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High orbit for the RadioAstron project

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RadioAstron project is an international collaborative mission to launch a free flying satellite carrying a 10-meter radio telescope in elliptic orbit around the Earth [1,2]. The RadioAstron mission uses the satellite SPECTR (astrophysical module), which is under development by Lavochkin Association of Russian Aviation and Space Agency. According to the currently accepted resolutions, Space Radio Telescope (SRT) will be launched (in 2005-2006) from the Baikonur Space Center by the Proton carrier rocket (CR) and 11C824F upper-stage rocket (USR). The SRT antenna consists of a deployable parabolic reflector (10-m diameter) which is made of 27 carbon fiber petals and central solid portion (3 m in diameter). The radio telescope has focus to diameter ratio F/D=0.43 and overall RMS surface accuracy 0.7 mm. Observing frequencies are 0.324, 1.66, 4.83 and 22.2 GHz. A concentric feed arrangement at prime focus will provide the possibility of observing at two frequencies or two circular polarizations simultaneously. For RadioAstron mission it is proposed to use one K-band circular polarized channel at fixed frequency 22.232 GHz. The second simultaneously operating channel with opposite circular polarization can be switched in the band from 18.392 GHz to 25.112 GHz (the number switching frequencies N=8). It will be provided for a wide band synthesize in the Earth-Space interferometer for the astrometrical tasks. The maximum data rate of downlink is 128 Mbit/s (32 MHz wide band for one circular polarization). Data transmission is being done by VIRK system through the high gain antenna at frequency 15 GHz. VIRK provides also the two–side coherent link (phase transfer) at 7.21 up/8.47 down GHz.

The aim of the mission is to use the space telescope to conduct VLBI observations in conjunction with the global ground VLBI network in order to obtain images, coordinates, and evolution of angular structure of different radio emitting objects in the Universe with the extraordinary high angular resolution. Since the observations with the base up to $\sim$ 10 000 km at a wave of $\sim$ 3 mm with a resolution of 50 μs of the arc are regular on the Earth [3], a base of $\sim$ 450 000 km is necessary for the shortest wave of 1.35 cm in the RadioAstron mission and the 10–fold gain in resolution up to 5 μs. The orbit of the RadioAstron provides three types of study, i.e. 1) rough images of radio sources with ultra–high angular resolution, using all baselines up to the radius of the apogee, that is much larger than Earth diameter; 2) high accuracy measurements of coordinates, proper motion and changes in source structure, with ultra–high angular resolution determined by the largest baseline; 3) high quality imaging of radio sources, with moderate resolution, by observing either with small projected base lines Earth–spacecraft, i.e. close to the orbital plane, or near the perigee. In both cases the effective baselines are only several times larger than the Earth's diameter. For this aim an orbit was chosen with high apogee and with period of satellite rotation around the Earth equal to 9.5 days, which evolves in result of weak gravitational perturbations from the Moon and the Sun [4]. The perigee radius varies from 10 000 to 70 000 kilometers, the apogee radius — from 310 000 to 390 000 kilometers. The main orbit evolution is in the rotation of its plane around a weakly evolving apsides axis. The normal to the orbital plane traces an oval on the celestial sphere with the major axis about 150 degrees, and minor axis about 40 degrees, in about 3 years. The linear parameters of the orbit vary with a period of about 1.5 years, and angular parameters vary with a period about 3 years.

The Dorman–Prince method of the 8(7)th order was used for numerical integration. In the calculations of the SRT orbit, we used the model of the GEM–T2 geopotential truncated to the 17th order [5]. The model of ephemerides DE403/LE403 developed at the JPL NASA, USA, was used to take into account perturbations from the Moon and Sun [6]. The effects of the solar radiation and the Earth atmosphere were ignored in the calculations.

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