An update of the comet candidates among the quasi-Hilda objects

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Introduction

The quasi-Hilda comets (QHCs) are located close to the Hilda asteroids in the vicinity of the 3:2 mean motion resonance (MMR) with Jupiter. The QHCs are Jupiter-family comets (JFCs) that have moved from outside to inside of Jupiter's orbit, and the JFCs have evolved from the transneptunian region.

However, there are some Hilda asteroids that have similar dynamic behaviour to JFCs. Since it is not easy to physically distinguish them from the population of QHCs, it is necessary to develop a dynamical study of the orbital evolution of these objects. Gil-Hutton & García-Migani (2016, GG2016 hereafter) founded 11 QHCs after a dynamical analyse of the population.

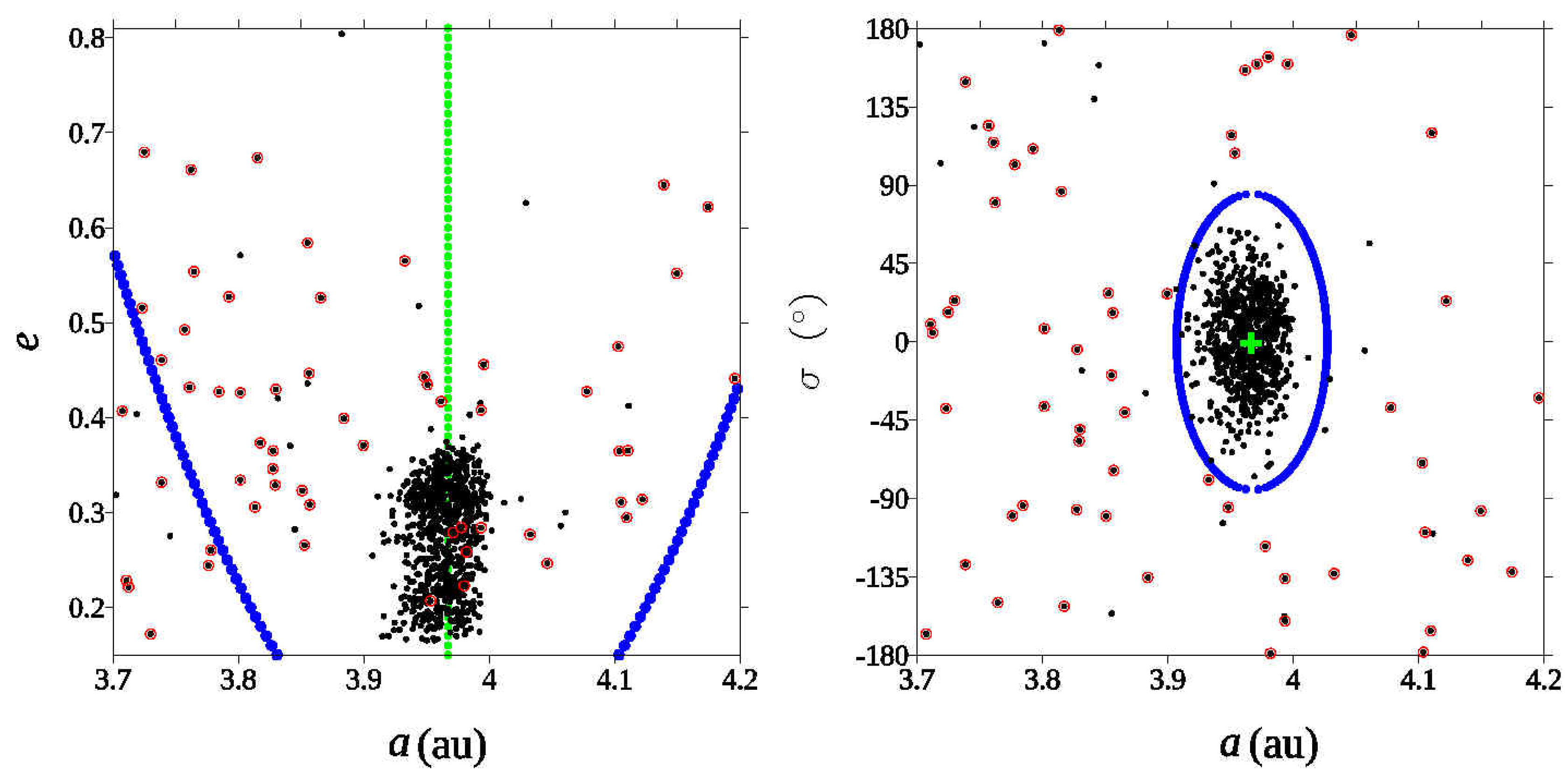
In this poster we present the update of the QHCs candidates that have recently arrived from the Centaur zone, which could become active near the perihelion of their orbits.

New QHCs candidates

Following the same criteria as the one employed in GG2016 we select a sample of 828 pre-candidates. The sample was numerically integrated for a backward time-span of 50 kyr taking into account the perturbations of all the planets of the Solar System. We found 47 new objects with a dynamical evolution that would indicate a recent income from the outer Solar System. The new QHCs candidates and their orbital elements are in the Table.

Object	a (au)	e	i (°)	Object	a (au)	e	i (°)
7458	3.730	0.172	1.76	2011 DL_{12}	3.829	0.329	13.48
30512	3.850	0.323	25.70	2011 MX_9	4.103	0.475	19.23
85490	3.762	0.661	2.57	2011 QQ_{99}	3.801	0.426	3.21
254010	3.982	0.258	17.05	2011 UB_{301}	3.801	0.334	21.13
424570	3.980	0.223	6.62	2011 UG_{104}	3.993	0.407	29.59
431336	3.776	0.244	20.40	2011 US_{383}	3.827	0.365	7.87
508861	3.815	0.673	4.16	2011 WD_{180}	3.884	0.399	15.69
551740	4.046	0.246	24.02	2014 MZ_{101}	4.110	0.365	17.62
615767	4.122	0.314	9.86	2014 OM_{449}	3.993	0.284	19.81
2000 AC_{229}	4.149	0.551	52.43	2014 VF_{40}	3.757	0.492	24.48
2000 CA_{13}	3.764	0.553	1.45	2015 PV_{306}	4.109	0.294	12.41
2002 QD_{151}	3.710	0.228	4.75	2016 CD_9	3.707	0.407	5.92
2004 QR_{38}	3.995	0.456	11.29	2016 JF_{46}	3.778	0.260	16.17
2004 RP_{111}	4.174	0.622	14.14	2016 NQ_{77}	3.829	0.429	13.09
2005 EC_{272}	3.738	0.460	7.15	2016 WP_{51}	3.950	0.434	14.98
2005 UK_{380}	3.899	0.370	3.03	2016 BS_{30}	3.827	0.346	11.66
2005 XR_{132}	3.761	0.431	14.47	2017 FU_{158}	3.725	0.679	23.84
2007 RM_{150}	3.856	0.446	11.11	2018 PE_{48}	3.738	0.332	12.74
2008 QZ_{44}	4.195	0.441	11.35	2019 JB_{49}	3.852	0.265	10.52
2008 SZ_{283}	3.961	0.417	14.80	2020 FV_{35}	3.813	0.305	4.12
2009 QM_{24}	3.784	0.427	13.75	2020 UO_{43}	4.139	0.645	1.75
2009 TC_{54}	3.817	0.373	5.87	2020 XH_{11}	4.032	0.276	27.53
2010 ES_{189}	4.103	0.364	31.61	2021 JF_{52}	3.932	0.565	24.75
2010 JB_{184}	3.977	0.284	21.18				

Empirical criteria



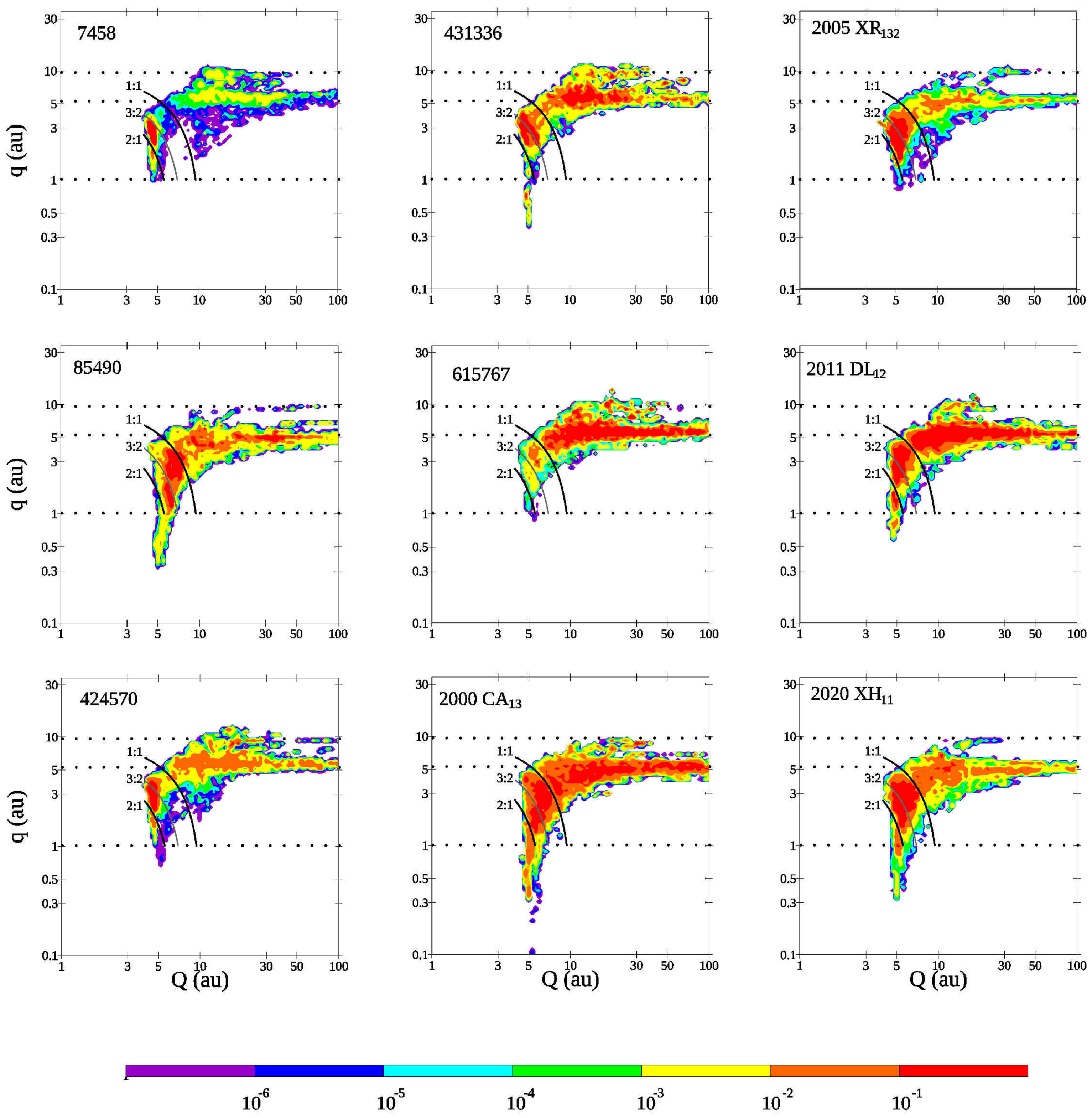
The Figure shows the 828 pre-candidates (black dots) and the candidates (red circle). In the left panel the objects are in the (a, e)-plane. We can see that almost all objects are close to the 3:2 MMR with Jupiter ($a_0 \sim 3.9607$ au), whose nominal position is indicated by a vertical green line. Moreover, if we apply the simple pendulum model we can show the approximate position of the separatrix in blue line.

However, the semimajor axis of the objects do not indicate the real influence of the resonance. Hence, in right panel we represent their distribution in the (a, σ)-plane by calculating the osculating value of the characteristic or resonant angle σ. We can see that the QHCs candidates are in the periphery of the MMR, beyond the blue ellipse in right panel. Then, we propose an empirical criteria to identify QHCs candidates: $\sigma = \pm 1500\sqrt{0.06^2 - (a - a_0)^2}$.

Dynamical analysis of the candidates

The evolution of the 47 QHCs candidates from the Centaurs or transneptunian region toward their actual position as QHCs is chaotic. Then, as in GG2016, we perform a dynamical study of chaotic orbits from a statistical point of view by following the backward temporal evolution of clones of each object.

We analyse the dynamical evolution of the 47 new QHCs candidates by mapping the time-averaged distribution of 100 clones of each candidate in the (Q, q)-plane. Since we observe similar dynamical characteristics for all the candidates, we present the results of some QHCs as examples.



The Figure shows the results of 9 QHCs candidates as examples of the main dynamical characteristics observed. We also include the nominal position of the 3:2 MMR, the 2:1 MMR and the 1:1 MMR with Jupiter as reference.

We can see how Jupiter and Saturn produce a gravitational scattering over the clones, increasing their aphelion distances: horizontal strips of density with almost constant perihelion distances at $q \sim 5.2$ au and 9.5 au (i.e. dotted horizontal lines). This dynamical behavior is consistent with objects coming from the outer Solar System. Moreover, the candidates are able to visit the region below 1 au where the comets could show intense activity.

conclusions

In this article we continue with the identification of QHCs candidates, initiated in GG2016. We report 47 new QHCs candidates, which plus the 11 candidates found in GG2016 update the QHCs to a total of 58 candidates. With this result we were able to define an empirical criterion in the resonance plane, which allows us to define a region where the QHCs candidates are most likely to be found. Moreover, we can deduce that all the QHCs candidates are able to visit the inner region of the Solar System and those with $q < 1$ au could be affected by strong activity. Therefore, these objects represent an important opportunity to confirm the QHCs candidates.

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