

## ASSIGNING WCS STANDARDS TO ROZHEN FITS ARCHIVE. PRELIMINARY TESTS

GALIN BORISOV<sup>1</sup> and ORLIN STANCHEV<sup>2</sup>

<sup>1</sup>*Institute of Astronomy, Bulgarian Academy of Sciences*

<sup>2</sup>*Department of Astronomy, University of Sofia*

E-mail: gborisov@astro.bas.bg

**Abstract.** Assigning physical coordinates to FITS image pixels is important to standardize the Rozhen fits files. Among wide spread WCS software available, here we present tests based on the IDL implementation of the WCS standards. Our goal is to apply this implementation for calculating and adding the necessary WCS FITS keywords in the image headers. The obtained results are verified by comparing the image object positions with the astrometry from HIPPARCOS and USNO A-2.0 catalogs.

### 1. INTRODUCTION

There are several conventions that have been defined about specification of the physical or world coordinates attached to each pixel of an N-dimensional image (Greisen and Calabretta, 2002; Calabretta and Greisen, 2002). One common example is to link each pixel of an astronomical image to a specific direction on the sky (such as right ascension and declination). By world coordinates, one means coordinates which serve to locate a measurement in some multi-dimensional parameter space. In general the FITS world coordinate system (WCS)<sup>1</sup> of an image is defined by keywords in the FITS header. The basic idea is that each axis of the image has the following keywords associated with it:

- **CTYPE<sub>i</sub>** - Type of coordinate on Axis **i**, 8 characters (The FITS WCS standard defined 25 different projections which are specified by CTYPE keyword.)
- **CRPIX<sub>i</sub>** - Reference pixel on Axis **i**.
- **CRVAL<sub>i</sub>** - Value of World Coordinate as Axis **i** at reference point (**CRPIX<sub>i</sub>**).
- **CD<sub>ij</sub>** - A matrix of partial derivatives of the world coordinates with respect to the pixel coordinates.

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<sup>1</sup> <http://tdc-www.harvard.edu/wcstools/wcsprogsh.html>

There are a number of software packages for reading, using or modifying the astrometric information and WCS parameters in the image header. Some of the most common packages are IRAF<sup>2</sup>, WCSTools, WCSLib<sup>3</sup>, TERAPIX Software and the packages in the astronomy IDL library.

In this work we use IDL astronomy library for computing the astrometric keywords. For visualization and inspection of the obtained results we use Aladin as a Java Standalone application by Centre de Données astronomiques de Strasbourg.

## 2. USED IDL ROUTINE:

**STARAST** - Computes an exact astrometric solution using the positions and coordinates from 2 or 3 reference stars and assuming a tangent (gnomonic) projection. If 2 stars are used, then the X and Y plate scales are assumed to be identical, and the axis are assumed to be orthogonal. Use of three stars will allow a unique determination of each element of the CD matrix and automatically append them as an appropriate FITS WCS keywords in the image header.

**INITIAL DATA** - For this work we used CCD images from two telescopes at Rozhen National Observatory as well as plate archive data (WFPDB). Here are some technical details for the telescopes. In Table 1 we show the technical parameters of the VersArray CCD camera.

Schmidt telescope - Rozhen Observatory

Scale: 120 arcsec/mm

Scan resolution: 1600 DPI => 1px = 16  $\mu$ m

The scans have nonstandard orientation - the image coordinates are transposed

1px = 1.92 arcsec = 5.333e-4 degrees

2mRCC Telescope with FoReRo2 - Rozhen Observatory

RC Scale: 12.89 arcsec/mm

FoReRo2 Scale: 36.8 arcsec/mm

1px = 0.88 arcsec = 2.444e-4 degrees

**Table 1:** Technical details for the VersArray CCD camera used with the 2mRCC telescope.

VersArray: 512B CCD camera parameters	
CCD CHIP MODEL	E2V CCD77-00

<sup>2</sup> <http://iraf.noao.edu/>

<sup>3</sup> <http://www.atnf.csiro.au/people/mcalabre/WCS/>

<b>VersArray: 512B CCD camera parameters</b>	
CHIP DIMENSIONS	512x512 pixels
PIXEL DIMENSIONS	24x24 $\mu\text{m}$
READOUT NOISE	3.3 electron/pixel RMS
CCD CHIP COOLING	liquid nitrogen

### 3. METHODS AND RESULTS

The coordinates of the center of the images are roughly known, so we need to perform a “3 stars astrometry”, using STARAST IDL routine in order to determine them more precisely.

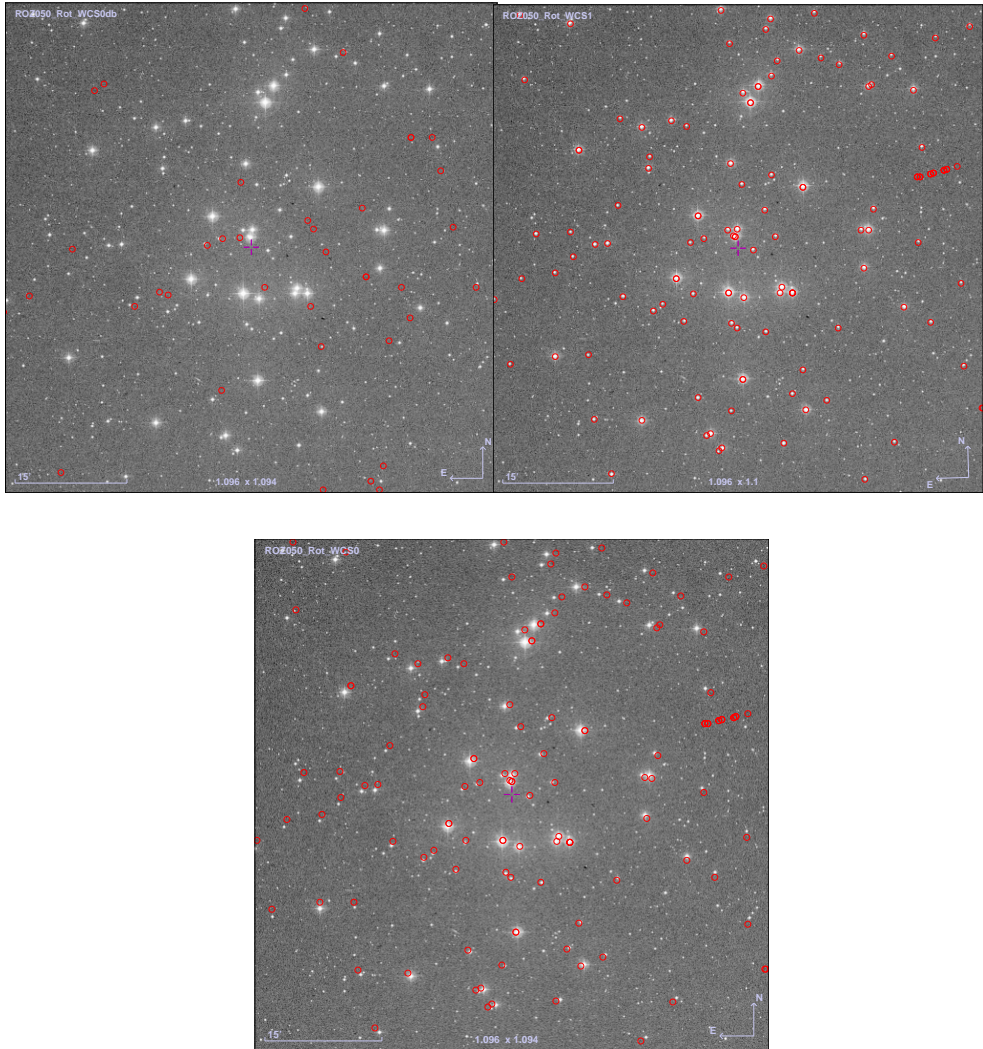
The procedure we used is as follows:

The first step is to choose 3 stars in the field of the image, which are apart from the center. With their catalog positions we compute the coordinates of the unknown center of the image. This is our “first approximation” astrometric solution.

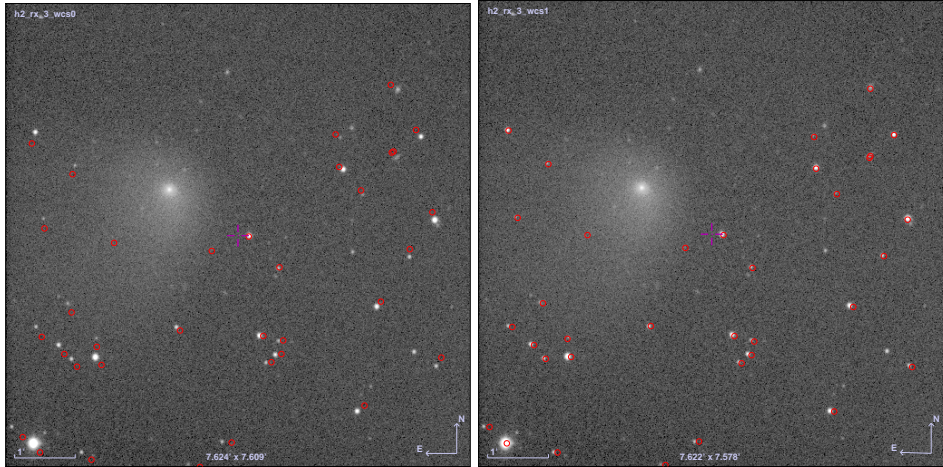
The sub-figures 1 & 2 (indicated with “wcs1”) represent the catalog coordinates (red circles) over plotted onto the FITS images. The figures clearly show that the obtained results are quite good.

We found even more simple approach which we call “zero approximation”.

First we add the matrix elements CD1\_2 and CD2\_1 in the FITS header as zero values. These WCS keywords are connected with the frame orientation. Second, for the CD1\_1 and CD2\_2 values we use the pixel size in degrees. The pixel coordinates of the image center corresponds to the CRPIX1 and CRPIX2 WCS keywords. Initially predicted center coordinates (in degrees) are added in the FITS header as CRVAL1 and CRVAL2 keywords. According to the results (represented in subfigures 1 and 2, labeled with “wcs0”) it seems that the astrometric solution could be used as a rough estimation of the standard FITS WCS keywords. The approach we use is a straightforward procedure for adding the FITS WCS keywords in the image header even during the observation, without using any third party software (IDL, IRAF, etc.)



**Figure 1.** Central part of the Schmidt plate ROZ 050 002581, Object: Praesepe.



**Figure 2.** 2mRCC - FoReRo2 image of the comet P/2010 H2.

In the sub-figure 1 (indicated with “wcs0db”) it is obvious that when using the central coordinates available in the Wild Field Plate DataBase (WFPDB)<sup>4</sup> the “zero approximation” gives unsatisfactory results. We believe that this is due to some uncertainties in the proposed central coordinates.

#### 4. CONCLUSIONS

Here we suggest several simple steps for adding standard WCS keywords in the headers for the Rozhen FITS images. This could be the first step to make the Rozhen Fits Archive more consistent with the VO standards.

Our results show that the “first approximation” solution (computing the unknown center coordinates of the image by using the catalog coordinates for 3 stars, chosen to lie remote from the image center) gives more appropriate results than the “zero approximation” approach when the WFPDB data were used.

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#### References

- Calabretta, M. R., Greisen, E. W.: 2002, *A&A*, **375**, 1077.  
 Greisen, E. W., Calabretta, M. R.: 2002, *A&A*, **375**, 1061.

<sup>4</sup> <http://www.skyarchive.org/>