DEFLECTION MISSIONS FOR ASTEROID 2011 AG5

Daniel Grebow*, Damon Landau*, Shyam Bhaskaran*, Paul Chodas*, Steven Chesley*, Don Yeomans*, Anastassios Petropoulos*, and Jon Sims*
(*)*Jet Propulsion Laboratory, California Institute of Technology*
4800 Oak Grove m/s 301-121, Pasadena, CA 91109-8099
Phone: (818) 393-8288, Email: daniel.grebow@jpl.nasa.gov

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ABSTRACT

As our eyes on the solar system improve, our knowledge of solar system bodies increases, and we gain a better understanding of the objects that pass close to Earth. To date, there are nearly 9,000 known near-Earth asteroids (NEAs), where approximately 1,000 of these were discovered in the last year. Considering the number of known NEAs and our current rate of discovery for them, it is inevitable that we will stumble upon many small bodies that pass very close to Earth, and even some that might be on impact trajectories with the Earth. In the case that we find an asteroid that might be on an impact trajectory, it is imperative that we develop a tested and reliable method for deflecting the asteroid's course safely away from Earth.

One asteroid that currently poses a serious threat of impacting Earth in 2040 is 2011 AG5. (See Figure 1.) 2011 AG5 was discovered on January 8, 2011 by the Mt. Lemmon Survey conducted in Arizona. The estimated diameter of the asteroid is 140 m, and the mass is estimated at 4×10^9 kg. The asteroid travels in a 17:10 resonance with Earth, where the next Earth close approach occurs on February 3, 2023. At this time the asteroid will pass within five lunar distances of Earth, with a 1-in-500 chance of passing through a 360-km-wide keyhole. Should the asteroid pass through this keyhole, it will impact the Earth on February 5, 2040, and the estimated energy released by the impact would be 100 MT.

In this paper we will survey the mission prospects available for deflecting the course of the asteroid 2011 AG5 with a kinetic impactor. We will present options that rely on chemical as well as solar-electric propulsion (SEP) for transporting the impactor spacecraft. There are a variety of pre- and post-keyhole mission scenarios for an assortment of launch vehicles all of which will be discussed in the paper. While a nominal deflection of $10R_e$ (R_e = Earth radii) is deemed safe, we will also consider missions that wait up to four years prior to the estimated Earth impact and deflections as small as $2R_e$, as well as sending multiple impactors to deflect the asteroid. We will describe the benefits of sending an in-situ rendezvous spacecraft to arrive at the asteroid prior to the impactor spacecraft. The role of the rendezvous spacecraft is to characterize the size, shape, composition and rotation of the asteroid, as well as providing valuable astrometric data. The paper will address navigation concerns for terminal guidance, as well as contingency options.

There are opportunities to observe the asteroid from the Keck Observatory in October 2012, and later from the Hubble Space Telescope in April 2013. With the observation opportunities available, we estimate that by 2016, the encounter uncertainty for the asteroid will be less than

$1R_e$. At that time, should the observations indicate that the asteroid 2011 AG5 is headed for the 2023 keyhole, the mission opportunities presented in this paper will be invaluable to NASA and other space agencies around the world. In the more likely event that the observations indicate that the asteroid will miss the keyhole, these mission concepts remain an excellent proof-of-concept for future asteroid deflection missions.

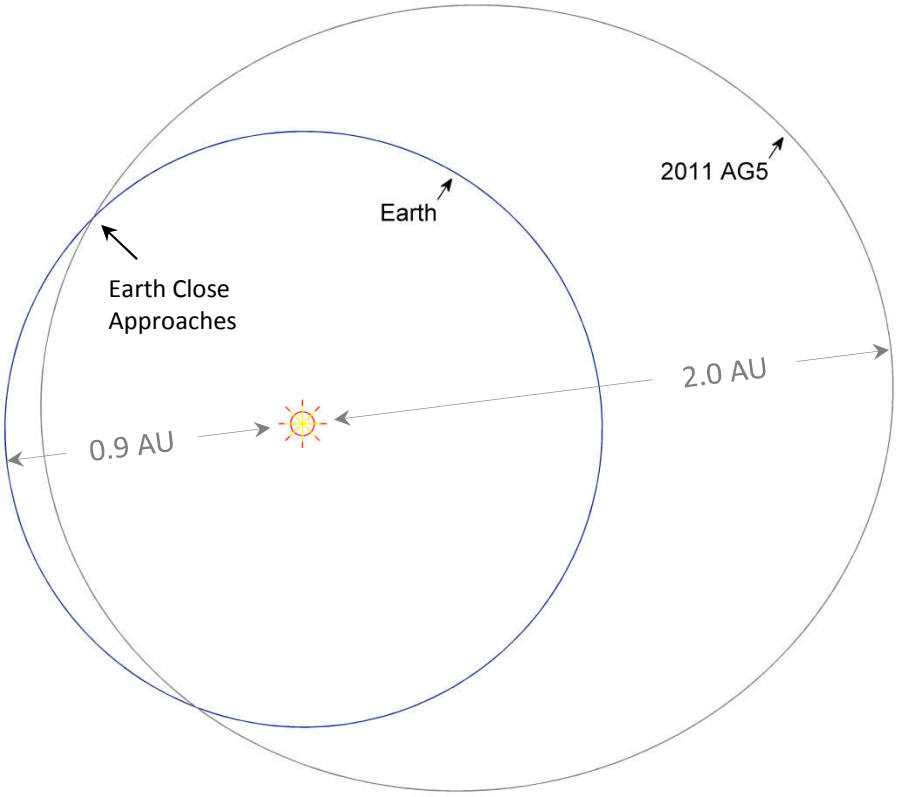

Figure 1. Heliocentric View of 2011 AG5's Orbit.