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Unraveling the Astrophotography: Physical Principles and Techniques for Processing Astronomical Images from CCD and DSLR

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Abstract.
This work aims to present the methodology used by us as ministrants of telescope and astrophotography workshops. Our mini-course empowers participants to perform a basic operation of motorized telescopes, maintenance, and optics collimation and also provides an average knowledge of the main processing techniques used today in astrophotography. Here, we present the main topics of those courses, that goes from the basics of the optics of all kinds of telescopes to the final processing procedure of the astrophotography.

Resumo. Este trabalho tem como objetivo apresentar um relato de curso e metodologia utilizada por nós enquanto ministrantes de mini cursos de Telescópio e Astrofotografia. Nosso minicurso capacita seus participantes a operação básica de telescópios motorizados, manutenção e colimação das óticas envolvidas e também proporciona um conhecimento médio das principais técnicas de processamento de astrofotografias utilizadas nos dias de hoje. Aqui, apresentamos os principais tópicos de nosso mini-curso, desde ótica básica de todos os tipos de telescópio, até o processamento final de astrofotografias.

Keywords. Teaching of Astronomy – Techniques: image processing – Miscellaneous

1. Introduction

Today, it is not very easy for us to take a break from our modern life and look the night sky, much so because of the visual pollution from the city's lights as also for the lack of interest caused by the false common knowledge that there is nothing interesting to see. Most people also believe that you need crazy expensive equipment to click some quality pictures of the sky. Some schools and universities in Brazil have observation projects but don't have qualified personnel to operate the telescopes. As we don't have a specific course to operate telescopes, most teachers find themselves with great equipment but no experience on the subject. Since 2012 (Leão et al. 2016), our Astronomy and Astrophysics group (SOFIA Observatory) hosts courses about telescopes and astrophotography with the idea of enabling those teachers and students to operate such equipment the best way possible. Since the first time this workshop was given (de Almeida & Leão. 2012), we have always received good feedback from participants regarding the methodology and material used. Our methodology gave light to some related works as Amaral et al. (2016) and Santos et al. (2012).

By the end of each workshop, all participants will have learned: basic and intermediate definitions of OTAs (Optical Tube Assembly), telescope handling and maintenance, concepts and use of DSLRs (Digital Single Lens Reflex), getting astronomical images using reflecting telescopes and main techniques of image processing. Finally, we hope that the participants can leave the course with enough knowledge to be able to make their own astrophotography using the techniques of recording and processing given. Thus, knowing how to mount the telescope, register astronomical objects and process these files revealing the recorded images.

2. Physical principles of telescopes and DSLRs

In this first step, we approach the optics of our image acquisition equipment that is divided into two main parts: the lens; and the sensor. The lens can be interpreted as the optical instrument that converges the light of the object to be photographed at a focus point where the sensor is mounted. The sensor can be interpreted as the analog or electronic device that collect the light coming from the optical instrument. We discuss some types of OTAs used for observation and astronomical recording. First, we must understand what the optics of a telescope consists of. This is the system of lenses and/or mirrors that converge light from the object to a focal point. There are several types of OTAs that differ by the construction and path that the light makes to the focal point. This section of the workshop focus on: OTAs (Optical Tube Assembly), mounts, refractor telescopes (chromatic objective, chromatic aberration, apochromatic APO-ED), reflector telescopes (Newtonian, Cassegrain, Gregorian, Catadioptric, Schmidt, Maksutov), barlows, prisms and filters. The physical principles related to telescopes covered during the workshop are: focal Ratio, magnitude, optical magnitude limit, brightness, resolution, the principle of diffraction, airy disk, Dawes limit, magnification, field of view.

Once we have seen everything we can about OTAs and mounts, we cover the equipment responsible for the acquisition of light from the telescopes and the transformation of this raw signal into digital signals that will be further processed. There are several types of camera with different types of sensors and lenses. Before getting onto the cameras, we need to understand how the digital sensors that store these images work. Regardless of whether it is CCD or CMOS the working principle of these sensors is the photoelectric effect. All the physical principles of CCD and CMOS are covered during the workshop with practical and theoretical problems. This section of the workshop covers: cameras (PowerShot, SLR and DSLR), sensors (CCD and CMOS) and lenses. The physical principles are: lenses, aperture, ISO, the photoelectric effect,A/D (Analog to Digital) and exposure time.

3. Techniques for Processing Astronomical Images

Astrophotography exists for several reasons, and each astrophotographer develops his own motives and ideas about this activity. But we all have in common the desire to do the best possible job with the equipment that we can afford. Good astrophotography can take days, weeks and even months to go the way we want. There are several registration techniques that help us get better RAW images so that, in the processing, we have less work. This part of the workshop aims to give a better understanding of the acquisition techniques and the processing procedures at the final stage of the work. This is the most extensive part of the workshop and here we list just the main topics: registration techniques, afocal, PowerShot and cellphones,direct focus, CCD (equipment adjustment, collimation, auto guider, periodic error correction, focus, darks, bias, luminance, nebulae and galaxies, exposure time, number of frames, preview on DS9, planets and Moon, the maximum number of frames, RGB), DSLR (nebulae and galaxies, T-ring, universal support, camera settings, mosaic, high dynamic range (HDR)), image processing techniques (direct processing, RGB image processing, stacking in 3 colors, level Adjustment in Liberator FITs, processing in Photoshop, mosaic methods in Photoshop, HDR with Photomatix and Photoshop, stacking images in DeepSkyStacker, adjust levels in Lightroom, final Settings in Photoshop, acquisition and processing Techniques with DSLR only, acquisition of the Milky Way), visual pollution. Once we cover all these topics we are able to produce a good quality astrophotography.

4. Results

We show next one example of how the knowledge provided with our workshop and of course, some time, can helps us to create a fine astrophotography. The Fig. 1 shows our earliest attempt to photograph the Trifd Nebula M20 in 2011 with a 12 inch telescope.

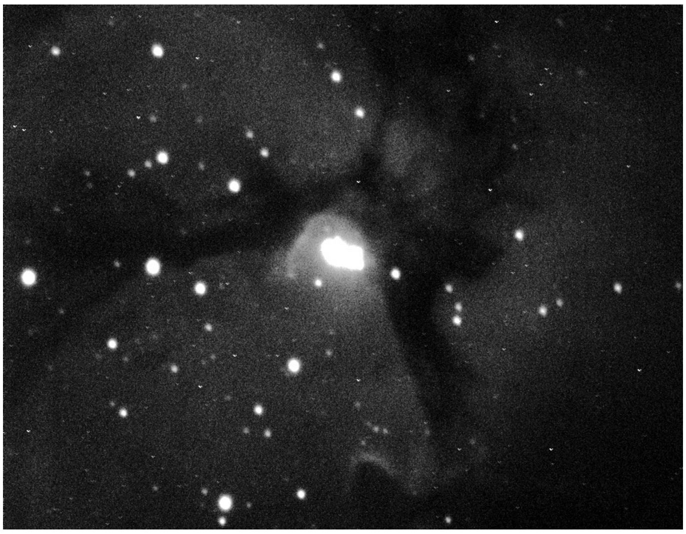

FIGURE 1. M20 - Single frame of Trifd Nebula by Leandro de Almeida using a 12 inches Telescope with a DSI II camera.

Now, by using all the knowledge available in our workshop, the result is quite fascinating. We can see the final result in Fig. 2, and that same astrophotography received the Nacional Astrophotography prize in 2013.

FIGURE 2. M20 - Mosaic of the Trifid Nebula in RGB by Leandro de Almeida using a 12 inches Telescope with 2 and 3x barlow and a DSI II camera.

5. Conclusion

The conclusion of this work is that it doesn't matter the price of your equipment if you don't have the knowledge to extract the results. All pictures shown during our workshops were produce using only a meade LX90 12, and a Greika telescope 6 with a DSI B&W with RGB filters.

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