Numerical Orbital Simulation for a Spacecraft to Rendezvous Two NEOs - Apophis and 2001 WN5.
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Background: Over the last two decades, Near-Earth Objects (NEOs) have received increasing attention due to their potential of catastrophic impact on Earth as well as for their scientific value, such as expanding our knowledge about the early evolution and composition of the Solar System.

99942 Apophis (2004 MN4) is well known because it set the record for the highest rating on the Torino impact hazard scale with level 4 on December 27, 2004. With the subsequent improved observations of its orbit, the possibility of its impact on Earth was virtually eliminated. As calculated by the JPL Center for NEO Studies (CNEOS) and by the ESA NEODyS-2, Apophis will have a non-threatening close encounter with the Earth at 0.1 lunar distances (LD) on April 13, 2029.

On the other hand, about 10 months before Apophis approaches, another NEO -2001 WN5- is expected to pass within 0.65 LD from the Earth on June 26, 2028. 2001 WN5 is an Apollo NEA with H=18.3 (some 900 m size) on an eccentric (e = 0.467) orbit and a period of 818 days. Its relatively fast (4.25 hr) spin period ([2]) makes it an interesting target for a space mission. The extraordinary close approaches of the two NEOs with the Earth make them potential targets for spacecraft rendezvous. Moreover, it is possible to establish a single orbit for a spacecraft to rendezvous those two NEOs, which has never been done in human history of asteroid space missions.

Aim: The aim of this work is to numerically fit an orbit for a spacecraft to rendezvous both Apophis and 2001 WN5, which can be used to set up a future space mission to visit the two NEOs.

Methods: We numerically integrated the orbits of Apophis, 2001 WN5 and the 8 planets using the N-body orbital simulator MERCURY 6.2 package [1] with the hybrid symplectic/Bulrisch–Stoer integrator. The orbital elements of the NEOs were obtained from the JPL small-body database.

We then generated millions of test particles launched from the Earth representing the spacecraft. The Delta-V of the spacecraft is limited to less than 6 km/s as a reasonable thrust for modern spacecraft.

References: [1] J. E. Chambers (1999) MNRAS, 304, 793. [2] B. Warner et al. (2009) Icarus, 202, 134–146 (and 2019 update: http://www.minorplanet.info/lightcurvedatabase.htm)