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Studies of Modern Star Catalogs Based on Photoelectric Observations of Lunar Occultations of Stars

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Abstract—An important area of investigation in astronomy is the relationship between fundamental and dynamical coordinate systems. Valuable material for such studies is provided by photoelectric occultation observations of stars by the Moon, which can provide high precision of detecting rapidly occurring processes and have been carried out over a long time interval. This latter feature is especially important for analyses of the stellar proper motions dynamics. A method has been developed to use photoelectric occultation observations to determine the orientation and rotational parameters of the axes of the coordinate system used for modern star catalogs relative to the coordinate axes of a highly accurate dynamical ephemeris of the Moon. A complete database of photoelectric occultation observations has been created for this purpose, containing data for 57 365 events. The combination of photoelectric occultation observations and other astronomical observations such as lunar laser-ranging data enables the highly accurate determination of parameters of the Moon's dynamics, such as systematic errors in catalog coordinate systems, including various geodetic reference systems. The parameters of shifts and the rotation of the axes of the Hipparcos Celestial Reference Frame relative to the DE421 dynamical system are obtained. This paper is based on a talk given at the conference "Modern Astrometry 2017," dedicated to the memory of K.V. Kuimov (Sternberg Astronomical Institute, Moscow State University, October 23–25, 2017).

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1. INTRODUCTION

Appreciable results on the construction of an inertial coordinate frame in which the time scale is uniform and space is isotropic and homogeneous have been obtained. According to a decision of the IAU, the Hipparcos Celestial Reference Frame (HCRF) is considered to be a template for such a system. The choice of fundamental system for Hipparcos was not simple. A traditional determination of the fundamental parameters in terms of the mean equator and mean equinoxes was based on dynamical principles, and the practical application of these principles required observations of objects in the solar system (to obtain the ecliptic) and the rotation of the Earth's axis (to obtain the equator); it was also necessary to apply the dynamical theory of the inertial variations of these directions. At the same time, it is obvious that a kinematic determination of a non-rotating coordinate system (i.e., a system determined relative to distant galaxies) is more suitable for Hipparcos, because it can readily be implemented and is more accurate than a dynamical determination. This choice excluded three degrees of freedom, but left the orientation parameters of the catalog uncertain. This situation became clearer in 1991, when the IAU adopted a resolution proposing to base future fundamental celestial coordinate systems on the positions of extragalactic radio sources. This led to the need to construct an optical coordinate system in the International Celestial Reference System (ICRS). The Hipparcos catalogue, which contains more than 100 000 stars whose positions have been determined with very high precision, unattainable at that time with ground observations in the optical, could provide such a system. Various methods based on observations of planets and their moons, minor celestial bodies etc. have been used to investigate the orientation parameters of the dynamical coordinate system relative to the HCRF. Studies of the orientation parameters of the Hipparcos catalogue have been carried out most thoroughly by Schwan [1–3], who developed a comparison method that differs from methods used earlier.

One of the best known approaches is to use asteroids as point-like objects when analyzing observations. The Institute of Applied Astronomy of the Russian Academy of Sciences has carried out a large amount of work on reducing observations of minor

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