Dynamika obiektów współorbitalnych z Ziemią

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- Types of the coorbital motion

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- Selected objects

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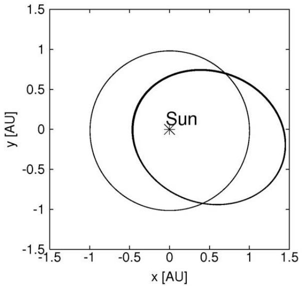
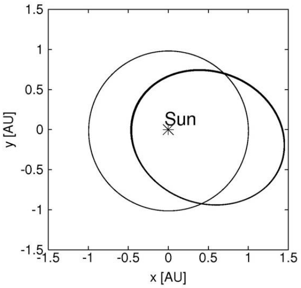
- 2004 GU9
- 2006 FV35
- Cruithne

Conclusions and summary

- $1:1$ mean motion resonance



- 1 : 1 mean motion resonance
- Coorbital region: $|a - a_{planet}| \lesssim r_H$



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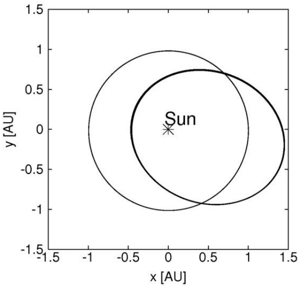
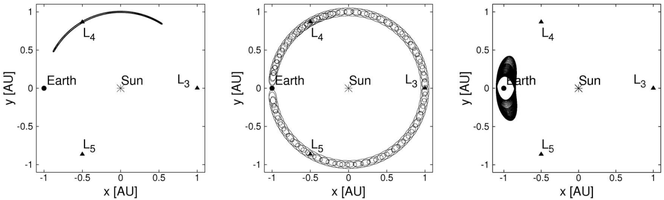
- For the Earth: $r_H \approx 0.01$ AU



Three types of coorbital behaviour



(a) (b) (c)

Figure: (a)- **Tadpole orbits (TP)** – taking place around the triangular Lagrange equilibrium points L_4 or L_5. (b)- **Horseshoe orbits (HS)** – around the Lagrange points L_3-L_4-L_5. (c)- **Quasi-satellite orbits (QS)** – they librate around the longitude of their associated planet and stay close to the planet over many orbital periods

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- Some of these objects show transitions between horseshoe and quasi-satellite motion (Christou 2000, Brasser et al., 2004)

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- The orbit computations were done for 1000 years into the future and into the past

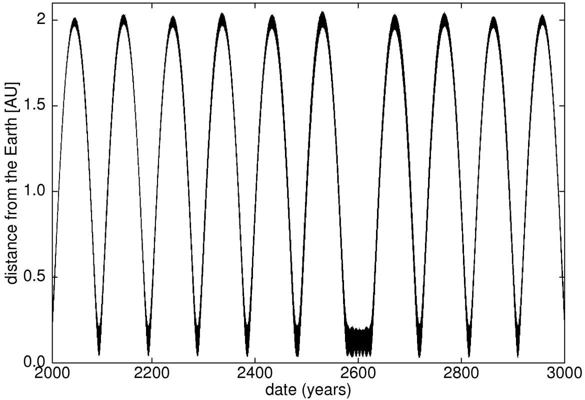
Selected objects

Table: Osculating orbital elements of examined co-orbital objects.
Epoch: April 10, 2007 (JD 2454200.5), Equinox: J2000.0.

Object	a [AU]	e	$i[^\circ]$	$\Omega[^\circ]$	$\omega[^\circ]$	$M[^\circ]$	arc (yr)
2002 AA29	0.9939	0.0130	10.7431	106.4494	101.7282	2.7027	2.01
2003 YN107	0.9927	0.0139	4.3018	264.8437	80.4850	217.7923	1.28
2004 GU9	1.0006	0.1365	13.6497	38.8775	281.1509	244.8943	5.92
2006 FV35	1.0010	0.3775	7.0998	179.6192	170.8588	226.9023	11.99
Cruithne	0.9976	0.5147	19.8100	126.2930	43.7470	99.1446	33.66

2002 AA29-distance from the Earth

$a = 0.9939$, $e = 0.0130$, $i = 10.7431^{\circ}$



View of the trajectory of 2002 AA29 during its QS phase in geocentric reference frame

$a = 0.9939$, $e = 0.0130$, $i = 10.7431^{\circ}$

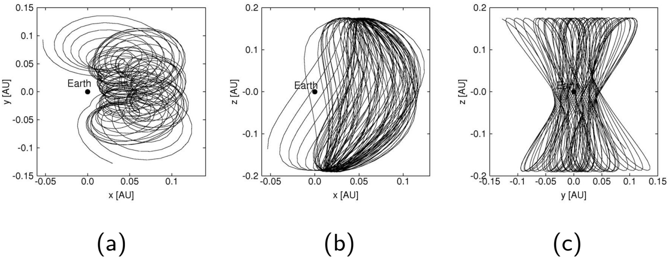
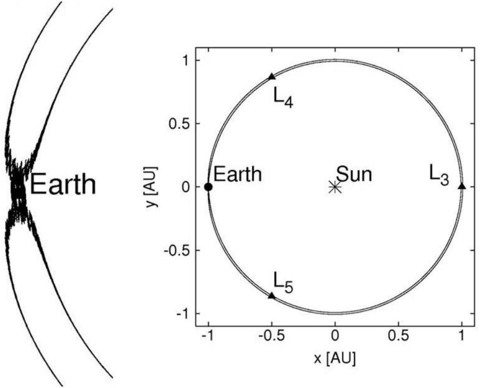


Figure: (a)-motion in x-y projection. (b)–motion in x-z projection. (c)-motion in y-z projection.

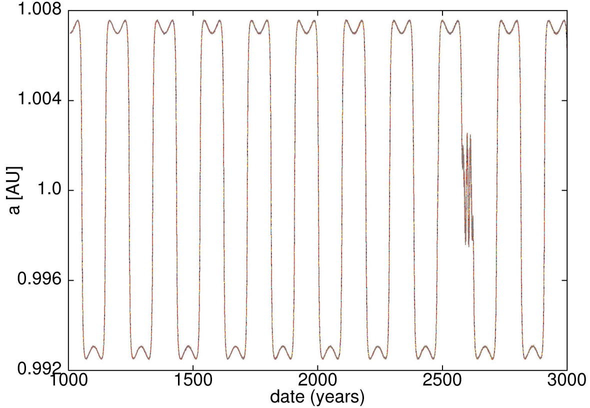
2002 AA29-motion with respect to Earth in a corotating frame

$a = 0.9939$, $e = 0.0130$, $i = 10.7431^{\circ}$



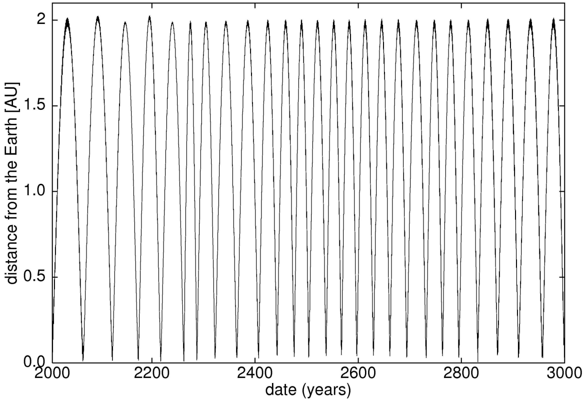
2002 AA29-evolution of semimajor axis

$a = 0.9939$, $e = 0.0130$, $i = 10.7431^{\circ}$; nominal orbit and 9 selected clones



2003 YN107-distance from the Earth

$a = 0.9927$, $e = 0.0139$, $i = 4.3018^\circ$



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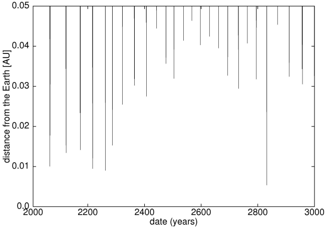

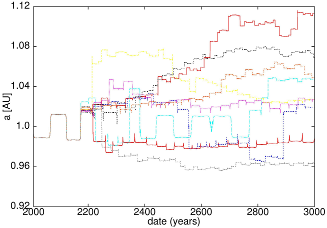

2003 YN107-motion with respect to Earth in a corotating frame

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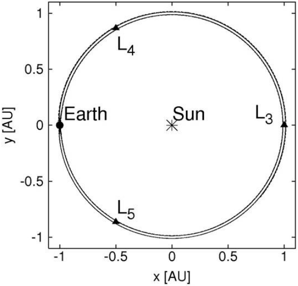
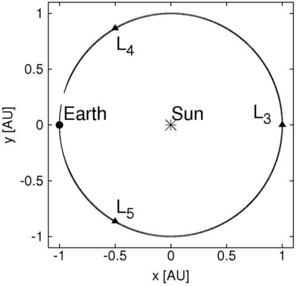


2004 GU9-motion with respect to Earth in a corotating frame

$a = 1.0006$, $e = 0.1365$, $i = 16.6497^{\circ}$



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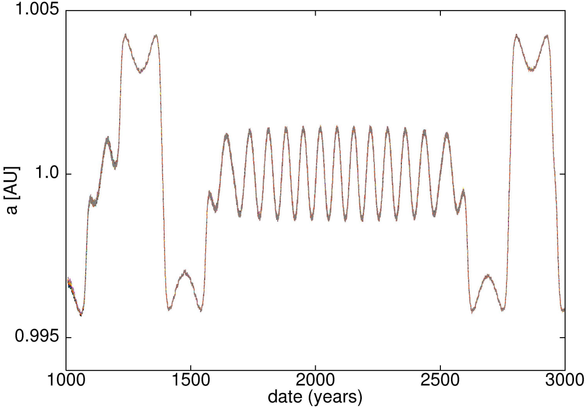
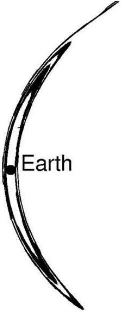
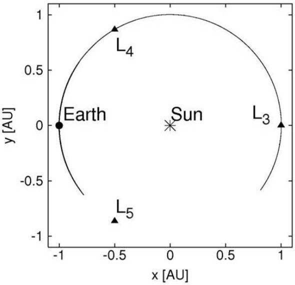


2006 FV35-motion with respect to Earth in a corotating frame

$a = 1.0010$, $e = 0.3775$, $i = 7.0998°$





2006 FV35-evolution of semimajor axis

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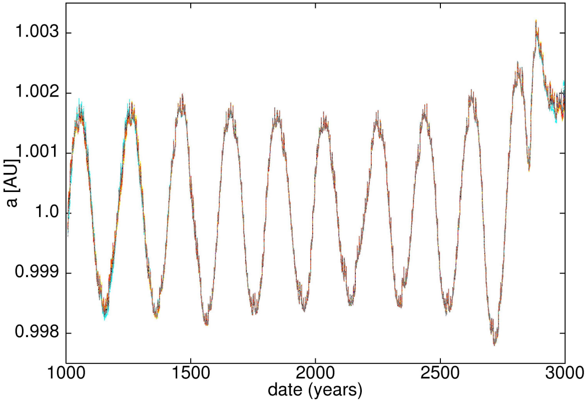
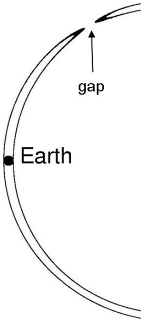
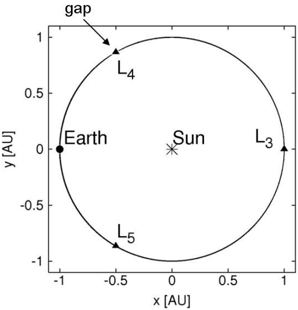


Cruithne-motion with respect to Earth in a corotating frame

$a = 0.9976$, $e = 0.5147$, $i = 19.8100^{\circ}$





Cruithne-evolution of semimajor axis

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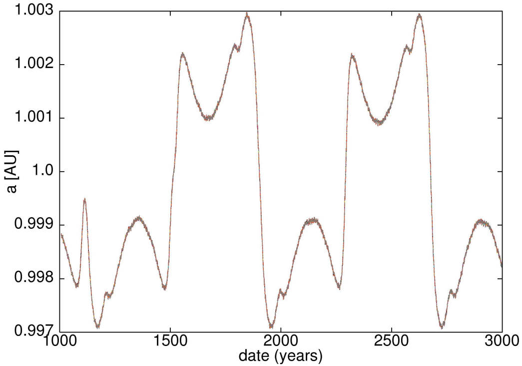

Summary

Object	$t_{QS}[ys]$	$\overline{r_{QS}}$ [AU]	HS-QS type
2002 AA29	45	0.14	transient
2003 YN107	10	0.07	transient
2004 GU9	1000	0.30	transient
2006 FV35	$>$2800	0.64	transient
Cruithne	200	0.95	compound

Conclusions

- Two types of HS-QS transitions: compound HS-QS orbits (Cruithne) and transient HS-QS orbits (remains asteroids)

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- QS states can be repeated

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- Two types of HS-QS transitions: compound HS-QS orbits (Cruithne) and transient HS-QS orbits (remains asteroids)
- In contrast to true satellites, quasi-satellite orbits lie outside the planet's Hill sphere
- QS states can be repeated
- Between QS states the other types of resonant motion are possible