



Elhari, Ibrahim <iae@njit.edu>

NEO Dataset question

Chodas, Paul W (US 3900) <paul.w.chodas@jpl.nasa.gov>

Tue, Apr 23, 2024 at 8:38 PM

To: "Elhari, Ibrahim" <iae@njit.edu>, "Gutt, Patrick A" <pg262@njit.edu>

Cc: "Farnocchia, Davide (US 392R)" <davide.farnocchia@jpl.nasa.gov>, contact-cneos <contact-cneos@jpl.nasa.gov>, "O'Neill, Ian J (US 1821)" <ian.j.oneill@jpl.nasa.gov>

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Hi Ibrahim and Patrick,

Further to Davide's response, there is a very specific mathematical definition to the term "Potentially Hazardous Asteroid" (PHA). It relies on only two parameters: the Minimum Orbital Intersection Distance (MOID), which must be ≤ 0.05 AU, and the absolute magnitude H , which must be ≤ 22.0 . The MOID depends on the orbit for the object, which we compute and frequently update on our SSD website. We also compute the MOID and provide that, as well as the absolute magnitude H . For example look at our page for Apophis:

https://ssd.jpl.nasa.gov/tools/sbdb_lookup.html#/?sstr=Apophis

The Earth MOID is provided on the box on the top right and the absolute magnitude is provided in a box farther down the page. Apophis satisfies the above constraints and is therefore categorized as a PHA. No need to use ML to determine whether an object is "potentially hazardous": just look at the 2 conditions above.

We compute our own orbits for NEOs, using the available observations of each of them. As you can see from our page, our orbit determination is based on 7364 optical observations plus 40 radar observations. It's a very elaborate process to determine an orbit, and it's important to keep track of the uncertainties in that estimated orbit (which we also provide on our page). Also note that our current orbit estimate is our 218th: we update the orbit solution whenever we get new data, and each orbit solution is more precise than the preceding one, as the observational dataset grows. And, we compute orbits and provide a webpage for ***every*** NEO (and in fact, every small body in the Solar System). You could use orbit query system to get a table of MOIDs and H -values for all NEOs with just a few keystrokes.

Note that we also compute each object's close approaches (e.g. click Show Close Approach Data on the Apophis page). Some folks think they can determine whether or not an object is hazardous simply by looking at the upcoming close approaches, but that doesn't work because the tabulated close approaches are only for the nominal solution and don't account for uncertainties in the position of the object on its orbit. As Davide said, we have a system called Sentry that we created to predict possible future impacts while accounting for the all-important orbital uncertainties. That's another very elaborate process, described here:

<https://cneos.jpl.nasa.gov/sentry/intro.html>

Finally, I need to offer a word of caution. Orbits and their uncertainties follow highly deterministic complex physics-based equations of motion. An ML approach can't determine whether an object has a chance of impacting just by looking at orbital elements and making inferences based on some sort of pattern. Well, OK, a very simple script could look at the one important parameter we already compute and provide on our webpage, i.e. the MOID, and make some sort of determination (MOID less than 1 Earth radius). But even the MOID is not sufficient to predict whether or not an impact is possible over, say, the next 100 years. For that you need a full-up simulation that accounts for the uncertainty in the MOID and possible changes in its estimated value due to close approaches to other perturbing bodies. And that's something we pay very close attention to in our Sentry system.

I hope these additional thoughts are useful.

Paul Chodas

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From: "Elhari, Ibrahim" <iae@njit.edu>

Reply-To: "Elhari, Ibrahim" <iae@njit.edu>

Date: Tuesday, April 23, 2024 at 3:59 PM

To: "Farnocchia, Davide (US 392R)" <davide.farnocchia@jpl.nasa.gov>

Cc: contact-cneos <contact-cneos@jpl.nasa.gov>, "Gutt, Patrick A" <pg262@njit.edu>

Subject: Re: [EXTERNAL] NEO Dataset question

Hi Davide,

Thank you so much for the speedy response & the links.

Yes, it helped and provided further clarification.

Thanks again.

Best,

Ibrahim & Patrick

On Tue, Apr 23, 2024 at 6:26 PM Farnocchia, Davide (US 392R) <davide.farnocchia@jpl.nasa.gov> wrote:

Hi Ibrahim and Patrick,

[Quoted text hidden]