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Author: Mr. Maxim Pupkov  
Bauman Moscow State Technical University, Russian Federation

Dr. Natan Eismont  
Space Research Institute (IKI), RAS, Russian Federation  
Mr. Konstantin Fedyaev  
Space Research Institute (IKI), RAS, Russian Federation  
Mr. Vladislav Zubko  
Space Research Institute (IKI), Russian Academy of Sciences (RAS), Russian Federation  
Mr. Andrey Belyaev  
Space Research Institute (IKI), Russian Academy of Sciences (RAS), Russian Federation  
Mr. Nikita Simbiryov  
N.E. Bauman Moscow State Technical University, Russia, Russian Federation  
Prof. Ravil Nazirov  
Space Research Institute (IKI), RAS, Russian Federation

## POSSIBILITIES OF HALO-ORBIT MISSION EXTENSION FOR ASTEROIDS EXPLORATION

**Abstract**

A famous International Sun/Earth Explorer – 3 launched into vicinity of the  $L_1$  collinear Sun-Earth libration point in 1978 was the first spacecraft which demonstrated the very possibility to fly along halo orbit. After completion its primary mission, the spacecraft started a new phase of the flight being renamed to International Cometary Explorer. Developed by Robert Farquhar, an extended mission had a goal of reaching the magnetotail of the 1P/ Halley comet and a near-nuclear region of the 21P/Giacobini-Zinner comet. After multiple gravity assist maneuvers near Moon the spacecraft had been put onto a transfer trajectory to these comets in 1983 and successfully reached them. It is interesting to mention that the last contact with the spacecraft took place 36 years after the launch date what means that there are good chances to use the same approach for other extended missions.

Our investigation is aimed to exploring possibilities of asteroids' physical characteristics determination by measuring their gravity from a flyby trajectory at a close distance. In particular, it is possible to estimate mass of an asteroid with a good accuracy by measuring changes in spacecraft trajectory parameters caused by gravitational attraction of the asteroid.

As an example of using this approach we consider the Spectrum-Roentgen-Gamma space observatory (SRG) launched in July 2019 and currently located in a vicinity of the  $L_2$  collinear Sun-Earth libration point. The main scientific goal of the observatory is to chart a map of the Universe in X-rays using onboard telescopes. Also SRG is equipped by star trackers for attitude of instruments determination and control.

According to calculated estimations of required correction maneuvers values to keep the observatory in a libration point vicinity, after completion the main mission there will left SRG onboard propellant enough to use the spacecraft for the close flyby of the Apophis (99942) asteroid in 2029 when it approaches the Earth. With the developed scenario of demanded for this extended mission maneuvers it will be possible to determine the mass of Apophis with a high accuracy. Besides also in 2029 the similar scenario fulfillment is reachable for another asteroid (1997) XF<sub>11</sub>.

It should be mentioned that the same conception for an extension of a spacecraft mission may be applied to other candidate space projects initially intended for operations in vicinities of collinear libration points.