VARIABLE STAR OBSERVATIONS WITH MEKASPEK

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1 Introduction

If you observe variable stars you are for example interested in their brightness variation during time. Thus you need an instrument which can measure very fast and detect brightness fluctuations in a sensitive manner. Nowadays you are still used to observe with terrestrial telescops through the earth atmosphere with its disturbing extinction effects which varie in airmass (time) and wavelength. You can get rid of these diturbances measuring simultaneously the variable object, a constant nearby comparison star and the sky background in as much as possible spectral ranges.

The solution of all these requirements is the **MEKASPEK** – the '**ME**hr-**KA**nal-**SPEK**tralphotometer'. It is a high speed multi-channel spectrophotometer developed at the Universitäts-Sternwarte München (USM) with financial support through the DFG (Ba 867/2-1/2-2). MEKASPEK has seen first light. We present first results on observed binaries, flare stars and other variable objects (← **??**).

2 MEKASPEK: Main Properties

Getting a slight impression of the technical characteristics of the MEKASPEK follows a list of the most important properties for astronomers when using our photometer. For further information see Mantel,.... ????.

- simultaneous measurement of
  - *object*
  - two nearby *comparison stars*
  - *sky* background
- high time resolution up to *10 ms*
- spectral resolution: $\lambda/\Delta\lambda \approx$ *50*
- spectral range: *3700 – 9000 Å*
- luminosity range: *8 . . . 15 mag* (at 80 cm telescope)

3 MEKASPEK: Technical Components

At the beginning of each night you have to move four optical fibers to the position of each interesting lightsource in the focal plane in order to realize the simultaneous measurement. These four fibers direct the collected light to a spectrograph and a highspeed photoncounting detector (MEPSICRON) which is connected to a VME-bus computer system – the data saving and control unit of MEKASPEK. During the whole observing run you are able to watch online the spectra of each fiber-channel or immediately as light curves in a selected colour system. However, alike which observing mode you use, at the end you will receive observing data with both: *high time resolution* and *broad spectral information.*

Moreover this photometer has the great advantage that it is not fixed to a preset colour system, on the contrary: you are able to present, compare and analyse your data in each colour system you want to namely after your observations. Just recording one dataset through one observing night you can study both: high speed multicolour photometry and low resolution spectra.

Reference (`Literatur`).

4 Standard Reduction

Now you collected all your data, your observations are finished. May be you were not very lucky – the weather was not so good, clouds distored your light curves. But now the simultaneous measurement of the object, the comparison star and the sky background will save the situation. Subtracting the sky counts either from the object counts and from the counts of the comparison star furthermore dividing these object counts by the ones of the comparison star you will derive the so called *reduced data* of the object:

$$obj_{\mathrm{red}} = \frac{obj - sky}{comp * - sky}$$

Assuming the comparison star to radiate on a constant level its intensity variation through the whole night represent the extinction effects due to the earth atmosphere. Thus at the end your reduced data will be released from extinction effects and disturbing intensity dips due to clouds. All of the sudden a given up light curve will show the expected features!

The figure on the left shows from top to bottom: the original data of the cataclysmic variable IP Peg, the simultaneously measured comparison star and the sky background, finally the reduced data: the typical eclipse features (huge hump and egress step of the eclipse) are suddenly visible – see also next figure.

5 Cataclysmic Variable: IP Peg

In the year of 1990 the Universitäts-Sternwarte München startet a long term observation program of the cataclysmic variable IP Peg on the observatory Wendelstein to search for outburst precursors in the light curve in order to finally detect the rising branch of an outburst. Meanwhile a huge dataset has been collected using both USM photometer MEKASPEK and his predecessor MCCP (Multichannel Multicolour Photometer, Barwig *et al* (1987)).

IP Peg's 3.8 h orbital period is the longest of the handful of known deeply-eclipsing dwarf novae, and the only one above the 2-3 h period gap. The orbital light curve shows a remarkably strong orbital hump and eclipse features of the hot spot and white dwarf, which serve us as diagnostics for the determination of period changes (figure). The analysis show a sinusoidal orbital period variation with a period of 4.7 years. In Wolf *et al* (1993) we presented two possible explanations: a third body (late M dwarf) with a most probable mass between 0.08 and 0.16 $M_\odot$. On the other hand attempts to explain the change in period by magnetic activity on the secondary star failed, because the required variation in luminosity of the secondary is not observed.

Reference

Barwig, H., Schoembs, R., Buckenmayer, C., 1987, *Astr. Astrophys.* , **175**, 327.

Wolf, S., Mantel, K.H., Horne, K., Barwig, H., Schoembs, R., Baernbantner, O. 1993, *Astr. Astrophys.* , **273**, 160.

6 Flare stars: UV Cet, EV Lac, EQ Peg

Two years ago a cooperation between the Max Planck Institute für extraterrestrische Physik München (MPIE) and the Universitäts-Sternwarte München (USM) were founded to work on flare stars. Flare stars irregularly show light bursts on short time scales, rising times are tenths of a second, decreasing times range from minutes to hours. Flares originate in the chromosphere due to magnetic field reorganization. Particles (protons/electrons) are accelerated along the magnetic field lines downwards entering the photosphere. Here the optical continuum and the bremsstrahlung will be emitted.

In order to understand the flare processes in January 1992 Schmitt, Haisch and Barwig (1993) did simultaneous observations in the x-rays and optical range using ROSAT and MCCP on the observatory Wendelstein of the USM, respectively. They detected for the first time correlated x-ray and optical flares of UV Cet on a timescale of 15 s, a phaenomenon never observed on our nearest flare star: the sun. They found an almost 30 s time delay between the x-ray flare and the flare seen in the optical U and B band. The following two years this phaenomenon had to be proven. In July 1993 and June 1994 we organized a similar campaign using ROSAT and MEKASPEK on the 1.23 m telescope of the observatory Calar Alto. This time we examined EV Lac and EQ Peg, respectively. For both observation periods we simultaneously detected flares. For the first time an extremly strong flare on EQ Peg has been observed simultaneously in the x-ray and optical spectral range. Again the x-ray bursts occured about 20 s (EV Lac) and 4 min (EQ Peg) after the light burst in the optical spectral range – another evidence for this time delay feature.

Reference

Schmitt, J.H.M.M., Haisch, B., Barwig, H. 1993, *Astrophys. Journal* , **419**, L81

7 Flickering: SS Cyg

In ... 19?? the cataclysmic variable SS Cyg has been observed on the observatory Wendelstein of the USM. The observations has been performed with MEKASPEK using a integration time of 2 s. The mean spectrum clearly shows the first three dopplerbroadend Balmer emission lines H_α, H_β and H_γ originated in the accretion disk. In order to examine the light variations in SS Cyg in more detail, two light curves were derived from the MEKASPEK dataset: the Balmerline and the optical continuum light curve. As the prominent light feature is only visible in the continuum light curve and not in the light curve of the emission line this feature has to have its origin in optical thick regions like the inner disk or the hot spot of the accretion disk where the mass stream of the secundary hits the disk. The integral flux measurement of the H_α emission line confirms this assertion as no significant variations could be recognized during the whole time interval. This analysis shows another advantage of the spectro-photometry generated with MEKASPEK: you are able to localize the origin of specific light variations, if they are emitted from optical thick or thin regions.