A PROPOSAL FOR ASTROMETRIC OBSERVATIONS FROM SPACE

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ABSTRACT. Some aspects of the realisation of a celestial reference frame using a space astrometry facility are considered. An observational program is described, consisting of observing stars up to magnitude 14, radiostars and bright QSO's, planets, asteroids and of laser signals from the Earth. A scheme of an astrometric facility consisting of two telescopes on board the satellite is proposed. The overview strategy with "*inita*" is estimated, and the estimates of the accuracy of a single observation (0."02–0."05) and of the output catalogues (0."001–0."007) are made.

1. Introduction

The HIPPARCOS experiment has opened a way to the construction of a high-precision quasi-inertial reference frame by means of space facilities. New perspectives of astronomy in space are caused by a significant increase in the obtained data accuracy, by the number of the observed objects, and by a possibility to link directly the frames of reference (fundamental, dynamic, radiointerferometric, geodetic) which are employed .

We present here some goals for a proposed mission called AIST (from the Russian Астрометрический Искусственный Спутник-Телескоп: Astrometric Artificial Satellite Telescope). The ideal program for the astrometric mission should include observations of the bright stars, QSO's, asteroids, planets, the Sun, and laser sources on the Earth. It is most convenient to use the astrometric satellite rotation (dynamic method) for realisation of the project which is designed for effective operation in orbit during the course of some years.

2. Method of Vlasov

One of the most appropriate in the dynamic method of angular distance measurements is the scheme of Vlasov (Transactions IAU 1970), depicted in Fig. 1. According to this approach six reference objects (*inita*) have been chosen on the celestial sphere so that the angular distances between the neighbouring inita be nearly 90 degrees. The coordinates, proper motions and parallaxes of the inita in the chosen frame of reference have to be measured several times more precisely than those of the objects in the output catalogue, that is not worse than 1 milliarcsec. Three arcs are measured from each object within one of the 8 inita's triangles to the vertices of this triangle. While knowing the coordinates of the inita one can compute those of the object at the moment of observation. Satellite

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rotation causes the consecutive scans on the celestial sphere to intersect in the points near I_1 (Fig. 1) and then near I_2 and I_3.

According to our calculations the method under consideration has secured high homogeneity of the determined precision of the astrometric parameters on the entire sphere. For instance the distribution of mean square position error within the *inita's* triangle is shown in Fig. 2 in the case

$$\mathrm{var}(S)=5.7s + 1,$$

where s is the true arc and S is the measured arc in term of radians.

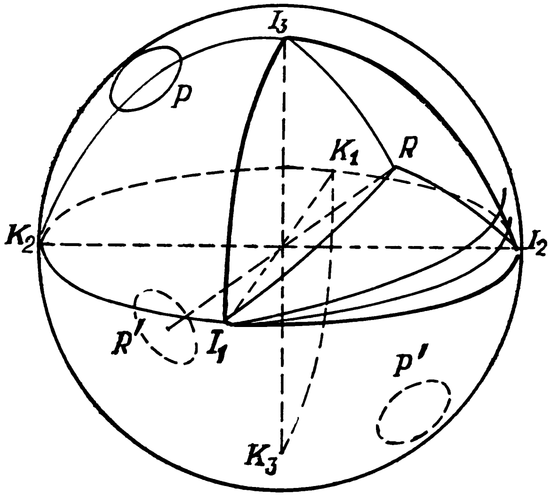

Fig. 1. Typical scans with AIST

3. Astrometry in space

A peculiarity of astrometry in space by the dynamic method requires that the satellite rotation has to be controlled with great accuracy by one's observations. The AIST frame (Chubey 1989; Chubey *et al.* 1989) Fig. 3, is available for ω (rotation vector) components reconstruction and measuring of the angular distances between the stars in each scan.

The frame consists of two telescopes: reflectors of the Ritchey-Chretien system with the working fields $2w$ = 60 arcmin, foci 3 m, objective diameters 25 cm. These telescopes with the primary mirrors M_1 and M_2 and the secondary mirrors m_1 and m_2 are mounted rigidly on the general axis O_1-O_2 facing one another. A standard with the reference angles 180 and 190 degrees is placed in the middle of the apparatus between the objectives. This standard is comprised of two double-faced flat mirrors. Two-dimensional CCD detectors are mounted in the focal coordinate system O_1,X_1,Y_1 and O_2,X_2,Y_2. Reciprocal position of these systems is controlled through the using a light marks index sets L_1 and L_2 rigidly placed in the surfaces of detectors to gain advantage the collimation observation technique.

In such a manner possible displacements of the central angular standard block with circular and ring apertures are controlled. The optical system combines the images of four fields P, P', R, R' on the celestial sphere in the

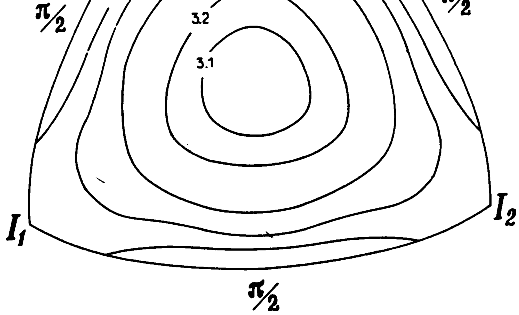

Fig. 2. Typical errors within an inita

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focal plane. The satellite must be principally revolving around the axis W, as it is shown in Fig. 3, or around the axis V. In any case the vector's ω components may be determined if even only one object is observed at a given moment in any field from pairs P, P' and R, R'. The theoretically advantageous choice of principal moments of inertia $I_W = 2I_U = 2I_V$ or $I_V = 2I_U = 2I_W$ is assumed to be practically available in our design (Popov 1986).

In order to obtain the arcs between the *inita* and program objects it is necessary to know its local coordinates and rotation matrix, as it is done in HIPPARCOS "great circle reduction" procedure (van der Marel 1988). The Euler rotations around the U,V,W axes may be derived by integration of Euler's kinematic equations. It is possible to provide the acceptable conditions for separating of unknowns in the previously mentioned equations by dint of optimisation of satellite cover, form and mass distributions. Some systematic errors are reduced in the case where the direction of rotation is changed to the opposite; the scale error is essentially reduced due to the *inita* scheme of operation. The errors connected with discordance of optical elements are checked by special collimation observations (Chubey 1989).

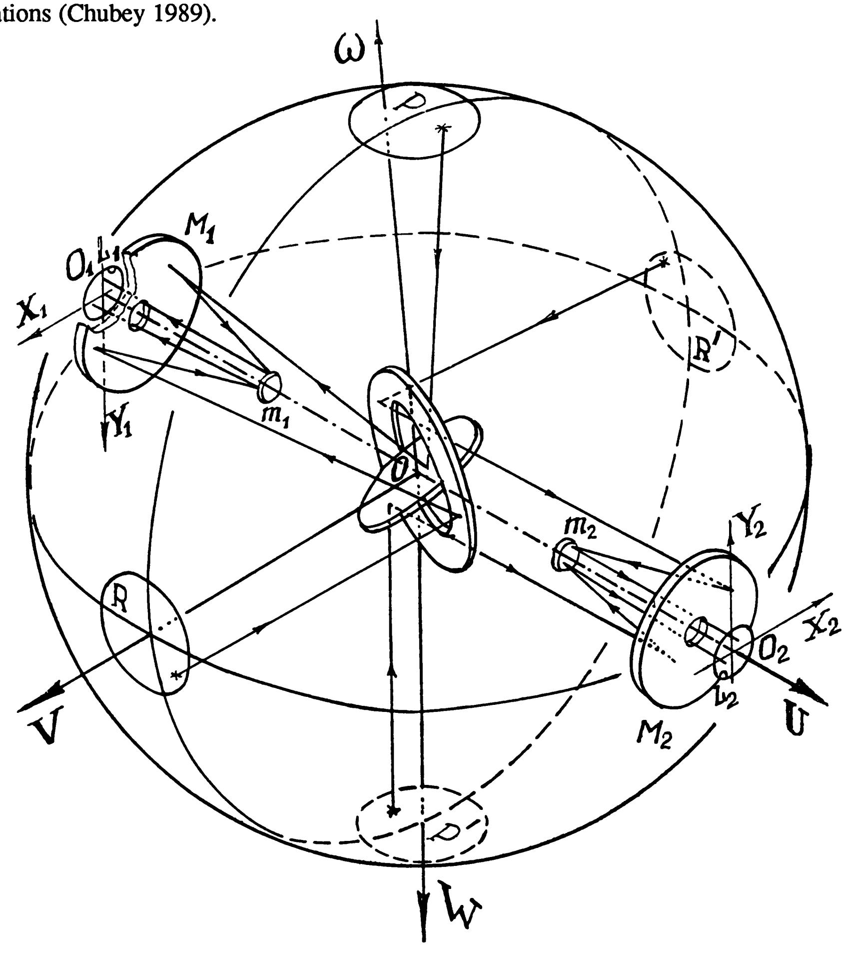

Fig. 3. AIST schematic

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The optical limit of telescopes with declared parameters under rotational velocity being about 150 arcsec/sec will be 13–14 magnitudes, and the accuracy of single measurements will be about $0''\!.15$ under the condition that the integration time is 10 ms (Chubey *et al.* 1989). One star transit permits us to derive its image trail in the local reference frame with an accuracy of $0''\!.01$. The accidental errors of astrometric parameters in the output catalogue will be decreased by a factor of 7 during 4 years of AIST operation.

4. Summary

It is impossible to make comparison of the design in question with others within the limits of this concise report. So we shall emphasise only the peculiar features and advantages of the AIST design:

- high homogeneity of the accuracy of the output parameters ;
- controlling of all systematic errors connected with the optical scheme;
- Possibility of absolute measurements of the objects' coordinates in distances 180 and 90 degrees, and as a result the possibility of including of bright extended objects and ground-based light signals in the observation program;
- possibility of measuring of different arcs and permanency of the measurements in time and on the sphere.

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