SCATTERING ENCOUNTERS AND THE PREDICTABILITY HORIZON OF NEAR EARTH ASTEROIDS G. Tommei[1] and G.B. Valsecchi[2], [1]Department of Mathematics, University of Pisa (giacomo.tommei@unipi.it), [2]INAF-IAPS Roma (Giovanni.Valsecchi@iaps.inaf.it).

Introduction. The computation of the orbit of a Near Earth Asteroid (NEA) and the prediction of possible impacts with our planet are complex tasks because, in many cases, the observations are few and the dynamics is strongly affected by close encounters with the Earth and other planets. Even if a Least Squares (LS) orbit is available, the uncertainty can be large and we need smart methods to handle it. The best way to proceed is to consider a set of orbits belonging to a Confidence Region (CR, a subset of the 6-dimensional space of the orbital elements) where the astrometric residuals are acceptable. Such orbits, obtained with an appropriate sampling (geometrical or random) of the CR, are called Virtual Asteroids (VAs, [1]); they can have a very low Minimum Orbit Intersection Distance with our planet (MOID, [2]) and thus be dangerous. The goal of the Impact Monitoring (IM) is to understand whether the CR contains some Virtual Impactor (VI), that is a subset of initial conditions bringing to an impact with the Earth in the future.

Dynamics and scattering encounters. The search for VIs is strongly affected by close encounters that enhance the caoticity of the problem. For this reason it is fundamental to have a full comprehension of the close encounters, using analytical ([3]) and numerical approaches ([4]). An important and expensive (in terms of computational costs) step in IM is the propagation of the VAs (set of orbits of the order of thousands) for 100 years or more. Therefore, in the light of the expected increase in NEO discoveries, we wonder whether it is possible to identify an algorithm that tailors the propagation horizon to each object. In the NEO population there are objects with very different types of motion, and for which the OD procedure results in very different orbital uncertainties. If the CR is either large due to poor observational record, or becomes large due to intervening encounters, there is the possibility for the VAs to follow different dynamical paths, going through different sequences of close encounters, so that the predictability horizon (after which the dynamics will be even more chaotic) becomes short. An algorithm that would allow to identify the close encounter that causes the subsequent unpredictability of the orbit (the so called *scattering encounter*) would be useful both in the daily IM operations and also for the long term IM, that involves the analysis of objects with a very well constrained orbits, including, if needed, also the determination of non-gravitational accelerations, like the Yarkovsky effect.

The following topological definition of scattering encounter has been given in [5]:

Definition: a close encounter of a minor body with the Earth is said to be a *scattering encounter* if the post-encounter CR ceases to be simply connected.

Since it is not easy to visualize the situation in dimension 6, in Fig. 1 we have sketched the situation in dimension 3. The dashed red line is the Earth orbit, while the black continuous line is an hypothetical minor body orbit; on the left we have the nominal orbit of the asteroid and its CR, sketched with a blue ellipsoid before a close approach; we know that the geometrical shape could be more complex but in any case a simply connected object. Due to encounters the CR grows, stretching along the orbit, until after the scattering encounter it changes completely the topology: from a simply connected confidence region, homotopic to a point, it becomes an object having a non-trivial fundamental group, like the torus in the figure. The underlying meaning is essentially that the uncertainty region, after a scattering encounter, contains orbits having periods in different resonances with the Earth, due to the large variation of the post-encounter semimajor axis throughout the CR.

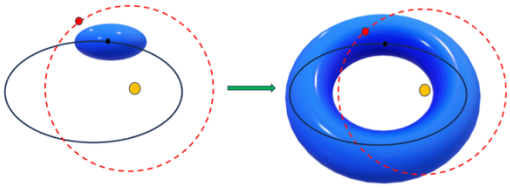

Fig. 1: 3D representation of the effect of a scattering encounter.

Conclusions. In the presentation I will introduce the problem of the predictability horizon for NEAs and, showing some examples, I will propose possible strategies to handle it.

References

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Acknowledgments: GT acknowledges the support from the Italian Space Agency through the grant *Monitoring Asteroids* n. 2022-33-HH.0.