OPTICAL OBSERVATIONS OF GEOSTATIONARY SATELLITES

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Abstract

A survey of celestial equator that is observable from Kavalur was made using satellite tracking camera AFU-75, to locate the positions of geostationary satellites that are accessible within the capabilities of camera from the tracking Station. This paper describes the specification of the camera, the method used for the observations, locations and the identification of geostationary satellites.

INTRODUCTION

A geostationary satellite is one which is always on the celestial equator and its orbital period is equal to one sidereal day. This condition is very difficult to satisfy due to the gravitational pull of Earth, Moon and the Sun and as a result, the satellite will move in the East-West and the North-South directions. The amount of drift is of course corrected regularly by the satellite attitude controlling station. The number of geostationary satellites launched by the various countries for the purpose of communication, meteorology etc. since 1962 to March 1978 exceeds well over a hundred and of those that are proposed for launching upto 1983 exceeds eighty (Morgan 1976; Pareks 1977).

The photographic observations of geostationary satellites could be very useful for geodetic and orbital dynamics applications (Massevitch *et al.*, 1977; Marek 1972; Slabinski 1971).

A survey of the part of celestial equator that is accessible from the Satellite Tracking and Ranging Station at Kavalur (latitude 12°, 34′ N, longitude 78°, 49′E), was made during February-April 1978 using satellite tracking camera AFU-75 to locate the positions of geostationary satellites that are observable from the Station. The total coverage of celestial equator was 130°; 70° from the local meridian in the East and 60° in the West direction and $\pm 5°$ across the celestial equator.

II. SPECIFICATIONS OF SATELLITE TRACKING CAMERA

The geostationary satellites were tracked using AFU-75 satellite tracking camera. The characteristics of this camera are given below:

Focal length	:	736 mm
Clear aperture	:	210 mm
Effective aperture	:	f/3.5
Field of view	:	14° × 10° (along and across the satellite track)
Limited elevation of camera setting	:	20° above horizon
Camera timing accuracy (UT)	:	0.001^s

III. THE METHOD OF OBSERVATIONS

Due to the weather conditions, moonlight etc. observations were spread over several days. Photographs were taken in overlapping mode so that no gaps were left in any part of the celestial equator. First a few trial photographs were taken in order to ascertain the visual magnitudes of satellites, so that sufficient exposure could be allowed to record their images on the photographic plates. The densities of satellite images were compared with the densities of nearby stars in spectral class G5. From the comparisons of densities of satellites and stars it was deduced that the visual magnitudes of satellites ranged from 10.5 to 12.5.

The celestial equator was scanned systematically in steps of 10° from the West to the East allowing a 2° overlap in adjacent frames.

For a particular setting of the camera, initial exposure was made for three minutes by opening the shutter. The start of the exposure (in terms of UT) was recorded on the film. After the first exposure, the film was moved by 1 cm and a second exposure was given for four minutes; once again recording the beginning of the exposures time (UT) on the frame. For each camera setting six exposures were given on each plate. Exposures were varied from 3 minutes to 8 minutes in steps of 1 minutes increment in exposure. In each case, stop exposure time was also re-recorded.

Each frame was examined systematically under a microscope with ×30 and ×40 magnifications. Positions of satellites images were marked on the frames. Those frames on which satellite images were recorded at a considerable distance away from the centre of the film were repeated and the satellites were brought at the centre of the film to ascertain the minimum error in recording of their co-ordinates due to the off-axis distortion of the camera lens. In each photograph, the stars are presented by long tracks whereas the satellite appears as a point or a a very short track. The film used was near infra red air survey film with an equivalent speed of about 32 DIN.

IV. THE SATELLITE POSITION DETERMINATION AND IDENTIFICATIONS

Smithsonian Astrophysical Observatory (SAO) star catalogues (1966) and nomograms were used for satellite

TABLE 1

Satellite Serial No.	Satellite latitude	Satellite longitude	Satellite Identification	Source of Identification
S1	0° 49′ 16″	82° 13′ 43″E	Two of the satellites	COMSAT
S2	0° 53′ 21″	83° 26′ 24″E	may be Statsionar 1	(1976)
S3	1° 31′ 42″	83° 32′ 24″E	and Palapa 1.	UN
S4	0° 03′ 32″	98° 12′ 24″E	One of the satellites	COSMAT
S5	0° 39′ 32″	100° 54′ 00″E	is Ekran.	(1976) UN
S6	0° 02′ 15″	33° 46′ 12″E	Statsionar II	COSMAT (1976) UN
S7	0° 41′ 06″	63° 34′ 48″E	Intelsat IV-F1	SAO COSMAT (1976)
S8	1° 26′ 30″	39° 13′ 12″E	Possibly Marots	COSMAT (1976)
S9	1° 16′ 12″	44° 27′ 00″E	?	
S10	0° 45′ 06″	50° 10′ 12″E	Either Symphonie or Skynet 2B	SAO UN

position determination (FK4 system, Epoch 1950.O). Therefore, satellite co-ordinates are in relation to reference stars position for epoch 1950.0.

Using SAO star catalogue, the right ascension and the declination of satellites were obtained. The latitudes and the longitudes of the satellites were computed according to known formulae (Smart 1977). In table 1 are given the field reduced positions of satellites that were photographed from Kavalur with AFU-75 camera.

V. CONCLUSIONS

(i) By using optical photographic methods, it is possible to locate several geostationary satellites in situations where the electronic tracking methods are not successful due to the frequencies transmitted by the satellites being unknown.

(ii) The campaign organised to locate geostationary satellites that are observable from Kavalur during February-April, 1978 has shown that it is possible to locate and identify many of geostationary satellites upto visual magnitude 12.5 using the AFU-75 camera.

(iii) Photographic tracking of true geostationary satellites simultaneously from distant stations separated by large distances along the equatorial region offers a good method of forming a global geodetic triangulation net of large triangles.

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