Astrometric Calibration of the ILMT data

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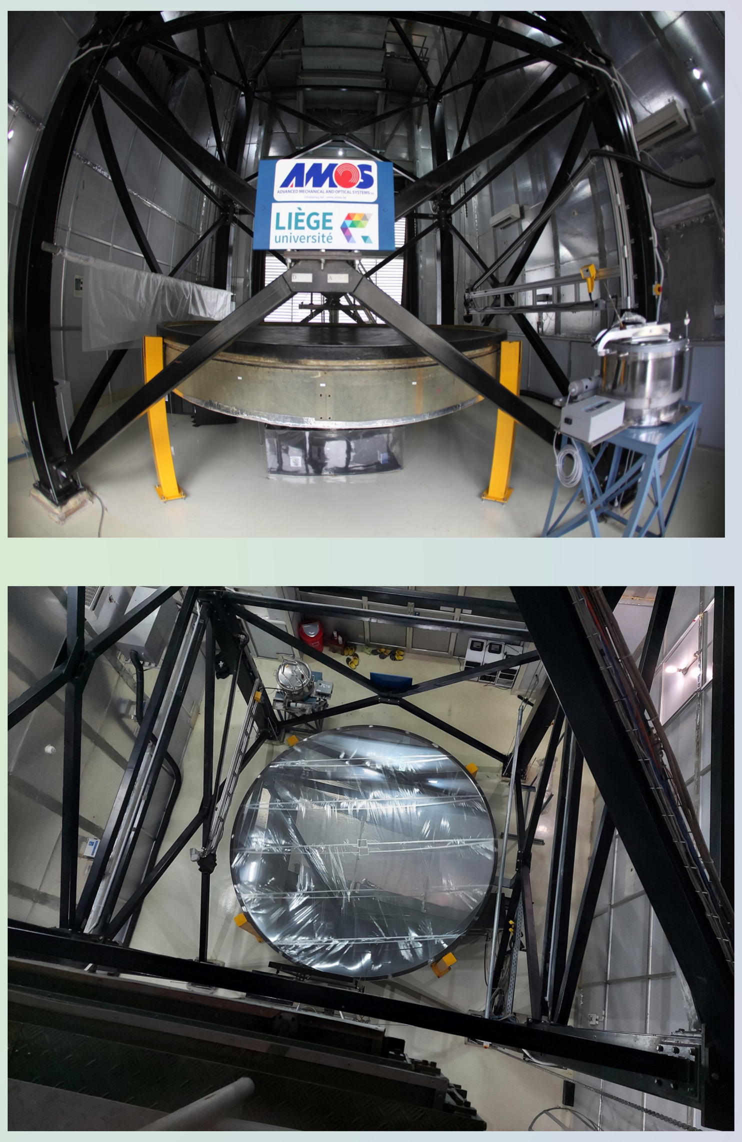
ABSTRACT

The 4m International Liquid Mirror Telescope (ILMT) has recently achieved its first light at the ARIES Devasthal Observatory, Nainital, India. It is coupled with a 4k x 4k CCD camera and has a field of view of ~22 x 22 arc-min covering a total sky area of ~120 sq. degrees. ILMT is unique as it will observe the same sky area towards the zenith direction every night and will perform a deep survey of that long and narrow strip by looking at all astronomical sources crossing its field of view. Since the science goals of any survey telescope rely heavily on the astrometry of the detected objects, we have developed a pipeline for the astrometric calibration of the data that will flow from the ILMT. Testing this pipeline on the commissioning phase data obtained with the ILMT, we have achieved a sub-arcsec accuracy in the astrometry of the detected objects, and the pipeline is ready to be implemented in real-time data. We present the methodology involved in this pipeline and the first results on the astrometry based upon preliminary data obtained with the ILMT.

1. INTRODUCTION

International Liquid Mirror Telescope

- A 4m zenithal mirror, characterized by f/2.4 focal ratio.
- Works on the liquid mirror technology.
- A special observing mode known as *Time Delay Integration (TDI)* mode is used to integrate the photons coming from the source.
- Integration time: 102 sec.
- Field of view: 22 arcmin x 22 arcmin.
- Total sky area covered: 120 sq. degree.
- Single scan limiting magnitudes: ~22.8, 22.3 and 21.4 in the g, r and i bands, respectively.
- First light: 29 May 2022, right now in commissioning phase.



Top: A side view of the ILMT.
Bottom: A top view of the ILMT.

2. OBJECTIVE & MOTIVATION

- Every night 40 sq. degree sky covered with each single TDI image ~3.3 degree long in RA and ~22 arcmin wide in DEC.
- Same sky will repeat every night with a shift of 4 arcmin in RA.
- ILMT being a survey telescope, precise astrometry is required for the detected sources, especially to identify peculiar transients in real time.

3. METHODOLOGY

Pre-processed long TDI image

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Extracting two small chunks from the two ends of the image

↓

Extracting GAIA coordinates of few stars in both the chunks using 'astrometry.net'

↓

Epoch conversion: J2000 to observation epoch

↓

Fitting transformation relations

$$\alpha = f1 + (x-x0)*f2 + (y-y0)*f3$$

$$\delta = g1 + (x-x0)*g2 + (x-x0)^2*g3$$

between pixel (x,y) and sky (α,δ) coordinates to find the best fit parameters f1,f2,f3,g1,g2,g3.

↑

Detection of all the sources in the full TDI frame using Sextractor and applying the best fit parameters to all the detected sources.

↑

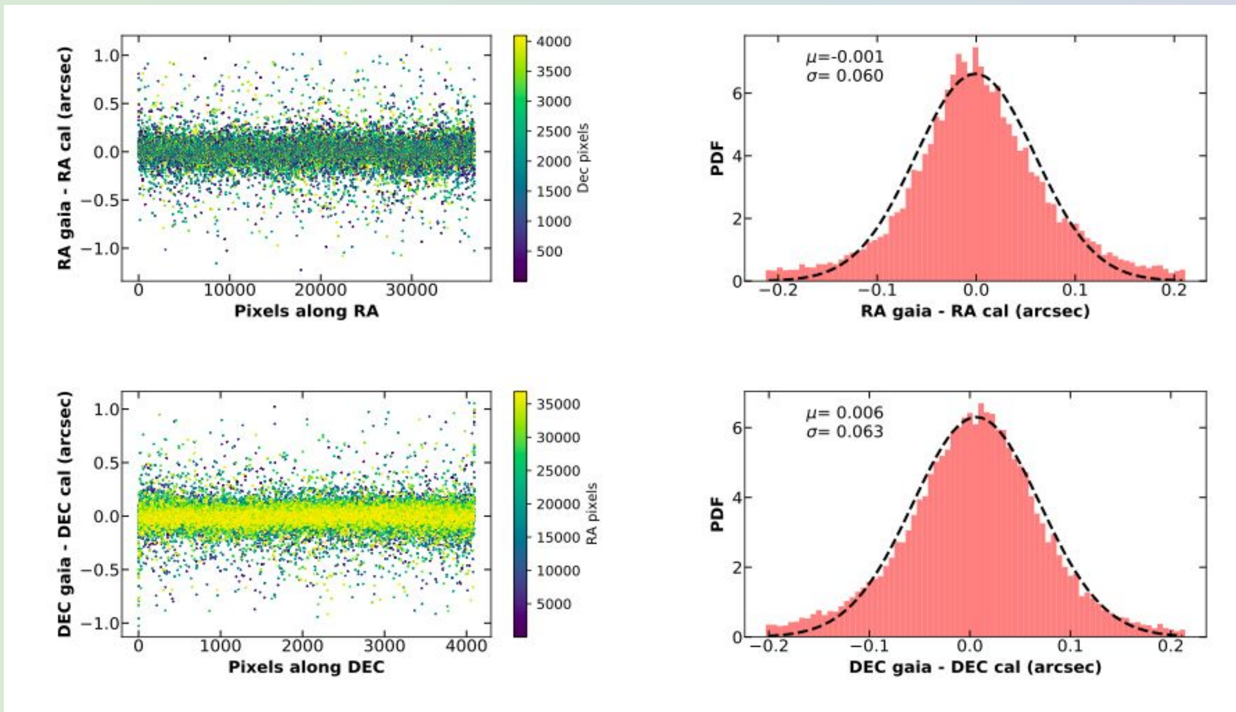
Epoch conversion: Observation epoch to J2000

↑

Updating the WCS information in the FITS images

4. RESULTS & DISCUSSSION

- The astrometric calibration pipeline has been applied to all the data obtained with ILMT in the Oct-Nov 2022 commissioning phase.
- Using the above methodology, a sub-arcsec (~0.05-0.1'') accuracy has been achieved in the astrometric calibration.
- The astrometrically calibrated data for Oct-Nov 2022 is made available through the ILMT archive (see Misra et al. ILMT poster).



Top left: Offsets in the calculated RA wrt GAIA as a function of pixels along RA. Top right: distribution of the offsets in the calculated RA. Bottom left and right: Same as in Top left and right, but for DEC.

5. FUTURE PROSPECTS:

- The astrometry pipeline will be upgraded to use the observatory latitude and sidereal time to astrometrically calibrate each TDI frame, and reduce dependency on external plate solving engines like 'astrometry.net', etc.

REFERENCES: **1.** Kumar, B. et al., 2018, MNRAS, 476, 2075 — **2.** Kumar, B. et al., 2022, JApA, 43, 10 — **3.** Dukiya, N. et al., 2022, JAI, 1140001 — **4.** Surdej, J. et al., 2018, BSRSL, 87, 68.

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