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The Representation of OTA Images' Astrometric Results with WCS-SIP Coefficients† ⋆

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Abstract Cross-matching the sources in the observed image with the star catalogs or earlier records is a necessary procedure for detecting the position or brightness variation of a specific source in the Optical Telescopes Array (OTA) survey. Therefore, knowing the celestial positions of these objects on the observed image is prerequisite. A method based on matrix manipulation is applied to converting the existing plate constants of OTA images into the World Coordinate System (WCS) and Simple Imaging Polynomial (SIP) coefficients, and recording such mapping relations on the FITS (Flexible Image Transport System) files of OTA for the convenience of use. The improvement on the astrometry of OTA resulted by this method, as well as the discussion about some problems of the OTA astrometry are also presented.

Key words astrometry, surveys, techniques: image processing

1. INTRODUCTION

At present, there are many astronomical projects in the time domain, which take supernovae, transiting exoplanets, space debris, etc. as the major scientific objectives, such as the ASAS (All Sky Automated Survey)[1], WASP (Wide Angle Search for Planets)[2], etc. A common feature of these projects is that the telescopes are basically the refractors of small

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aperture, because a telescope with a small aperture is easy to realize the wide viewing field, multiple telescopes may be combined into a super-wide viewing field, so as to bring about a very high survey efficiency. Such a project is generally known as Ultra-Wide-Field Optical Survey [3]. The three Optical Telescope Arrays (OTAs) of Purple Mountain Observatory, which are located in Yunnan, Xinjiang and Heilongjiang, respectively, are also belonging to such kind of large time-domain astronomical project, and are designed especially for the detection of space debris. Their characteristics of wide viewing field, large sky-area coverage, and high temporal resolution are suitable also for other scientific objectives, such as the supernova detection, etc. In addition, the Twelve Small Telescopes (TST) of Purple Mountain Observatory, which are under construction now, are composed of 12 telescopes of variable pointing with an aperture of 28 cm, and the viewing field of each telescope attains 50 square degrees. They are expected to finish construction in 2017 and put into operation in the Yaoan Station.

In the ultra-wide-field optical survey, in order to detect the variation of a source in position or brightness, it is necessary to cross-match the sources in the observed image with their known data of earlier observations at different epochs or of star catalogs. Therefore, the acquisition of celestial coordinates of objects in the observed image with a high astrometric accuracy and in a simple and convenient manner is indispensable. Moreover, the a priori information on the conversion from image coordinates to celestial coordinates is needed for the superposition treatment of images using the astrometric software SCAMP[4]. The coefficients, which reflect such a mapping relation, are generally recorded with a set of key words in the image file of the Flexible Image Transport System (FITS), and the celestial coordinates can be easily obtained from the image by using the common-used astronomical software. One of the aims of the World Coordinate System (WCS) standard[5−6] is to record the mapping relation between image coordinates and celestial coordinates, and to record the necessary mapping coefficients through a set of predefined key words in the head of the FITS file.

At present, in the common-used astrometric software packages, such as WCSTools[7] and SCAMP, all the astrometric results are expressed in the form of WCS, and at the same time the software packages contain a series of tools for the utilization of the WCS information. But, because of historic reasons, these software packages support insufficiently the current WCS standard, and among them the standard may be different, especially in the formulation of distortion. WCSTools defined a set of CO_x_x coefficients, which can be used only by itself; while SCAMP used PV_i_ma, which is originated from the draft of the WCS standard before 2000, and now is in conflict with a part of projective coefficients. Besides, the common-used astrometric software packages generally have a worse adaptability for extreme conditions, in order for ensuring the efficiency in most cases of application. For example, in the case of this paper, WCSTools and SCAMP can hardly prove equal to the task, because of the OTA's extremely wide viewing field, undersampling, and dense star field. Particularly,