Sonneberg Observatory Digital All-Sky Survey

Continuing sky monitoring by digital means

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Abstract

Sonneberg Observatory's traditional sky patrol (see SOPHIA poster) with photographic plates is continued by digital monitoring using different types of instruments. The cascade starts with all-sky cameras using fish-eye lenses. We have set up two cameras, one from the consumer market, the other as in-house development. An almost continuous monitoring from dawn to dawn is achieved by 20-seconds exposures with just 2.5 seconds read-out time, reaching stars of 6^m and 7^m in the zenith. The survey runs since four years with the main goals of bright star monitoring, detection of bright transients and fireballs, besides statistics of unusual atmospheric phenomena.

Introduction

Sonneberg Observatory run the Sky Patrol and Field Patrol from 1923 to 2010 by photographic means. With the development of solid-state detectors and computers during the last decades of the twenties century it soon became obvious that chemical photography will finally be stopped and be replaced by CCD and CMOS cameras.

For this reason we had work out a project called ASPA (All-Sky Patrol Astrophysics) in the mid 1990ies to set up a digital sky patrol at six sites around the world. Unfortunately, this project could not be realised.

Mainly as a matter of low budget but decisive to start any kind of digital sky patrol we set up a two-stage sky monitoring with digital cameras. One of them should be a permanent all-sky monitoring with a fish-eye lense, and the other should be a kind of field patrol using existing optical instruments.

All-Sky Monitoring

The first all-sky camera (Starlight Xpress Oculus, see figure 1, left) was mounted in March 2015 and is running since without minor technical interruptions only. Impressed by the results we (T.B.) developed an in-house fish-eye camera which runs since mid 2017 (figure 1, right).

Figure 1: Starlight Xpress Oculus (left) and in-house developed fish-eye camera (right) set up on the roof of main building.

The cameras are operated in the following way. From dawn to dawn (Sun elevation below $-10°$) the camera takes images of 20 seconds exposure time. This exposure time is adjusted in the way that stars at the celestial equator still appear as points. The read-out time of one image is in the order of 2.5 seconds. Thus, there are roughly 160 images taken per hour, summing up to about 600 images near summer solstices, and about 2000 images near winter solstices.

All images are stored as TIF files and also transformed (down-scaled and compressed) to JPEG. The JPEGs are further processed to a daily morning movie. By inspecting this film unusual events and transients can easily be spotted. As an example, figure 2 shows the fireball of 2018-06-30, on the bases of which a meteorite fall not far from Bamberg was predicted. (Unfortunately, not any piece was found.)

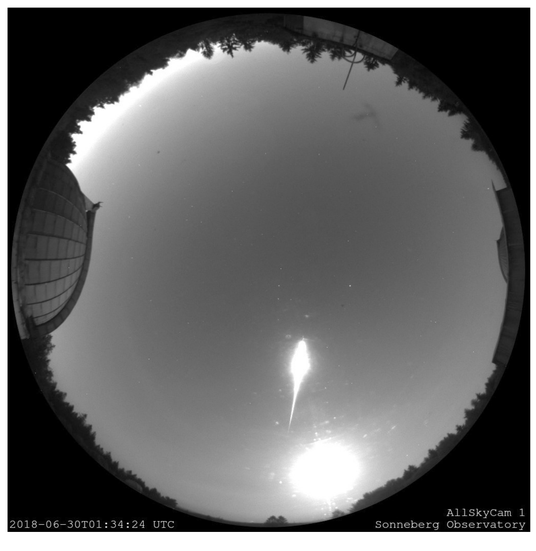

Figure 2: Fireball of 2018-06-30 taken with All-Sky-Camera 1.

The integral limiting magnitude of the cameras is about 6^m for the Oculus and 7^m for the in-house camera. For a comparison, Figures 3 and 4 show images of the two cameras taken at almost the same time.

Figure 3: Example image of All-Sky-Camera 1, taken at 2019-02-26, 20:00:00 UT.

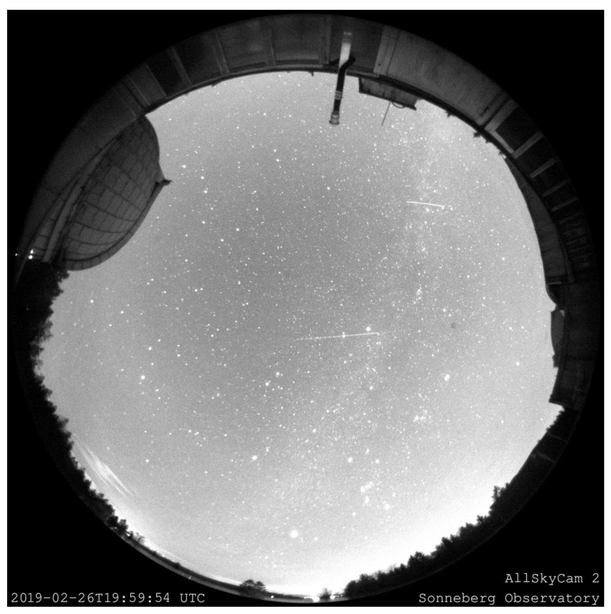

Figure 4: Example image of All-Sky-Camera 2, taken at 2019-02-26, 19:59:54 UT.

Owing to the limiting magnitude a few thousands of bright stars are monitored though the year with approximately 25,000 to 100,000 data points, depending on declination and weather conditions.

An automatic analysis of the images is currently missing. As a test case (in other context), K.S. has estimated δ Cephei, the famous prototype of pulsating stars, with Argelander's method. Figure 5 shows the folded light-curve of this star.

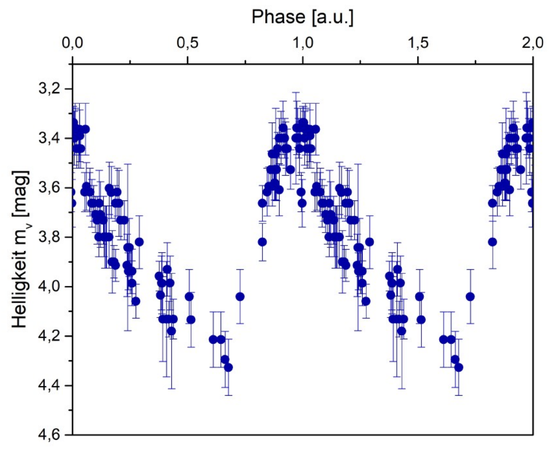

Figure 5: Light-curve of δ Cephei, estimated with Argelander's method.

Deeper monitoring of selected fields

By combination of a Tessar 80/360 mm objective and a Canon EOS 5D Mark 1 CMOS camera (see figure 6), there is a monitoring of selected fields running since 2014 (by W.F.; see also poster of M. Ennes and W. Fürtig). This camera reaches about 14^m at three minutes exposure time. By utilizing every clear night and even periods of clear sky of just one hour only, relatively dense light-curves have been achieved – even at this site in the middle of Europe.

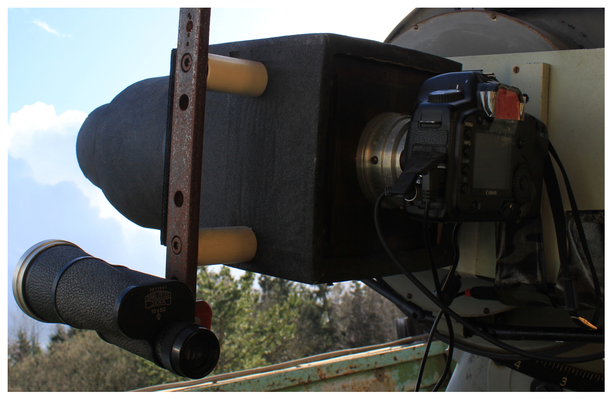

Figure 6: Digital field patrol with Tessar 80/360 mm objective and a Canon EOS 5D Mark 1.

The selection of the fields comes from prominent variable stars such as R Coronae Borealis or FG Sagittae. As the field of view is $3.8° \times 5.7°$, also other variables are recorded. As an example, figure 7 shows the light curves of R CrB, SX Her, and VV Cep over the last three to four years, reduced with `Muniwin` by E.S.

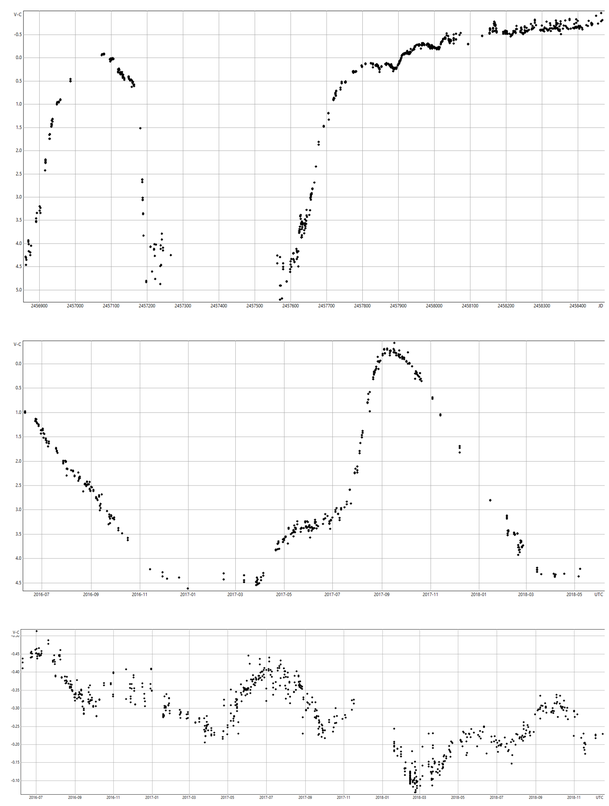

Figure 7: Light-curves of carbon star R Coronae Borealis (top), Mira star SX Herculis (middle), and eclipsing super-giant VV Cephei (bottom) (relative magnitudes in V).

Outlook

It is our aim to improve cadence and sky coverage for magnitudes down to approximately 12^m in V, as the next cascade of sky monitoring by automatic telescopes to study all kind of variable objects and transients.

S.G. has made a study for a parallactic platform carrying four telescopes which could be an inexpensive solution. See figure 8 with scetches of the platform and the superimposed telescopes.

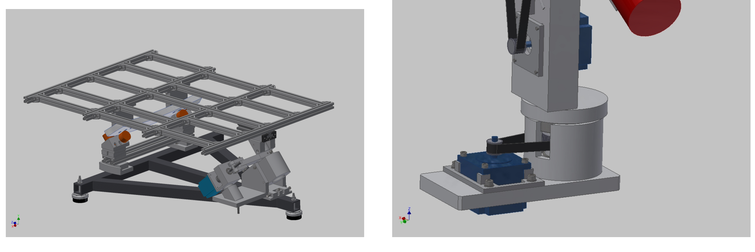

Figure 8: Study of parallactic platform (left) with four superimposed telescopes (right).

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