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The Stable Archipelago in the region of the Pallas and Hansa families

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Abstract

Among highly-inclined asteroids the region of the central main belt between the 3J:-1A and 5J:-2A mean-motion resonances has long been known to host the Pallas and Hansa dynamical families. This region is characterized by the presence of the ν_6, ν_5, and ν_{16} secular resonances, that in conjunction with the 8J:-3A mean-motion resonance divide the area into eight regions, the stable islands of the archipelago. Using a set of proper elements available at the AstDyS at the time, Gil-Hutton (2006) identified a family around (686) Gersuind and two more minor clumps around (945) Barcelona, and (148) Gallia in the space of synthetic proper elements. In this work I computed a new set of synthetic proper elements for 2310 numbered and 2142 multi-opposition objects in this region. The use of the Frequency Modified Fourier Transform method allowed to obtain non-negative estimate of the proper frequency of argument of pericenter precession g for members of the Hansa families characterized by values of e_{forced} larger than e_{free}, and solved the problem of the non-linear dependence of g versus n observed in Carruba and Michtchenko (2009).

My analysis shows that the two minor clumps of Gil-Hutton (2006) should now be considered dynamical families. Also, a new family in both domains of proper elements $(a, e, \sin(i))$ and frequencies $(n, g, g+s)$ around (1222) Tina was discovered in this work, as well as a new frequency family around (4203) Brucato. Nine minor clumps, one of which visible in both domains, were also observed. Since the majority of the members of the Tina and Barcelona families are in librating ν_6 ν_5 states, respectively, these families could be the first groups ever found to be located in linear secular resonances.

The taxonomical analysis of family members suggests that the Pallas family is compatible with a B-type composition (but two members are classified as C-interlopers), while the Hansa family is possibly a S-type one. SDSS-MOC3 data suggests that the Barcelona family might be an Sq group, and the Gersuind, Gallia, and Tina ones should belong to the S-complex. Geometric albedo data seems to confirm the possibility that the Barcelona and Gersuind families belong to the S-complex. Data on cumulative size distributions, collisions timescales, rotation rates and dynamics in this region were also revised in this work.

1. Introduction

Among highly inclined asteroids (asteroids with $\sin(i) > 0.3$, for which the analytical theory used to obtain proper elements is not very accurate (Milani and Knežević 1994), the asteroids in the region of the Pallas and Hansa families are characterized by a very interesting dynamics. This region is characterized by the presence of the ν_6, ν_5, and ν_{16} secular resonances, with in conjunction with the 8J:-3A mean-motion resonance divide the area into eight regions, the stable islands of the archipelago.

In these islands, the Pallas family was firstly suggested by Williams (1992) and Lemaître and Morbidelli (1994), while the largest family in the region, Hansa, was originally proposed by Hergenrother et al. (1996). Gil-Hutton (2006) defines the region of the Pallas and Hansa families (zone B in his paper) as the region between the 3J:-1A and 5J:-2A mean-motion resonances (which roughly corresponds to the region between 2.501 and 2.825 AU) and with $sin(i) > 0.3$. As discussed in Knežević and Milani (2000), while it is not possible to obtain accurate analytical proper elements for this region, even some of the synthetic ones, as is the case for some low-eccentricity members of the Hansa family (Carruba and Michtchenko 2009), are affected by errors: objects whose free eccentricity is smaller than their forced one present difficulties in obtaining accurate values of the pericenter precession frequency g. The presence of linear resonances in the region such as the ν_5, ν_6, ν_{16} and other non-linear resonances also introduces elements of errors for obtaining accurate values of proper elements and frequencies.

Yet, having an accurate data-set of proper elements is essential to obtain dynamical families and clumps, and, more in general, to investigate the local dynamics. In this paper I therefore first tried to obtain synthetic proper elements not only for the numbered asteroids in

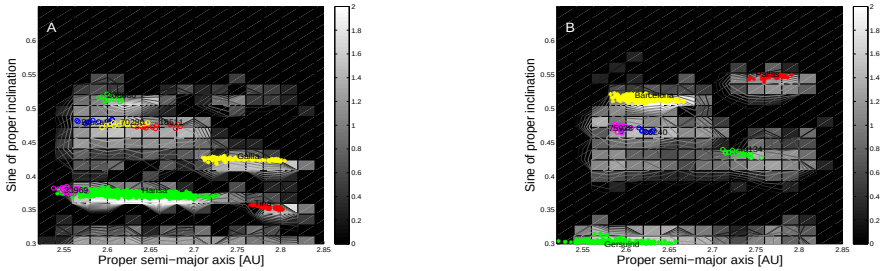

Figure 1: Density maps in the $(a, \sin(i))$ representative plane for small eccentricity bodies and classical groups (panel A), and large eccentricity bodies and classical groups (panel B).

the region, for which such elements are already listed in the AstDyS (http://hamilton.dm.unipi.it/astdys), but also for multi-opposition objects. Using the frequency modified Fourier transform method of Šidlichovský and Nesvorný (1997) and the method described in Knežević and Milani (2000) for obtaining synthetic proper elements and frequencies, I also tried to get better estimates of proper g for those Hansa asteroids that appeared to have retrograde values in the AstDyS data-set (Carruba and Michtchenko 2009). Overall, I obtained synthetic proper elements for 4452 asteroids in the region of the Hansa and Pallas families.

As a next step I identified families in the space of proper elements and proper frequencies using the Classical and Frequency Hierarchical Clustering System (CHCM and FHCM, respectively, Zappalá et al. 1995, Carruba and Michtchenko 2007, 2009). My analysis shows that the two former clumps of Gallia and Barcelona proposed by Gil-Hutton (2006) should now be considered full families in both proper frequency and element domains. I also confirm the existence of a family around (686) Gersuind. A new family around (1222) Tina and a frequency family (the group is visible as a clump in element domain) were identified for the first time in this work, as well as with nine other minor clumps. Since the majority of the members of the Tina and Barcelona families are in librating ν_6 ν_5 states, respectively, these families could be the first groups ever found to be located in linear secular resonances.

Families sub-groups and asteroids pairs candidates (Pravec and Vokrouhlický 2009) were also detected in the region.

Fig. 1 displays density maps in the $(a, \sin(i))$ representative plane for small eccentricity bodies and classical groups (panel A), large eccentricity bodies and classical groups (panel B). Family members are shown as asterisks, while clump members are displayed as small circles. The effect of the linear secular resonances ν_5, ν_6, ν_{16} in removing the observed population of asteroids is quite clear in the density maps.

The taxonomical analysis of family members suggests that the Pallas family is compatible with a B-type composition (but two members are classified as interlopers), while the Hansa family is possibly a S-type one. SDSS-MOC3 data suggests that the Barcelona family might be a Sq group, and the Gersuind, Gallia, and Tina families should belong to the S-complex. The Brucato frequency family owns asteroids that belong to both the C- and X- complex, and might not be the product of a collisional event.

Analysis of the data on geometric albedo, absolute magnitude, cumulative distributions and collision timescales, Yarkovsky isolines and C-target functions, light curves, and dynamics in the region were carried out, following the approach of Carruba (2009).

As often in science, this work answered some questions but produced several new ones, in many cases completely unexpected when this work started. The large amount of unanswered questions is once again a proof of the vitality of asteroid dynamics as a field of research. More information on this work is available in Carruba (2010).

References

[1] Carruba, V.: Dynamical erosion of asteroid groups in the region of the Phocaea family, MNRAS, Vol. 403, pp. 1834-1848, 2010.

[2] Carruba, V.: The stable archipelago in the region of the Pallas and Hansa families, MNRAS, submitted.