On some dynamical properties of Phocaea asteroids

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The Phocaea group is located in the inner asteroid belt, and consists of asteroids having orbital inclination higher than about 20 degrees, and eccentricity ranging between 0.15 and 0.3. This region is known to have dynamical boundaries which completely surround it and produce a confinement of objects inside it [1,2]. An inner boundary in semi-major axis, often related to the 7/2 mean-motion resonance (MMR) with Jupiter, is located at about 2.25 au. However, a non-negligible number of asteroids is still present beyond this limit. The outer boundary, at around 2.5 au, is set by the powerful 3/1 MMR with Jupiter. Moreover, the region is delimited by important secular resonances (SRs): the $\nu_6 = g - g_6$ at low inclination, and the $\nu_5 = g - g_5$ and $\nu_{16} = s - s_6$ at high inclination. Also, the asteroids from the region interact with many mean-motion and secular resonances. The most relevant SRs are $g - g_6 - s + s_6$, $g - g_5 + s - s_6$ and $g - g_6 - 2s + 2s_6$, as can be recognized by the alignments of objects associated with these resonances (see Figure).

The aim of this work is twofold. First, to investigate the possible relevance of secular resonances with the inner planets for the Phocaea asteroids. Second, to check weather or not the inner boundary of the region in terms of semi-major axis, i.e. 7/2 resonance with Jupiter, could be crossed under the influence of gravitational and/or non-gravitational forces.

Our results confirm the non-negligible importance of secular resonances involving inner planets for the dynamics over long time scales of the asteroids in the Phocaea region. The most obvious interaction is found with the $s - s_4 + g_3 - g_7$ resonance. The results for the 7/2 resonance show that a significant fraction of the bodies larger than about 600 m, and most of the bodies smaller than the above limit, can transit across the resonance without being removed from the Phocaea region. This means that, despite being effective in pumping up asteroid eccentricities in this region, the 7/2 resonance is not an absolute dynamical boundary for sufficiently small objects, below some hundred meters in diameter.

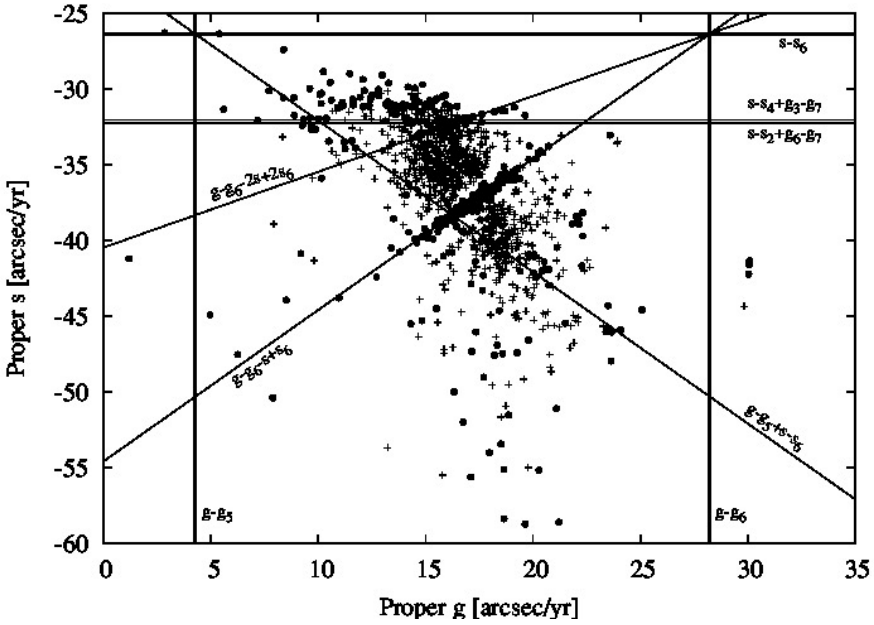

Figure: The asteroids in the Phocaea region projected on the plane of proper frequency g of the longitude of perihelion versus proper frequency s of the longitude of node. The objects with smaller errors in proper orbital eccentricity and inclination are plotted as crosses, while objects with larger errors are plotted as full circles. The lines show the locations of several secular resonances which are indicated in the plot.

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References: [1] Knežević Z., Milani A., 2003, A&A, 403, 1165. [2] Carruba V., 2009, MNRAS, 398, 1512.