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Measurement of Aureole and Suppression of Internal Stray Light of Aureole Photometer† ⋆

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Abstract A modern aureole photometer (AP) was developed for the site survey in West China, in preparation for the installation of future large solar equipments. The performance of this new AP was tested in preliminary observations, and a lot of sky brightness data were accumulated at a few sites in Yunnan Province. The result of data analysis shows that the aureole near the noon time on Jiaozi Snow Mountain is as low as a few millionths of the intensity at the solar disk center, indicating the low internal stray light level of our instrument. The internal stray light of the AP comes mainly from two parts: the edge diffraction of the ferrule for fixing the ND4 filter in the front end of the telescope tube, causing the stray light distributed in the inner region of the field of view, and the edge diffractions of the diaphragms placed inside the telescope tube, causing the stray light distributed in the outer region of the field of view. In order to suppress the stray light of the latter part, the experiment to change the aperture size of an additional diaphragm was performed. The result shows that the stray light in the outer region of the field of view can be effectively suppressed by reducing properly the aperture size of the diaphragm.

Key words: instrumentation: photometers—sun: corona

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1. INTRODUCTION

The solar physical research in China is now in a golden stage of rapid development. Recently, a new run of site survey in West China for new solar instruments is in orderly progress. The various atmospheric parameters required by the site survey, including the atmospheric extinction, vapor content, transparency, etc., can be derived from the multi-band data of the aureole photometer (AP). Solar corona is an important layer of solar atmosphere, its intrinsic brightness is extremely weak relative to the strong radiation background of solar photospheric disk. In addition to the scattering effect of terrestrial atmosphere, before the advent of coronagraph it could be observed only during solar total eclipses[1]. The direct observation on the solar corona is a long-term will for Chinese solar physicists. In fact, early in 1959 Su Ding-qiang et al.[2] made a detailed study on the design and manufacture of a ground-based coronagraph, but because of the lack of suitable site and other factors, up to now there is no any optical instrument for the routine coronal observations in China. The AP can be used to measure directly the aureole, namely the brightness of the large-area sky-background around the solar disk, hence to provide an important reference for the site survey of coronagraph. It has a significant meaning for promoting the coronagraph to come out in China, even for the whole site survey project of solar instruments. Around 1991, Li Qiu-sha et al.[3] made a rather simple AP, but its performance still has a certain disparity from the international standard. Under the background of a new run of site survey, it is necessary to develop a modern AP in consideration of the successful experiences in the world, and by the scientific observations of aureole to obtain the important atmospheric parameters of candidate sites. On the basis of international cooperation and under the support of National Astronomical Observatories, Yunnan Astronomical Observatory (YNAO) has developed the first modern AP in China. With this instrument, a large amount of data were obtained during the solar annular eclipse of 15th Jan., 2010 at Dali, thus its good performance is verified.

The modern AP was developed first by the members of the site survey project for the 4 m Advanced Technology Solar Telescope (ATST)[4] of the United States. For the conveniences of data comparison and instrument calibration, we have adopted basically the same optical design as theirs, including the size, aperture and other parameters, except that a new generation of CCD camera with better performance is adopted by us.

The particularity of this AP is the simultaneous imaging of the solar disk and aureole, thus the intensity ratio of the aureole and solar disk can be precisely measured. The brightness of the aureole is caused by the atmospheric scattering. It is predictable that in order to measure precisely the aureole, how to suppress the internal stray light of the instrument that is caused by the direct illumination of the solar disk is a key point. Hence, in the early testing stage of this new AP, in addition to the aureole observations at different candidate sites and for the comparisons of data, we have made some experiments to suppress the stray light. According to Reference [4], we have repeated the experiment to alter the number of the rings on the ferrule of the ND4 filter, and have basically verified the effectiveness of their method. This is very helpful for reducing the intensity of stray light in the intermediate region of the field of view. For suppressing the bright diffraction rings distributed in the outer edge of the field of view, we have made an additional experiment to change the diaphragm aperture and obtained a good result, as described in details in Sec.4 of this paper. It is