Near-Earth Object (NEO) 2005 YU_{55}: A Natural Interplanetary Cycler

With an Earth minimum orbit intersection distance (MOID) of 155,523 km and diameter near 400 m, near-Earth object (NEO) 2005 YU_{55} is classified as a potentially hazardous object (PHO). Figure 1 illustrates heliocentric geometry associated with a close encounter between Earth and 2005 YU_{55} during November 2011.

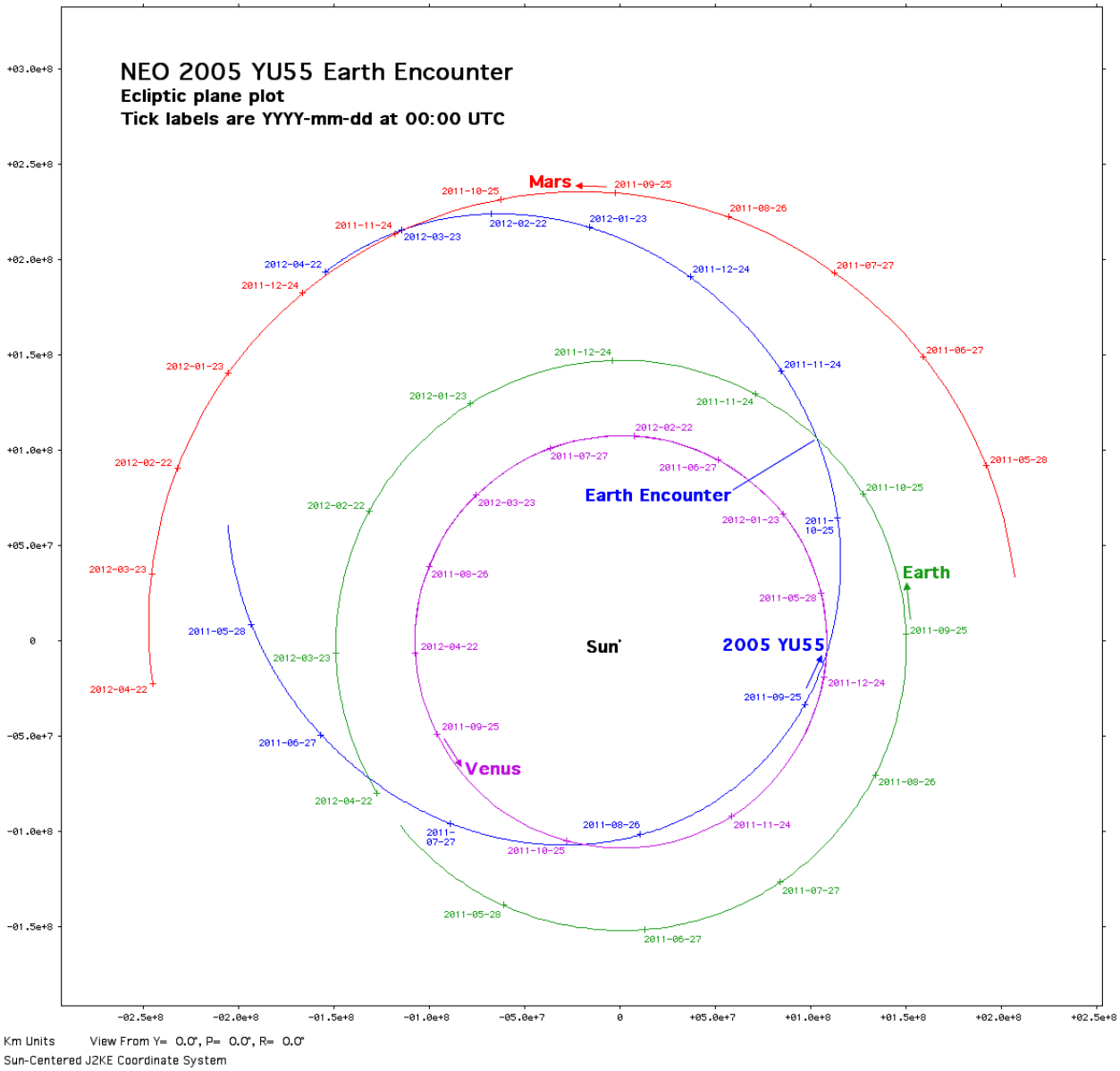

Figure 1. Heliocentric inertial motion of Venus, Earth, Mars, and 2005 YU_{55} in the ecliptic plane from May 2011 to May 2012.

Since 2005 YU_{55} has an inclination between 0.3° and 0.5° throughout the 21st century, potential encounters with Venus, Earth, and Mars are evident in Figure 1. Indeed, such an encounter with Mars occurred most recently on 14.6 July 2002 UTC at a distance of 5,940,400 km. Mid-April Earth encounters, with 2005 YU_{55} inbound towards its perihelion, are also evident in Figure 1. On 19.5 April 2010 UTC, the latest of these encounters occurred at a perigee distance of 2,273,000 km. Multiple radar observations of 2005 YU_{55} were obtained during this encounter,

resulting in a highly accurate orbit solution. With this solution, it was possible to reacquire 2005 YU_{55} with the Goldstone Solar System Radar in California on 4 November 2011. Because November Earth encounters occur with 2005 YU_{55} travelling outbound from its perihelion, this NEO appears in terrestrial skies only during daytime hours before perigee occurs. Optical observations are therefore not possible until after perigee during a November encounter by 2005 YU_{55}. Figure 2's geocentric trajectory plot reflects minor refinements (~1 s in timing; ~100 km in perigee) from 4 November 2011 Goldstone observations.

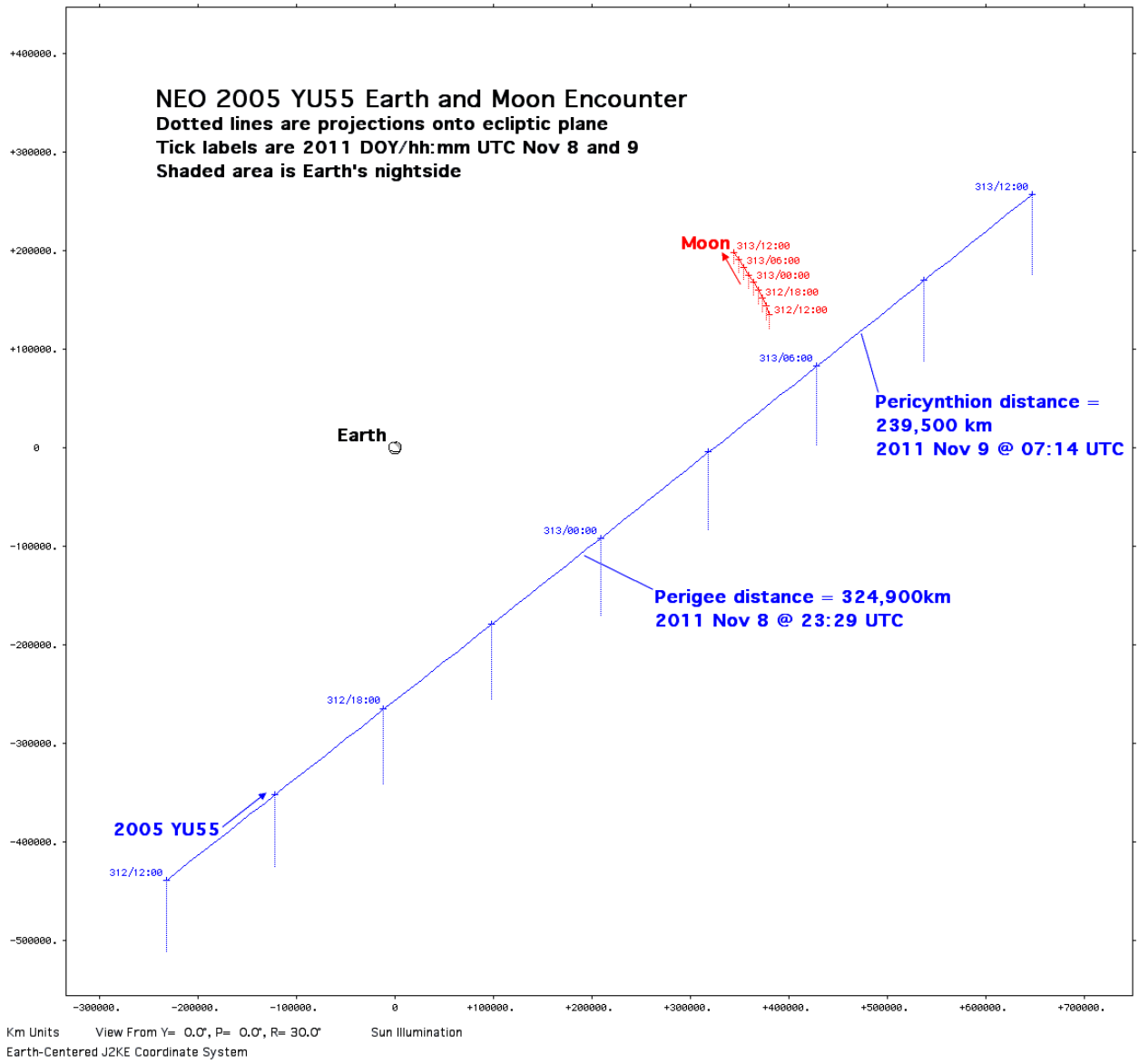

Figure 2. Geocentric inertial motion of the Moon and 2005 YU_{55} viewed 30° from normal to the ecliptic plane during the 24 hours centered near 2005 YU_{55} perigee.

The 9.0 November 2011 UTC Earth encounter by 2005 YU_{55} is yet another example of an interplanetary "Red Baron" scenario. In this case, however, "Snoopy" has radar to maintain his situational awareness even at low solar elongations.

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With a heliocentric semi-major axis a = 1.157 AU immediately after its November 2011 Earth encounter, 2005 YU_{55}'s orbit is classified as an Apollo. Consequently, 2005 YU_{55} completes a bit more than 4 heliocentric orbits as Earth completes 5 of them (this exact "4 : 5" resonance occurs when a = 1.1604 AU). After November 2011, 2005 YU_{55} has several encounters with Venus closer than 15 million km (0.1 AU): 13 million km on 20 October 2027, 340 thousand km on 19 January 2029, and 8.5 million km on 1 June 2030. Perturbations from the 2029 Venus encounter increase a to 1.166 AU, thereby reversing 2005 YU_{55} deviations from the exact 4 : 5 resonance with Earth that had accumulated since 2011. As a result, the next 2005 YU_{55} Earth encounter closer than 15 million km after November 2011 falls near 12 November 2041. By that time, 3-sigma prediction uncertainty in perigee time has increased to over ±15 hours and perigee could occur from 14.8 to 17.1 million km within this uncertainty. The chief cause of uncertainty in this context is the 2029 Venus encounter, but additional future observations (some possibly conducted far from Earth) should keep prediction uncertainty in check before a Red Baron scenario can develop in some later November. No future Mars encounter closer than 15 million km is predicted for 2005 YU_{55} prior to 2080.

Interplanetary transportation architectures called "cyclers" have been proposed using orbits similar to 2005 YU_{55}'s. Their advantage is large masses, such as interplanetary human habitat and supporting infrastructure, can be left in interplanetary space without need to repeatedly accelerate them into and out of planetary gravity wells. But, as 2005 YU_{55} demonstrates in the 21st century, close planetary encounters do not occur naturally with any operationally sufficient frequency. Cyclers must therefore be accelerated by propulsion at strategic intervals to achieve frequent close encounters. At heliocentric eccentricity near 0.43 throughout the 21st century, 2005 YU_{55}'s orbit is not optimal for access from Venus, Earth, or Mars even though its period is conveniently near Earth's and its heliocentric apses lie near the orbits of Venus and Mars. It remains to be conclusively demonstrated whether or not cycler propulsive overhead exceeds that of simply parking an interplanetary transport for reuse near Earth and the destination.

All data relating to 2005 YU_{55} appearing in the foregoing narrative was obtained from the Jet Propulsion Laboratory's *Horizons* online solar system ephemeris computation service via URL http://ssd.jpl.nasa.gov/?horizons. The orbit solution refined by Goldstone radar observations on 4 November 2011 is tagged "JPL#72".