DISCOVERY OF FOUR YOUNG ASTEROID FAMILIES
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INTRODUCTION
Asteroid families are groups of objects that share similar orbital parameters, and in most cases, also similar spectral characteristics (Milani et al. 2014; Nesvorný et al. 2015). These groups are thought to originate from a single parent asteroid, and are closely related to many aspects of asteroid-based research (Cellino et al. 2009; Hsieh et al. 2018).

Once created, families however undergo dynamical and collisional evolution (Novaković et al. 2015; Bottke et al. 2015), that both start immediately after the brake-up event. For this reason, a specially interesting subgroup of asteroid families are young ones, i.e. those formed less than 10 Myrs ago. They have attracted a lot of attention since the first such family has been discovered by Nesvorný et al. (2002). About 20 young families have been discovered so far, but new discoveries are still very important. Here we report discovery of four new young asteroid families.

METHODS
Asteroid families are usually identified in the space of proper orbital elements (Knežević, & Milani 2003), using the Hierarchical Clustering Method (HCM) proposed by Zappala et al. (1990). For identification of young families, a somewhat different approach is more suitable. Backward integration method (BIM) is a standard tool to estimate ages of young asteroid families (Nesvorný et al. 2003), that could be also used to verify a common origin of asteroid groups (Novaković et al. 2012a).

The BIM is based on the fact that immediately after the formation, members of an asteroid family have nearly the same orbital elements. These elements are then dispersed over time, and signatures of their clustering are erased. However, for young families, the epoch of past convergence of secular angles may still be revealed by propagated their orbits backward in time (Radović 2017).

Recently we have produced the largest catalog1 of asteroid proper orbital elements so far, that provides these data for more than 630,000 objects. As the procedure to compute proper elements includes numerical integrations of asteroids’ orbits, these are also available for the same objects.

Taking advantage of the availability of these data-sets, our strategy to identify young families consists of two steps. In the first step, we applied the HCM to the new catalog of asteroid proper elements to identify all small groups recognizable at velocity cut-off distance of 15 m/s. In the second step, we used the BIM to confirm the common origin and the young age of newly identified clusters.

RESULTS
Using the above described methodology we have identified four new young dynamical families. Three of them are located in the inner asteroid belt, namely the (525) Adelaide, (6142) Tantawi and (18429) 1994AO1, while the family of (2258) Viipuri is located in the middle part of the asteroid belt.

The differences in secular orbital angles of potential members of the new families are shown in Fig. 1. In each case, a tight clustering of nodal longitudes is clearly visible at some point. This suggests that asteroids from each of the groups have a common origin, and allows a preliminary estimation of their ages (Fig. 1).

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1 The catalog is available at Asteroid Families Portal (Radović et al. 2017)
Figure 1. The time-evolution of the average differences in the mean nodal longitudes for members of four new young asteroid families. The names of the families and their approximate ages are indicated in each of the panels.

Three new clusters consist of dark primitive objects, except for the Adelaide cluster whose members are asteroids probably of taxonomic S-type. Two of these clusters are subfamilies of larger and older families. Based on the data from Nesvorny (2015), the Adelaide cluster is located within the Flora family, while the Tantawi group is a sub-family of the Nysa-Polana complex.

DISCUSSION

The clustering of orbital angles that we have found for each of the new families suggests that their members originate from the common parent bodies. However, the exact mechanism of their formation is still to be determined. While large older families are formed by collisions, in the recent years it was shown that small young families may also be formed by rotational fission of critically spinning parent bodies (Pravec et al. 2018).

The ages of the new families obtained here are determined using the nominal orbits of their members only, and purely gravitational model. These results should be improved by including the Yarkovsky effect in the dynamical model, and taking into account the orbital uncertainties (Novaković et al. 2012b).

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REFERENCES

Bottke, W. F., Brož, M., O’Brien, D. P., et al. 2015, Asteroids IV, 701
Cellino, A., Dell’Oro, A., & Tedesco, E. F. 2009, Planet. Space Sci., 57, 173
Hsieh, H. H., Novaković, B., Kim, Y., et al. 2018, AJ, 155, 96
Knežević, Z., & Milani, A. 2003, A&A, 403, 1165
Milani, A., Cellino, A., Knežević, Z., et al. 2014, Icarus, 239, 46
Nesvorný, D., Bottke, W. F., Dones, L., et al. 2002, Nature, 417, 720
Nesvorný, D., Bottke, W. F., Levison, H. F., et al. 2003, ApJ, 591, 486
Nesvorný, D. 2015, NASA Planetary Data System, EAR-A-VARGBDET-5-NESVORNYFAM-V3.0
Nesvorný, D., Brož, M., & Carruba, V. 2015, Asteroids IV, 297
Novaković, B., Hsieh, H. H., & Cellino, A. 2012a, MNRAS, 424, 1432
Novaković, B., Dell’Oro, A., Cellino, A., et al. 2012b, MNRAS, 425, 338
Novaković, B., Maurel, C., Tsirvoulis, G., et al. 2015, ApJL, 807, L5
Pravec, P., Fatka, P., Vokrouhlický, D., et al. 2018, Icarus, 304, 110
Radović, V. 2017, MNRAS, 471, 1321
Radović, V., Novaković, B., Carruba, V., et al. 2017, MNRAS, 470, 576
Zappala, V., Cellino, A., Farinella, P., et al. 1990, AJ, 100, 2030