Report Research Activity

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This report summarises the activities carried out by the research fellow during the first six months of activity, from May 25th 2020 to November 24th 2020.

The research activity is supervised by Prof. Giovanni F. Gronchi and Phd Giulio Baù and it is related to techniques for Initial Orbit Determination (IOD) of space objects from observations. In particular it is focused computation of several asteroid orbits with the observations of the Isolated Tracklet File (ITF) available at the Minor Planet Center and the application of the IOD to asteroids and space debris.

This activity belongs to the European project Stardust-R and it is founded by an MSCA-ITN-ETN - European Training Networks (see http://www.stardust-network. eu/ for more information).

Developments and work in progress:

As in the first months of the project, we have mainly followed the work presented in the research papers of Orbit Determination with the two-body integrals I, II, III ([1] [2] [3]) and the book by A. Milani and G. F. Gronchi [5]. In particular, our work was focused on the use of the polynomial method (see [3]) with the aim of identify whether if two tracklets belong to the same observation and to construct a preliminary orbit (link2 problem) and similarly on the use of the method introduced in [4] with the aim of identify whether if three tracklets belong to the same observation and to construct a preliminary orbit (link3 problem).

To this purpose we have made use of the software Orbfit (http://adams.dm.unipi. it/orbfit/), introducing improvements in the implementation of said methods. In addition, thanks to the datasets provided by Robert Jedicke, these methods have been tested and analysed in various controlled conditions. For these datasets, we have found quite good results in terms of the total number of real identifications obtained.

A first exploration of the ITF was done using a strategy combining the link2 and link3 methods mentioned previously. The process can be described schematically in the following three steps:

1. Make a complete exploration of the ITF with link2 trying to link all the possible pairs of tracklets that satisfies some preliminary filters.

2. Construct all the possible triplets (X, Y, Z) such that (X, Y), (X, Z) and (Y, Z) are accepted solutions of link2.

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3. Apply link3 in these triplets.

The results obtained are being analysed using Matlab and R.

In addition we analyse the work [6] of Mossotti for the orbit determination problem and we construct a topocentric version of the method that produces better results. We are finishing analysing these results with the intention of publishing it shortly.

Virtual Secondment:

Due to the current COVID-19 emergency the secondment in the University of Belgrade is virtual. Under the supervision of Prof. Bojan and the collaboration of Phd Marco Fenucci we started to try to characterise some properties related to the Yarkovsky effect [7] in a set of asteroids.

We aim to develop a model to constrain the physical characteristics of the surface of rotating near-Earth asteroids, and in particular, the thermal conductivity and with this purpose we use different statistical techniques to develop and analyse the results, as for example, the estimation of mixture distributions.

Activities:

I have attended to the following schools and workshops:

- Stardust-R Global Virtual Workshop I, Università di Pisa, Pisa, 7-10 September 2020;

- Barcelona Mathematical Days 2020, Barcelona, 23-24 October 2020.

References

[1]   Gronchi, G.F., Dimare, L., Milani, A.: *Orbit determination with the two-body integrals.* Cel. Mech. Dyn. Astron. 107(3), 299–318 (2010)

[2]   Gronchi, G.F., Farnocchia, D., Dimare, L.: *Orbit determination with the two-body integrals. II.* Cel. Mech. Dyn. Astron. 110(3), 257–270 (2011)

[3]   Gronchi, G.F., Baù G., Marò S.: *Orbit determination with the two-body integrals. III.* Cel. Mech. Dyn. Astron. 123, 105–122 (2015)

[4]   Gronchi, G.F., Baù G., Milani A.: *Keplerian integrals, elimination theory and identification of very short arcs in a large database of optical observations.* Cel. Mech. Dyn. Astron. 127, 211–232 (2017)

[5]   Milani, A., Gronchi, G.F.: *The Theory of Orbit Determination.* Cambridge University Press, Cambridge (2010)

[6]   Mossotti O.F., *Nuova analisi del problema di determinare le orbite dei corpi celesti,* Pisa, Domus Galileana (1816-1818)

[7]   Vokrouhlický D., Milani A., Chesley S.R., *Yarkovsky Effect on Small Near-Earth Asteroids: Mathematical Formulation and Examples*, Icarus, 148, 118-138 (2000)

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