# Spectroscopic observations of comets with amateur means

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*Even today, where high sophisticated CCD cameras and telescopes with 0.4m-0.8m aperture are not unusual for amateur or public observatories, spectroscopic observations, particularly of comets, are not very common. One reason could be, that suitable spectrographs cannot be bought (or would be too expensive and/or too big and heavy). In most cases they have to be build. Details of our spectrographs will be given on our webpage (http://astro1.physik.uni-siegen.de/uastro/spektro/)*

*We present spectroscopic observations of comet C/1995 O1 (Hale-Bopp), C/1996 Q1 (Tabur) and C/2002 C1 (Ikeya-Zhang), carried out with self-made spectrographs attached to the 300/1440mm Newton reflector of the Siegen University observatory. For comet Hale-Bopp the sodium emission tail could be confirmed.*

## Introduction

In 1996 we started our first attempts in spectroscopic observations of comets. Therefore we built a slit spectrograph (YASSP1) using an Amici prism (Fig. 1).

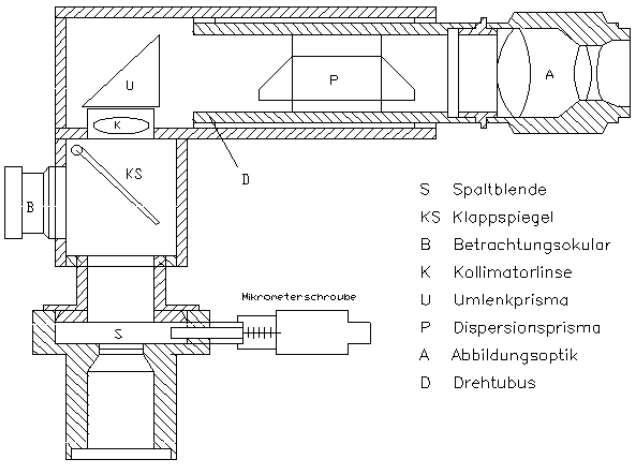


**Figure 1:** S Slit, KS Flip mirror, B control ocular, K collimator lens, P dispersion prism, A imaging lens (ordinary photo lens).

With this spectrograph we observed comet Tabur in October 1996. A couple of months later, we made a mechanical re-design of this spectrograph, but essentially (optical parts) it was the same. This spectrograph (YASSP2) was used for observations of comet Hale-Bopp in 1997. Because of different problems with this new concept and other tasks, we could not get very much data of reasonable quality. These spectrographs had a pixelscale of only about 1-2 nm / px.

In 2001/2002 a third spectrograph (YASSP3) was built by M.Jung. Now, a blaze grating (1200 lines/mm) was used and the optic was optimized for the f/4.8 focal ratio of our telescope. Wavelength calibration is possible using 2 or 3 background lines (Hg) because of the linear dispersion function. The linear dimension of the spectra is about 25mm. The pixelscale is about 5Å / px. Now we use the KAF-0401E and 1602E devices (Audine cameras), which have a better response, especially in the blue part. On 2002-Apr-22 a first spectrum of comet Ikeya-Zhang was obtained.

## Results and discussion

Figure 2 shows the final spectrum of comet Tabur, obtained on 1996-Oct-14 with YASSP1. It was taken with our 300mm Newton reflector and a CCD camera running the KAF-0400 device in 2x2 binning mode. For wavelength calibration we used spectra of streetlights, which could be easily taken, because the observatory is located in the city and the dome is surrounded by streetlights and buildings …
At the time of observation the comet had a visual total-magnitude of about 5.5mag. For the reduction a background image with the same integration time was subtracted. No flux calibration was made, thus the spectrum is folded with the CCD response function. The emission lines were identified by [1].

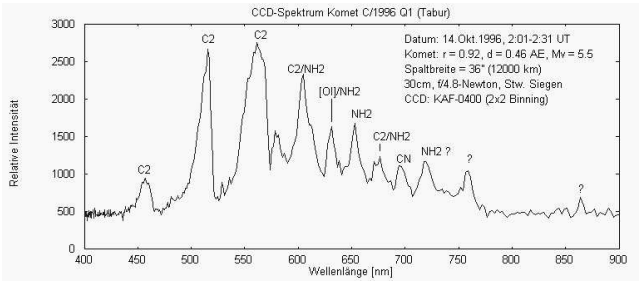


**Figure 2:** Reduced spectrum of comet Tabur in the range approx. 430 nm to 900 nm.

Some months later we observed comet Hale-Bopp on several nights with our second spectrograph. Figure 3 shows a sample of three nights. On 1997-Apr-20 we got the message, that a sodium tail was discovered at La Palma observatory (see IAUC 6631) and we could confirm this on the same night. Re-checking our previous taken spectra we found a weak emission line at 589nm on an image of 1997-Apr-06, for which we believe that this is a Na-emission from the comet and not from the background (we should note, that subtraction of the background image does

not always eliminate the background complete, because the imaging conditions like seeing, transparency etc. may change).

On 2002-Apr-22 a CCD spectrum of comet Ikeya-Zhang was taken with the new YASSP3 spectrograph (see Fig. 4). Again, this was made with the 300/1440mm Newton reflector at Siegen observatory and a self-made Audine CCD camera running the KAF-1602E device in 2x2 binning mode.

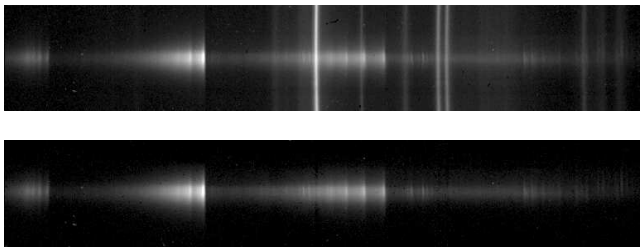

**Figure 4:** Raw CCD spectra of comet Ikeya-Zhang on 2002-Apr-22 in the range approx. 470 nm – 630 nm. Top: with background (the 546.1/577.0/579.1 nm Mercury lines are visible). Bottom: background subtracted.

A preliminary reduction of this spectrum is given in Figure 5. For the wavelength calibration, the three Mercury background lines at 546.1nm, 577.0nm and 579.1nm were fitted against a linear function, but no flux calibration has been done. Lines were yet not identified by wavelength, but the $C_2$ Swan bands and also some $NH_2$ emissions can be recognized. No Na emission is visible. But it should noted, that the sodium emission was detected by M. Fujii using a 0.28m and 1.01m telescope on March 3 (IAUC 7851).

**Conclusions**

We think, that it is possible for amateurs to make useful contributions to the exploration of comets, e.g. by investigating the spectral evolution over weeks, what in general cannot be done at professional observatories. Even with small instruments (D < 0.5m) comets of 6-8mag and brighter can be observed.

**Acknowledgment**

We thank the University of Siegen Observatory for assistance and access to their facilities.

**References**

[1] Brown, M.E. et al. (1996): A high-resolution catalog of cometary emission lines. Astron. Journal 112 (3), 1197-1202.

[2] http://astro1.physik.uni-siegen.de/uastro/spektro/index.html

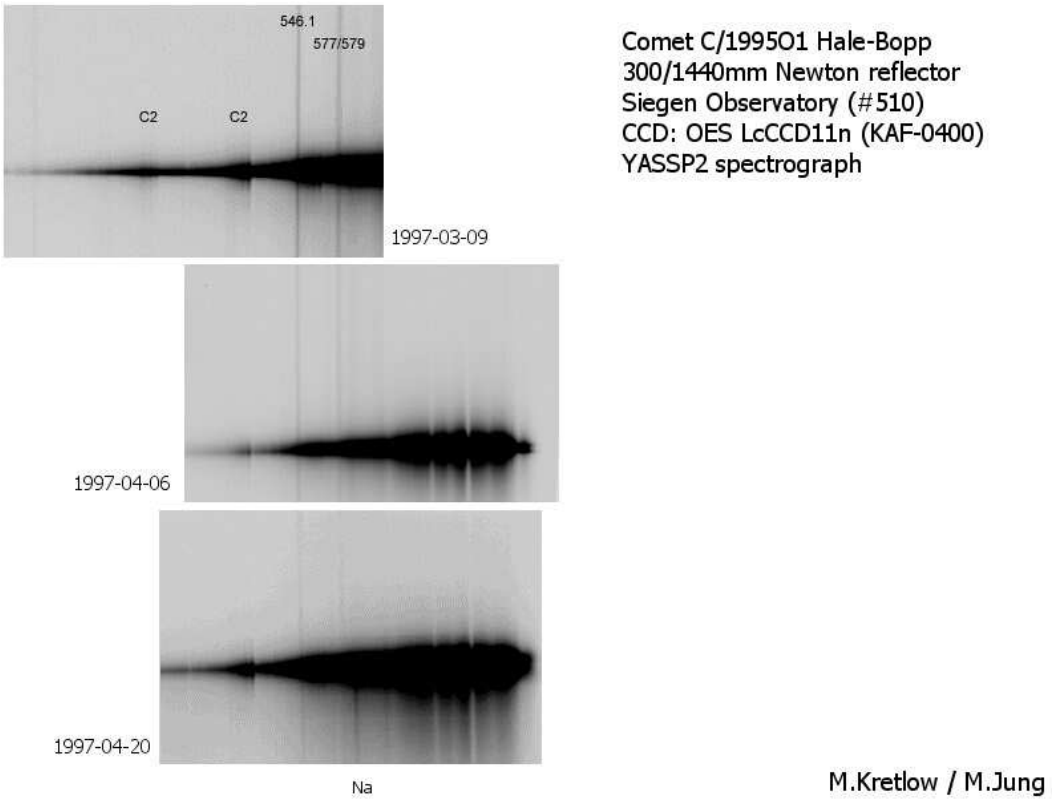


**Figure 3:** This composite image shows three raw CCD images. On April 20, the Na emission is visible. The image taken on Apr 06 shows also a very weak emission on the same position (probable not visible here in the paper; see [2] ).

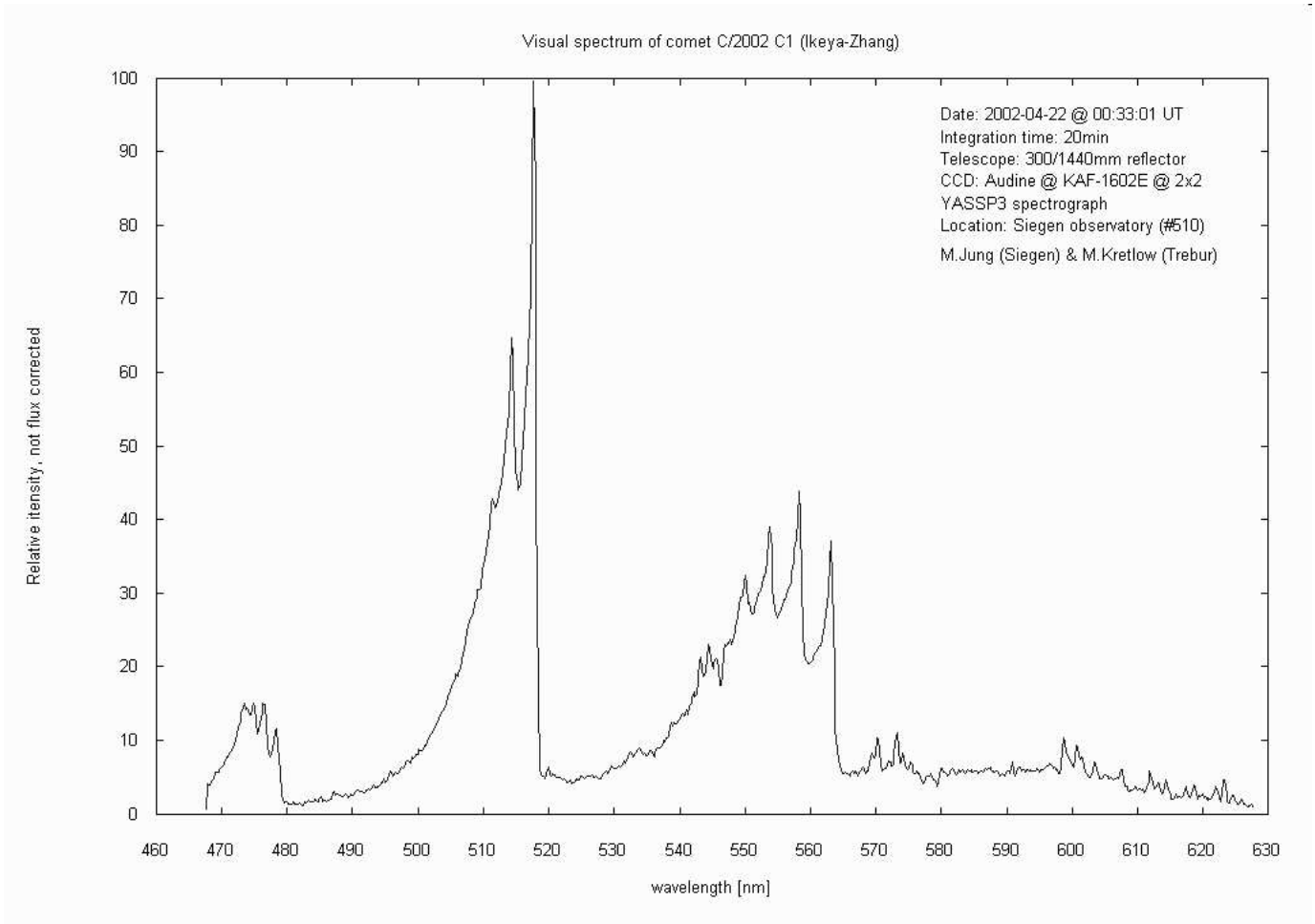


**Figure 5:** Preliminary reduced spectrum of comet C/2002 C1 (Ikeya-Zhang), taken on 2002-Apr-22 with the YASSP3 spectrograph on a 300/1440mm Newton reflector. The slit was centered on the head of the comet. The intensity is scaled to 100% for the strongest emission ($C_2$ at 515nm). Some of the smaller peaks between 570nm and 630nm should belong to $NH_2$ and probable to $H_2O^+$, but apparently no sodium emission is detectable.