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A portable wide-field instrument for mapping night sky brightness automatically

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Abstract. We present a portable automatic instrument for monitoring night sky brightness and atmospherical transparency in astronomical photometrical bands. Main requirements were: fast and automatic coverage of the entire sky, lightness, transportability and quick set-up in order to take measurements from more sites in the same night, easily available commercial components and software to be reproduced by any interested institution, included amateurs astronomers groups.

Key words. instrumentation:photometers – light pollution – site testing

1. Introduction

Many studies of light pollution require large quantities of measurements of night sky brightness that, in order to be useful, need to be associated with knowledge of atmospheric conditions during the measurements (e.g. Cinzano et al. 2000; Cinzano, Falchi & Elvidge 2001a,b). The measure of the atmospheric extinction is one of the simpler ways to evaluate the aerosol content of the atmosphere. In order to obtain contemporary measurements of night sky brightness below the atmosphere and stellar extinction, ISTIL set up a specific instrument called WASBAM (Wide-Angle Sky Brightness Automatic Mapper). The basic requirements were: 1) fast and automatic coverage of the entire sky in astronomical photometrical bands with a series of wide-field images; 2) maximum lightness, transportability and quick set-up in order to take measurements from more sites in the same night; 3) easily available commercial components and control software so that the same instrument could be easily set up by any interested institution, included amateurs astronomers groups and sections of the International Dark-Sky Association (IDA); 4) automatic registration of position, elevation, date, time, alt-azimuthal and equatorial celestial coordinates; 5) quick data reduction, automatized as much as possible.

2. Description

We choose a SBIG ST-7E camera with a Kodak KAF0401E CCD with 760×510 pixels (9×9 μm^2 pixel size) no-antiblooming and a spectral response from ≈430 nm to ≈830 nm FWHM. The shutter is electromechanical. Through an aluminium adapter

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made by Officine Marcon of San Donà di Piave, Italy, the camera was installed on an ultra-light computerized altazimuthal mount Celestron Nextar 4 on its tripode, kindly provided free of charge by the Italian Celestron dealer Auriga of Milan. The coupling of the Nextar mount with the SBIG camera and a SBIG CFW-8 filter-wheel allows the fully control of the instrument from a Dell Inspiron computer. *UBVRI* filters are Optec and SBIG. The short-focus lens, a cheap 16 mm f2.8 Zenitar provided by Adriano Lolli, produces images of about $25° \times 16°$ on the CCD with a scale of about 2' per pixel. An appropriate out-of-focus allows to avoid starlight under-sampling. The software Orchestrate by Software Bisque automatically controls all the operations through the software TheSky level IV for the pointing and the coordinate memorization (both altazimuthal and equatorial) and the software CCDSoft v.5 for the management of the CCD and the filter wheel. The set-up procedure (Cinzano 2002a) is quite fast, mainly requiring to place the instrument, insert the geographical position obtained with a GPS receiver, tune the alignment with two stars chosen by the instrument and start the Orchestrate procedure. The instrument automatically exposes a sequence of sky zones, e.g. the zenith, 8 zones at 45° altitude equally spaced in azimuth along the horizon and 12 zones at 20° altitude every 30° in azimuth. At the end, after the exposure of some flat-field, it is possible to move to the next site. The software CCDSoft allows to reduce all the images together with the standard procedure and determines the astrometry recognizing the standard stars to be used for the photometrical calibration and the extinction curve (Cinzano & Falchi 2003). These operations are made automatically with a procedure of Mathematica (Cinzano 2002b). We measure star and sky counts manually with IRAF or Quantum Image.

We did not use a Fish-eye lens, covering the entire sky in only one exposure, mainly because of the difficulty to accurately evaluate the geometry of the projection on the focal plane and the contamination of the standard star counts by nearby stars due to the strong out-of-focus. The problem will disappear when large CCDs with small pixels will be available for astronomical use at low prices. We did not use a digital camera because of the difficulty to properly reproduce the sensitivity curves of standard photometric bands with a colour CCD.

Fig. 1. The WASBAM instrument.

We are testing a spectrographic head with a De Amici prism which allows to take spectra of the sky background with a dispersion better than 1 nm pixel^{-1} at 550 nm.

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