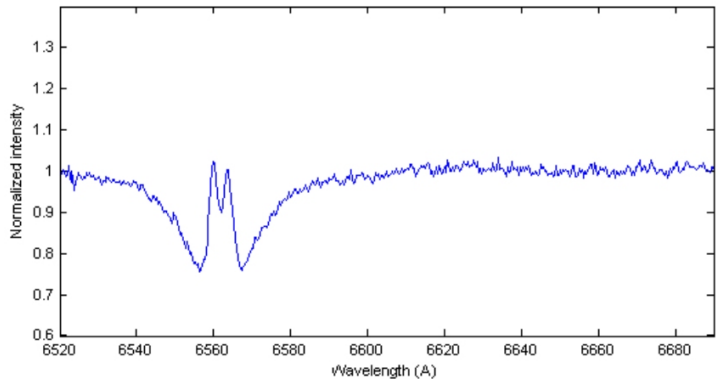

Figure 6: Hα amateur COROT survey spectrum of the $V = 6.14$ B9Ve star HD194244, obtained with a Celestron C11 and an LHIRES III spectrograph with 2700s exposure time.

possible, resulting in large time gaps. The true long-term description of the physical behaviour remains hidden. Delays in publishing results, sometimes for several years do not match the regular needs of a professional astronomer. Continuous monitoring is not a priority in professional spectroscopy. This however, is one of the cornerstones of amateur work using simple standard procedures (e.g., equivalent width and radial velocity measurements) combined with well-known equipment and good routines. An example is shown in fig. 7 for the Be star δ Scorpii.

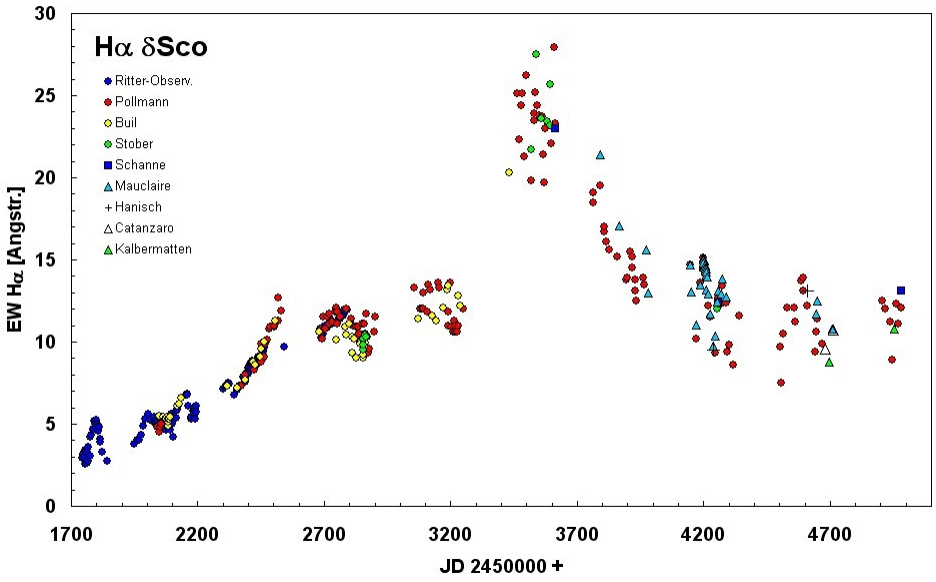

Figure 7: Hα equivalent width measurements for the Be star δ Scorpii over about nine years. Note that the first measurements taken by professionals (blue circles) have been dramatically extended by a group of amateur astronomers.

4 How to establish a ProAm campaign

If the professional community wants to take advantage of amateur measurements one should keep some basic issues in focus. Instrumental knowledge and observational hands-on skills are already present in the amateur domain. On the other hand, scientific knowledge (e.g., physics, procedures,

data interpretation) need to be contributed by those who have a complete university education in this field and already have the relevant experience. The professional community can not expect complete campaign proposals from amateur astronomers but should first take their specific spectroscopic needs to the amateurs and discuss them. For instance, the MONS campaign on WR 140 took only place because of a close contact between a professional scientist (Tony Moffat) and one of his previous students being now active in the German amateur community. The COROT Be stars survey project is mainly driven by a professional group[4] working close together with the amateurs in France[5], Germany[6] and worldwide. Potential ProAm campaigns need some basic details. After an announcement in the respective communities it is essential to give information about the physical background and basic parameters (e.g., S/N, spectral resolution, faq, etc.) to all interested observers. This is best done through a respective website. Unfortunately there are only two well established communities of significant size, namely in France and Germany. In these two communities respective discussion forums are available and it is recommended to use them for proper discussion. For the campaign management it is also recommended to separate science from administration issues. A highlight of each campaign is potential observing time at a professional observatory. Amateurs regularly do not have such access but are generally highly interested to go for it - often even at their own expense (if limited), as happened for the MONS campaign. Finally one should find some minimum financial resources (depending on the observatory site) to cover potential financial deficits (higher equipment transportation costs, unforeseen events, etc.).

5 Future plans and Summary

In May 2010 most of the key players in the WR140 MONS campaign organized a wrap-up meeting at Convento da Arrábida[7] close to Lisbon. The group, now called "ConVento", will establish an informal website covering future ProAm campaigns, respective information about specific stellar targets and a mailing list / discussion forum. Every interested spectroscopist and photometrist is invited to join the group. The link to this website will soon be found at www.stsci.de.

Considering the present situation in astronomy it seems obvious that skilled and sophisticated amateurs equipped with state-of-the art instrumentation in their domain, can successfully contribute their knowledge and enthusiasm to modern spectroscopic campaigns, either at their home observatories or at professional sites. The only obstacle to making continuous observations like those at professional sites is the local weather and the fact that amateur astronomer usually have to work in their daily job. This however can be circumnavigated by joint campaigns, as shown above. It is up to the professional community to uncover this valuable treasure.

Acknowledgements

I thank Tony Moffat, Thierry Morel and Gregor Rauw for their support.

[4] http://www.ster.kuleuven.be/ coralie/members.htm
[5] http://astrosurf.com/aras
[6] http://spektroskopie.fg-vds.de
[7] http://astrosurf.com/joseribeiro/e_arrabida.htm

Discussion

T. Rivinus: Having worked with amateurs I agree this can be a great experience, both teaching- and data-wise. As a word of caution, when working with amateurs you have to take a lot of care about calibration, both in terms of explaining the need for calibrations and their technical implementation. Keep in mind that off-the-shelf instruments often come without a calibration unit, designed for telescopes of 40 cm or less, which is the key of making them affordable for amateur astronomers.
T. Eversberg: First, when using data from other observes, I recommend not to take already reduced data. Do it by yourself, if possible. But, of course, flats, biases and darks should be taken by the observer. Second, standard spectrographs (off-the-shelf) normally come without reduction software. However, Echelle spectrographs are normally delivered including a complete MIDAS reduction loop. Third, a calibration unit (Neon or ThAr) is always included in off-the-shelf spectrographs, at least to my knowledge.

C. Martayan: The experience to work with amateurs was fantastic, for example for the follow-up/long-term monitoring of Be stars. I refer to the papers by Neiner et al. (2005), Thizy (2008)...
My second comment is about δ Sco. I do not know the civilian dates with respect to the JDs on your figure when the outburst occured. However this is a known Be-binary and the outbursts usually occur when the companion is crossing periastron.
My third comment: Currently we are closing the small professional telescopes and let us imagine that η Car explodes as a SN. It will be so bright that its luminosity will prevent the observations with the VLT or future ELTs. This kind of case will give a huge opportunity to amateurs for doing the best observations and provide scientific data of the event(s).
T. Eversberg: I agree.