Simulating of stellar tracks for observations by the polar ILOM -telescope. N.K. Petrova[1,2] and H. Hanada[3], [1]Kazan Federal University, 18, Kremljevskaja str., Kazan,420008, Russia. e-mail: nk_petrova@mail.ru, [2]Kazan State Power Engineering University, [3]National Astronomical Observatory, 2-12 Hoshigaoka, Mizusawa, Iwate 023-0861, Japan. e-mail: hanada@miz.nao.ac.jp

Introduction: The measurement of the rotation of the Moon is one of techniques to get the information of the internal structure of the celestial body. The Lunar Laser Ranging (LLR) has given unprecedented data on the lunar rotation, and gives some proposals of the core's state. In situ Lunar Orientation Measurement (ILOM) is an experiment to measure the lunar physical librations in situ on the Moon with a small telescope which tracks stars [1], [2]. Computer simulation of the future observation is being done with the purpose of their optimisation: effective placement measuring system on the lunar surface and formation scheduling of observations for monitoring the physical libration of the Moon. Analyses of simulated stellar tracks observable from the Lunar surface (in a polar zone) revealed the significant difference from daily parallels of stars in comparison with ground based observations.

Telescope on the Lunar surface for determination of the physical libration: The coordinate frame (xyz) given by the axes of inertia of the Moon is usually called the Dynamical System of Coordinate (DSC). The DSC is rigidly connected with the lunar body, if it is considered as absolutely rigid one. If the ILOM-telescope will be set ideally in the dynamical pole z, coinciding with the maximal moment of inertia C, then its motion together with the lunar body will be directly observed relatively to stars (Fig.1).

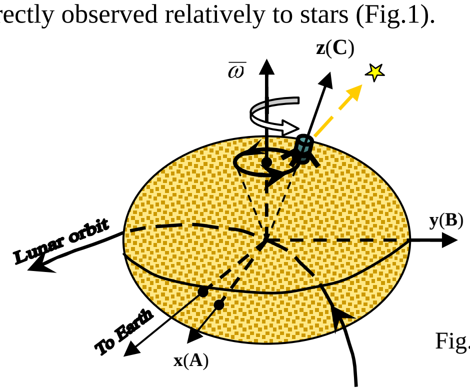

Fig. 1

The DSC was taken as a frame for the selenographic coordinate system. The software was elaborated for reduction of stellar ICRF equatorial coordinates at epoch J2000.0 to the selenographic system for any epoch of observation. Stars were taken from various stellar catalogues, such as the UCAC2-BSS, Hipparcos, Tycho and FK6. The analytical theory of the Lunar physical libration [3], [4] was used for simulating. The field of view of the telescope is proposed to be of 1^{o}. The first stage of the simulation consisted of selection of stars brighter than 11 magnitude at 1-year observation period along the precessional motion of the lunar pole and the construction of the tracks for every selected star.

Characteristics of stellar tracks with observations from the lunar surface: Calculation of the tracks for a period of 1 year showed an unusual behaviour of tracks some of the stars. At the beginning of the observations a star is approaching along a spiral to the centre of the telescope, and then, having reached a certain minimum, goes on untwisting spiral, thus forming in a field of view the loop-like trace (Fig. 3). This phenomenon cannot be observed from the Earth surface. This effect is also provided by the combination of slow rotation of the Moon and fast precession motion of the Lunar pole. As a result, those stars whose longitude is less than the current longitude of the Lunar pole move towards the pole. Owing to retrograde precession motion, the ecliptical longitudes of the pole and the star are being made equal, and then the star is moving away from the pole, i.e. away from the center of the telescope. Stellar polar distance initially decreases and then begins to increase again (Fig. 4).
At the Fig. 2-3 the track gallery of stars, situated at different distances from the center of the telescope and having different ecliptical longitude is shown. Period of "observation" is 100 days, for Fig 3b – 300 days.

Displacement of the true dynamical pole due to the physical libration: The analytical theory of LPhL allows to calculate the value of the polar distance *p* of a fictitious star with coordinates of the mean pole at the epoch JD2013. The polar distance (Fig. 5) is very sensitive to the chosen dynamical model of the Moon, which is given by the Stockes coefficients or by the dimensionless moments of inertia (Lunar prospecor – LP [5]; Clementine data GLGM [6]. LLR- data [7] and SELENE Gravity Model - SGM [8].

In general, the differences in the tracks calculated with different dynamical models are greater than 10 arcseconds during whole period of observation. Thus, it is hoped that the planned measurements of the coordinates in the ILOM project with the accuracy of 1 msc will reveal subtle new effects in the rotation of the Moon. Carried investigations may be used also to determination of exact position of a proper dynamical pole and, as a result, will provide the improvement of the selenographic coordinate system for future near surface high precision works involving e.g. spacecraft operations, high-resolution mapping, and gravity field determination etc.

a)

b)

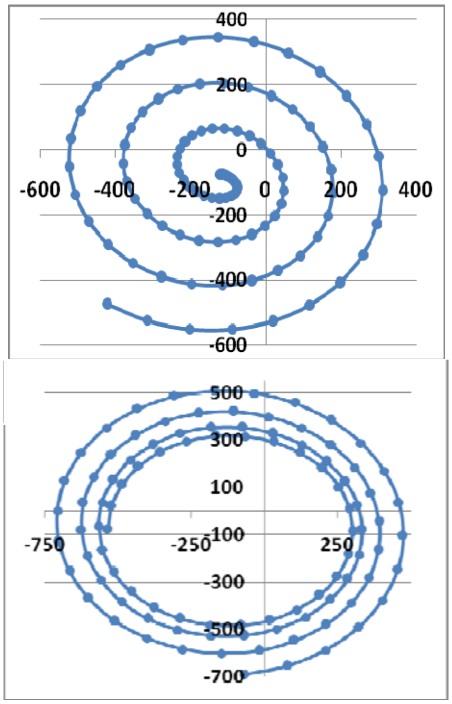

Fig. 2 (axis are given in arc sec)

a

b)

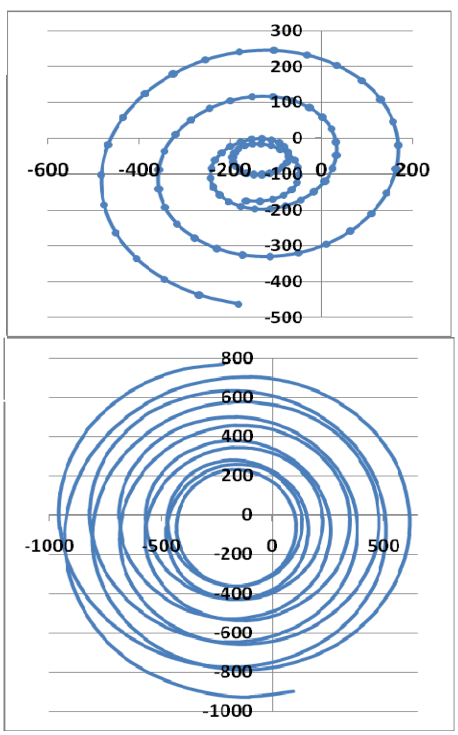

Fig. 3 (axis are given in arc sec)

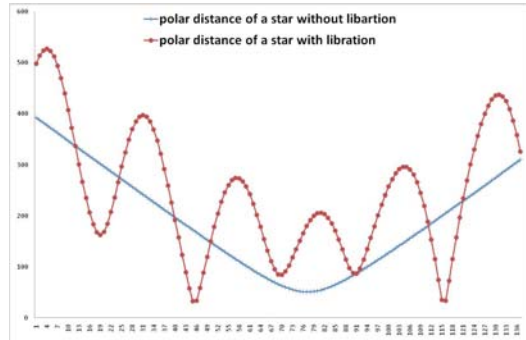

Fig. 4

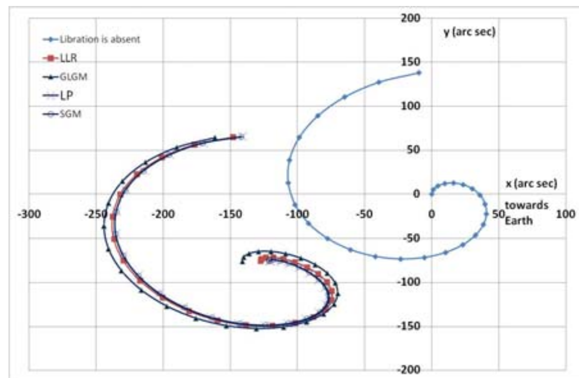

Fig. 5 Displacement of the dynamic pole due to the libration

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