CLASSICAL ASTROMETRY LONGITUDE AND LATITUDE DETERMINATION BY USING CCD TECHNIC

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ABSTRACT. At the AOB, it is the zenith-telescope (D=11 cm, F=128.7 cm, denoted by BLZ in the list of Bureau International de l'Heure - BIH), and at Punta Indio (near La Plata) it is the photographic zenith tube (D=20 cm, F=457.7 cm, denoted by PIP in the list of BIH). At the AOB there is a CCD camera ST-8 of Santa Barbara Instrument Group (SBIG) with 1530x1020 number of pixels, 9x9 mikrons pixel size and 13.8x9.2 mm array dimension. We did some investigations about the possibilities for longitude (λ) and latitude (φ) determinations by using ST-8 with BLZ and PIP, and our predicted level of accuracy is few $0.''01$ from one CCD zenith stars processing with Tycho-2 Catalogue. Also, astro-geodesy has got new practicability with the CCDs (to reach a good accuracy of geoid determination via astro-geodesy λ and φ observations). At the TU Wien there is the CCD MX916 of Starlight Xpress (with 752x580 pixels, 11x12 mikrons, 8.7x6.5 mm active area). Our predicted level of accuracy for λ and φ measurements is few $0.''1$ from one CCD MX916 processing of zenith stars, with small optic (20 cm focus length because of not stable, but mobile instrument) and Tycho-2. A transportable zenith camera with CCD is under development at the TU Wien for astro-geodesy subjects.

1. ASTROMETRY AND ASTRO-GEODESY WITH CCD TECHNIC

Nowadays, there are big possibilities for astrometry by using the good quality optic with modern computer and Charge Coupled Device (CCD) technic. Here, we put our attention to the BLZ and PIP instruments. Both were in the list of BIH and participated with their observations to take a part in new "Earth orientation parameters 1899.7-1992.0 in the ICRS based on the HIPPARCOS reference frame" (Vondrák et al. 1998). For the PIP with CCD, the process of measurement is the PZT's one, just to remove the observations by photo plate and to adapt CCD. If we fix the tube of BLZ in the zenith direction and follow PZT's process of observations we can use BLZ (with CCD) for λ and φ determinations. Both instruments can be full-automatic ones. The features of CCD astronomy can be found in (Martinez and Klotz 1998) and the manuals (Santa Barbara Instrument Group 1994, Starlight Xpress Ltd. 1999).

The Tycho-2 (at ICRS reference system) is an astrometric reference catalogue with positions (the precise is 60 mas for all stars), proper motions (2.5 mas/yr, precise) and two-colour photometric data for about 2.5 million brightest stars in the sky. Only 4% stars are without proper motion data. The star density is about 150 stars/sq.deg. for $b = 0°$ (50 for $b = \pm 30°$, and 25 for $b = \pm 90°$) and V is near 11.5 mag (with 90% completeness).

The sky field of BLZ with ST-8 ($1.''44$/px for both axis, x and y) is $37' x 25'$, and $10' x 7'$ for PIP. With BLZ and Tycho-2 we can "catch" about 20 stars or few stars with PIP. It is enough to reach few $0.''01$ accuracy of λ and φ. The accuracy of PIP can be double than BLZ's one because of better optic. The standard error of unit weight (for λ and φ determination with BLZ/PIP) was about $0.''15$ by using visual (for BLZ) and photo plate (for PIP) observations. It means, our predicted accuracy (for BLZ and PIP with one CCD image procedure) is quite good and open new possibilities for astrometry with CCD technic.

In geodesy, the rapid measurement of the direction of vertical has three goals: (a) the geoid determination by Vertical Deflection (VD) profiles, (b) the terrestrial network reduction to a geodetic ellipsoid, and (c) the inversion of VDs to determine density structures of the Earth's crust. The necessary accuracy of λ and φ is $\pm 0.''3$ (c) - $\pm 1''$ (a). Usual, it is the simultaneous λ and φ observation by small Zeiss astrolabes (about 15 star transits 60° during 1 hour) or zenith cameras. The geoid projects in flat countries mainly use gravimetry. Observation time is very short, but to get high geoid accuracy 200-500 points per 1000 km3 are necessary, whereas astrogeodesy requires only 10-20 VD points (Gerstbach 1997). Therefore in alpine countries, the astrogeoid is much more effective than gravimetry. At the TU Vienna, a special research project "CCD in astro-geodesy" started in 1999, sponsored by ÖNB. In the first 2 years Olympus CCD cameras were used with the Zeiss astrolabe (4/20 cm) and Kern theodolite DKM3a (7/40 cm). The accuracy was $\pm 1''$ (Gerstbach 2000), but the measuring time was not shorter than visually one. Therefore, we continue to develop the small zenith camera. We test the astro-camera MX916. The zenith camera has a teleobjective 1:4/20cm. Near Vienna, the MX916 pictures with 5^s exposures show the stars up to 12^{th} magnitude. The camera was turned manually. The relation turning axis - vertical is measured by two levels at the camera turning plate. The field of view is about 1.5x2°. First tests show 20-50 stars (faintest not used). The accuracy is less than $2''$ with 10 Hipparcos stars and $1''$ with 20 Tycho stars. Combining 4 images and Tycho-2 we expect $\leq \pm 0.''5$ of the vertical direction. In 2002/3, we hope the geodetic zenith camera will be used for geoid profile densification in Austria to improve the geoid from ±3 cm to ±1 cm.

2. REFERENCES

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