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ON ASSOCIATION OF COMET 96P/MACHHOLZ 1 AND ASTEROID 2003EH1

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Comet 96P/Machholz 1 in 2007

during fifth appearance

The short-period JFC - 1986 VIII Machholz or 96P/Machholz 1 was discovered by D. Machholz on May, 1986.

Green et al. (1990), Sekanina (1990) have suggested that the comet was in inactive – the dormant or extinct stage during a long time up to 1986.

Near-Earth asteroid (186256) 2003EH1 discovered on 6 March 2003 by LONEOS program, Lowell Observatory

H=16.7 mag

[d] =2.32 km

Summary of the current orbits of comet 96P/Machholz 1, NEA 2003EH1 and the Quadrantid meteor shower (J2000.0)

Object	a *(AU)*	e	q *(AU)*	i *(deg.)*	ω *(deg.)*	Ω *(deg.)*	T_j
96P/Machholz 1	3.03	0.96	0.12	58.31	14.76	94.32	1.94
2003EH1	3.12	0.62	1.19	70.88	171.35	282.96	1.96
Quadrantids	3.14	0.69	0.99	71.88	171.20	283.30	1.95

ω

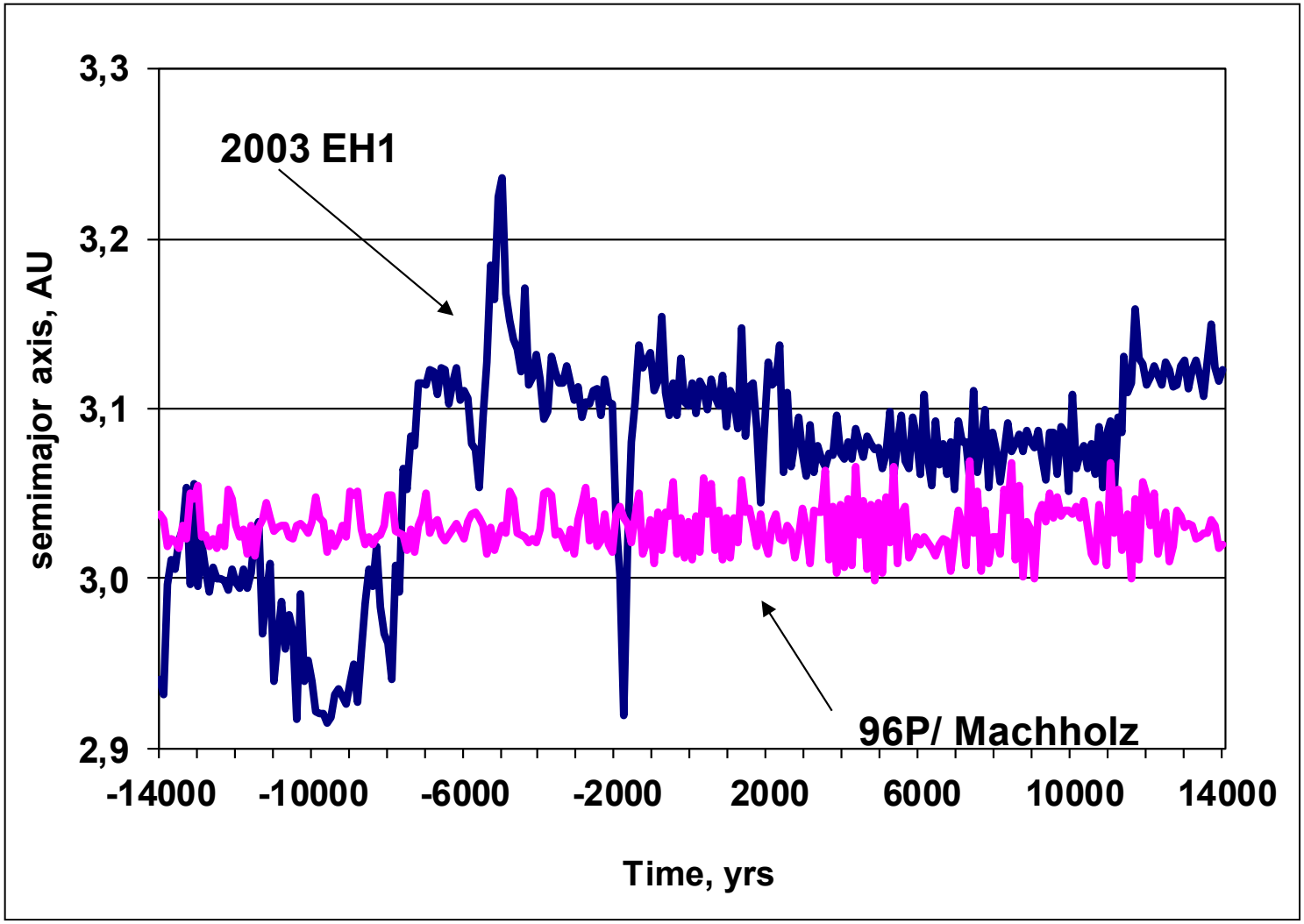
Classification of the orbits of Earth-crossing asteroids due to number of intersections with the Earth's orbit in one cycle of the perihelion argument ω rotation (Shoemaker et al. 1979):

- quadruple crosser
- octuple crosser
- quadruple crosser ω librator
- supercrosser

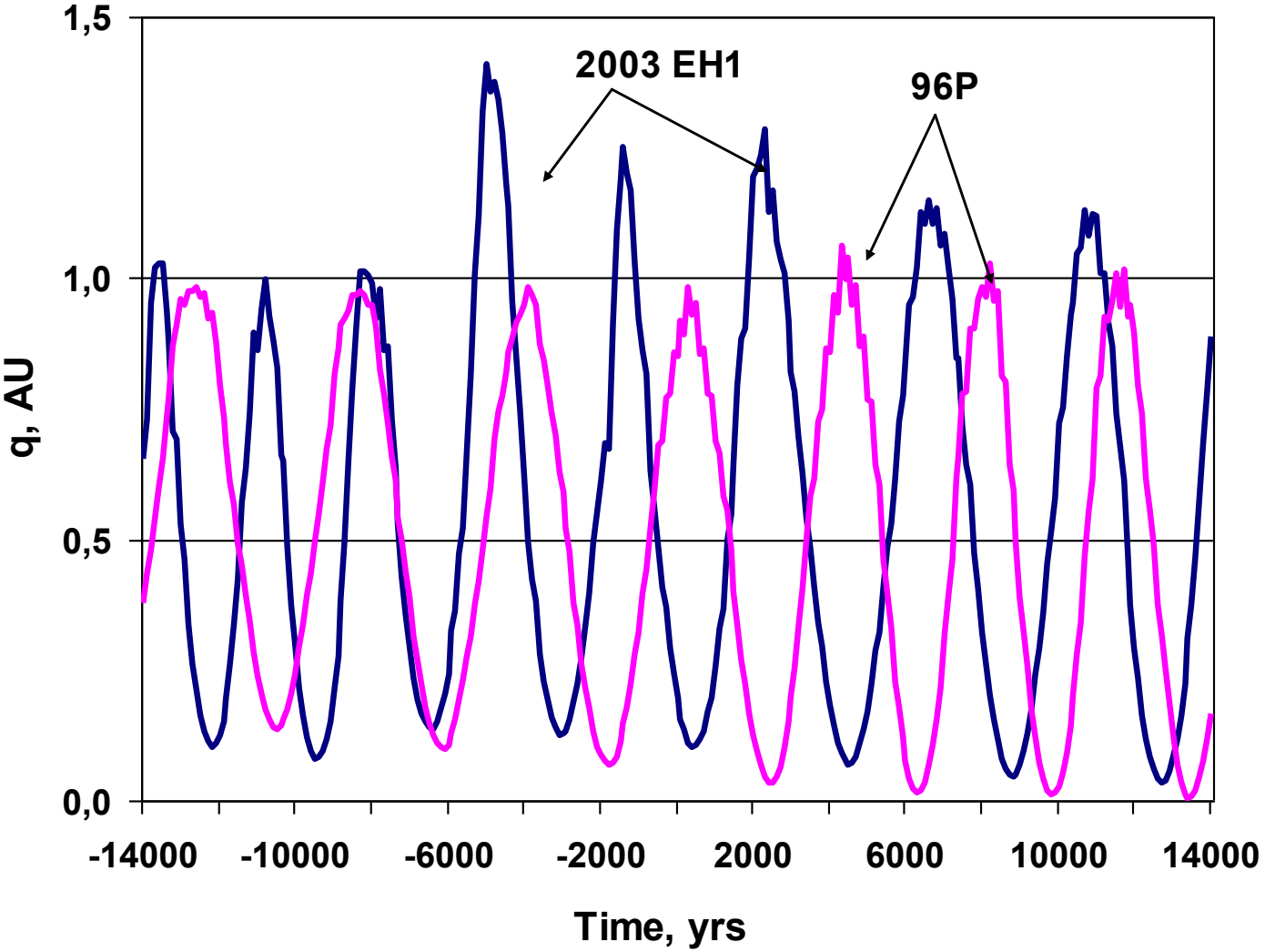
Orbital evolution

of comet 96P/Machholz 1

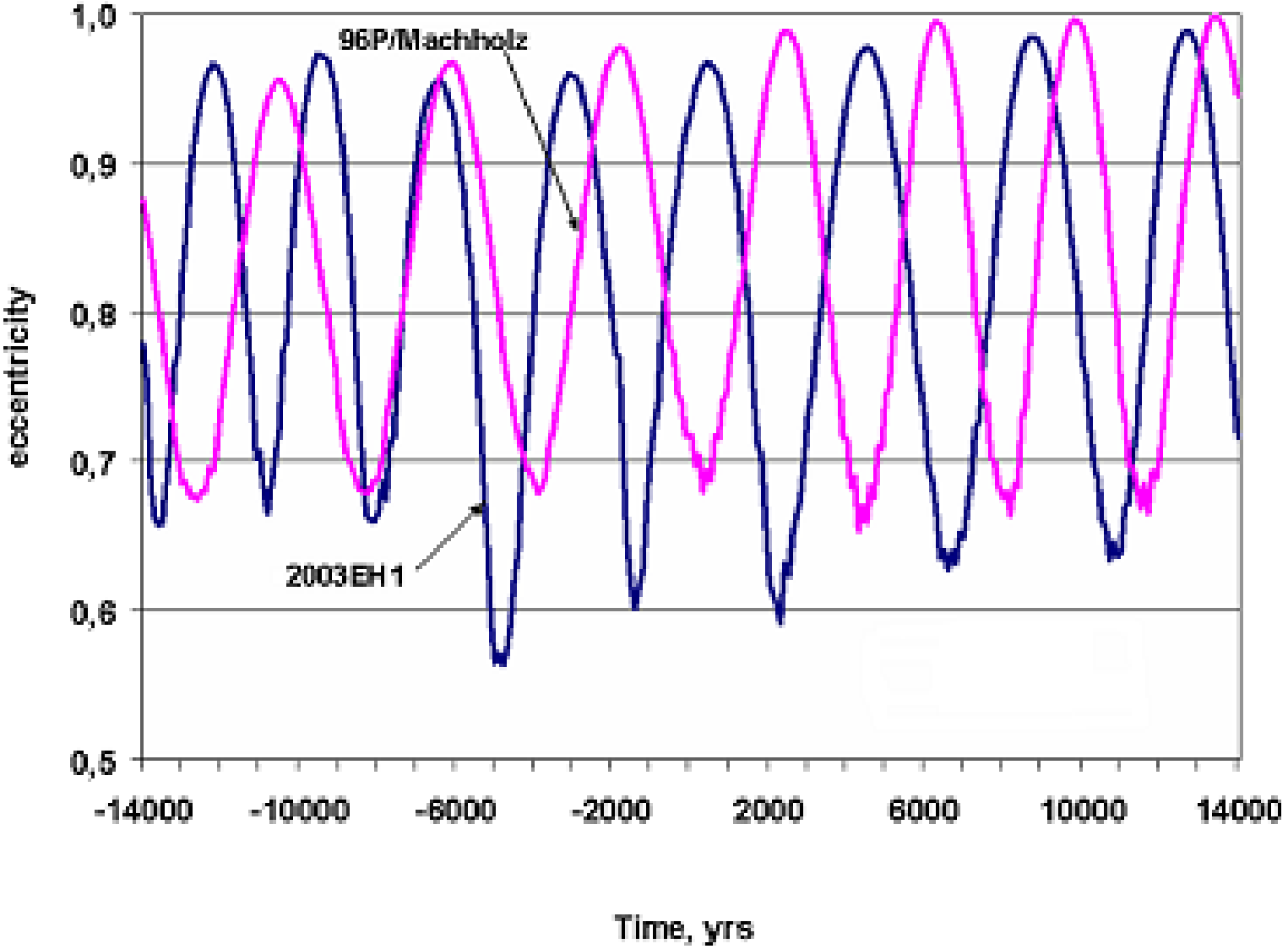
and the object 2003EH1



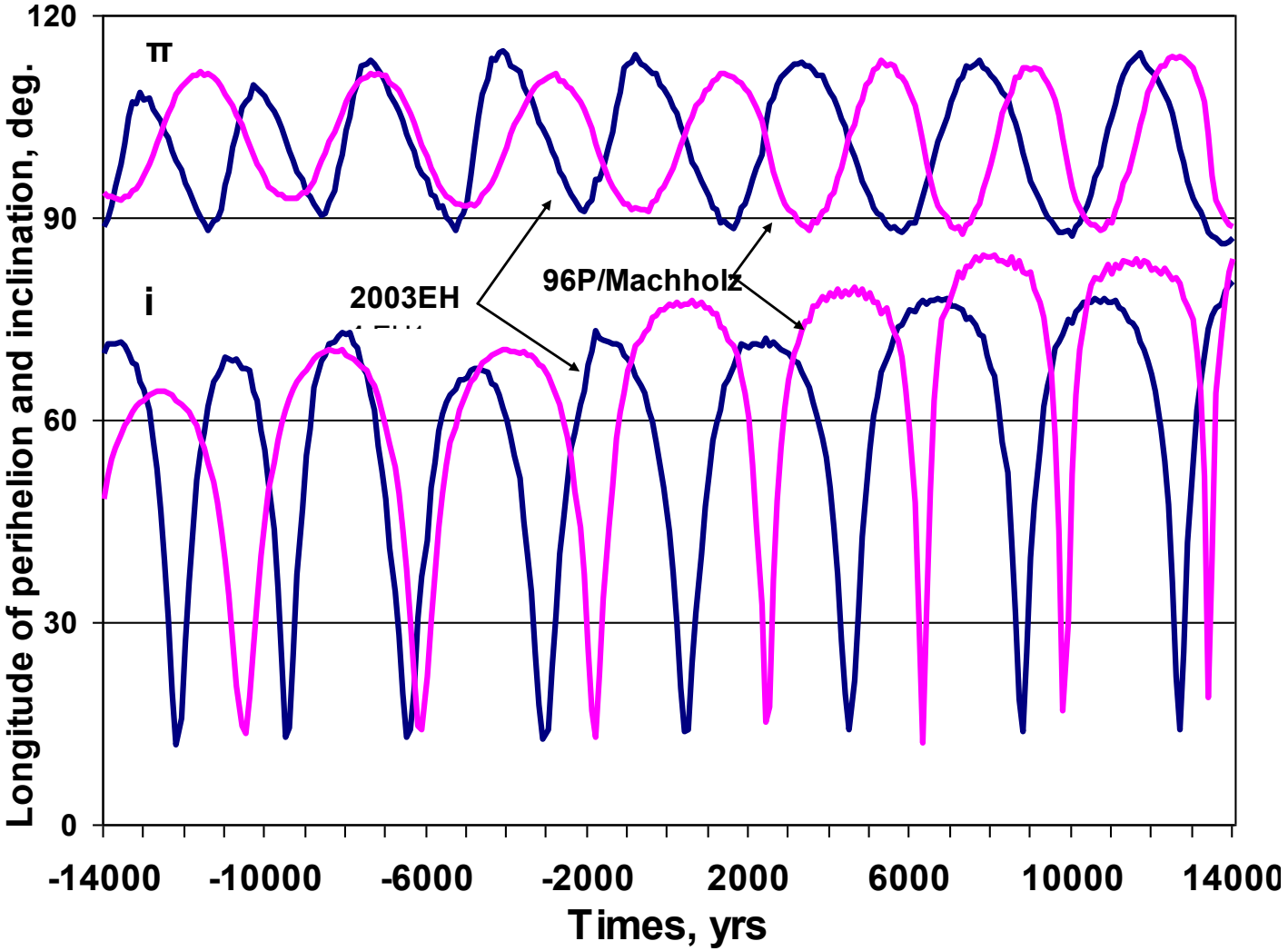
Long-period variations of the semimajor axis of the orbits of comet 96P/Machholz 1 and asteroid 2003EH1



Long-period variations of the perihelion distance of the orbits of comet 96P/Machholz 1 and asteroid 2003EH1

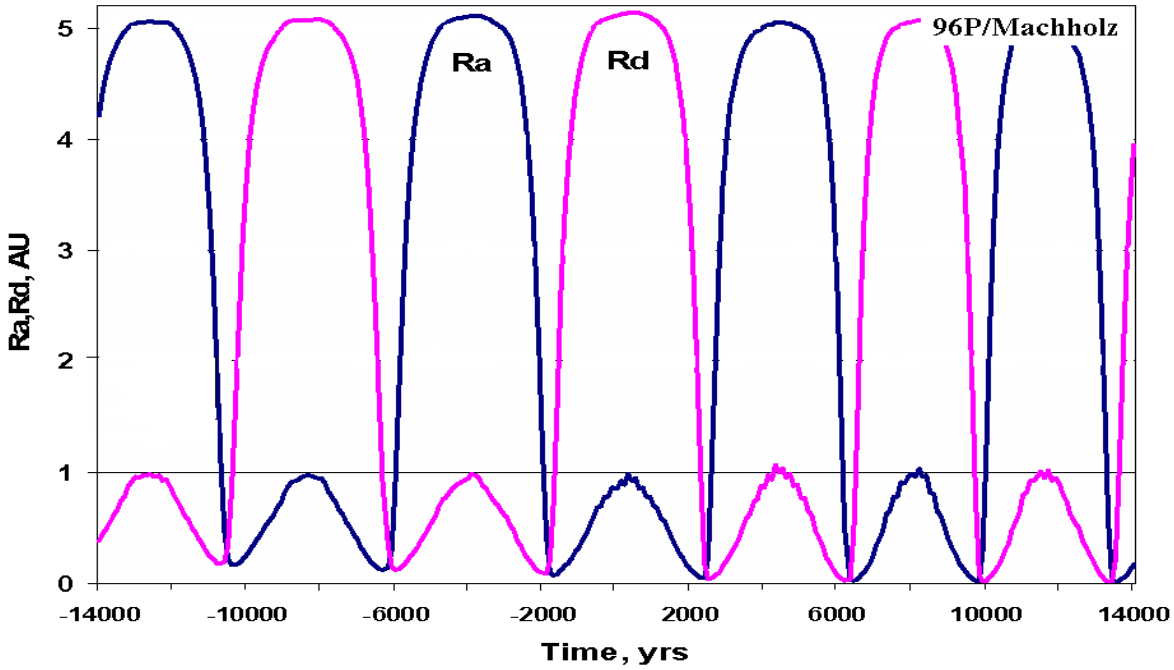


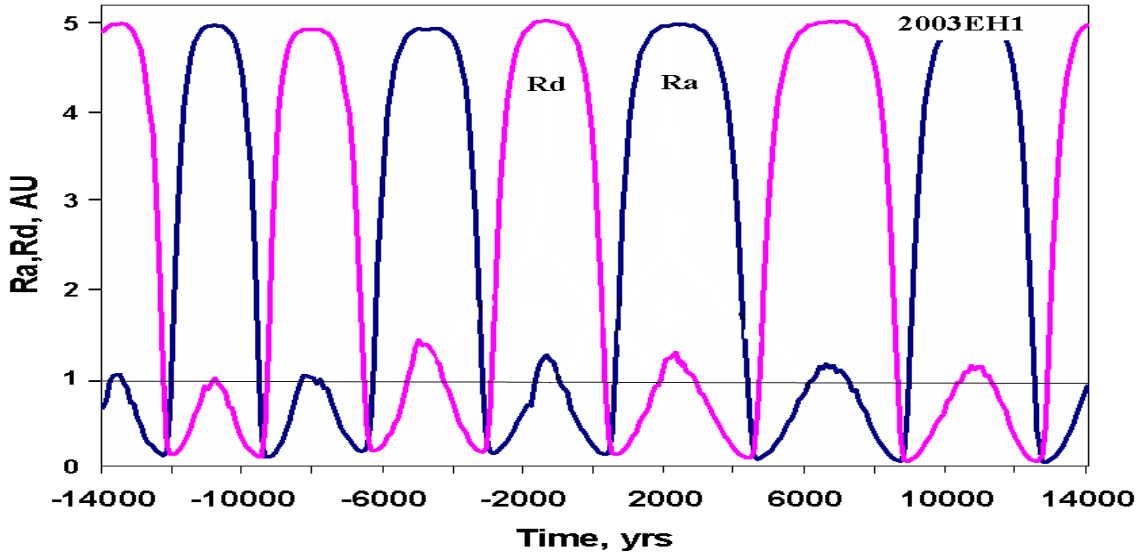
Long-period variations of the eccentricity of the orbits of comet 96P/Machholz 1 and asteroid 2003EH1



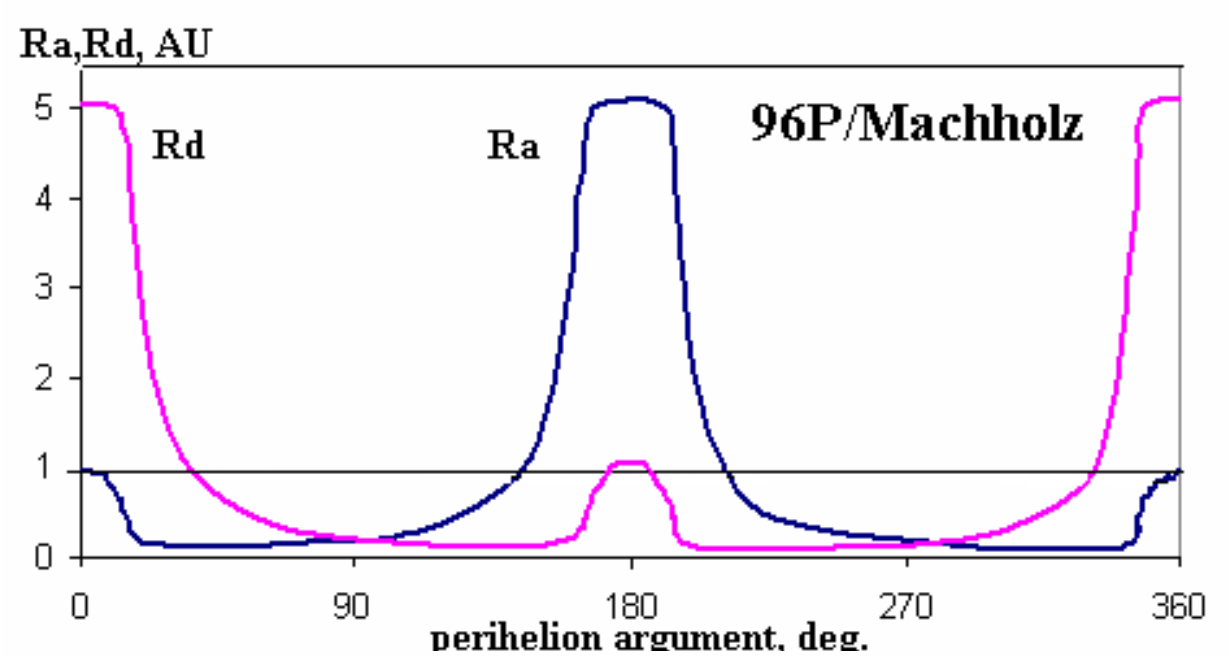
Long-period variations of the inclination and the longitude of perihelion π=ω+Ω of the orbits of comet 96P/Machholz 1 and asteroid 2003EH1

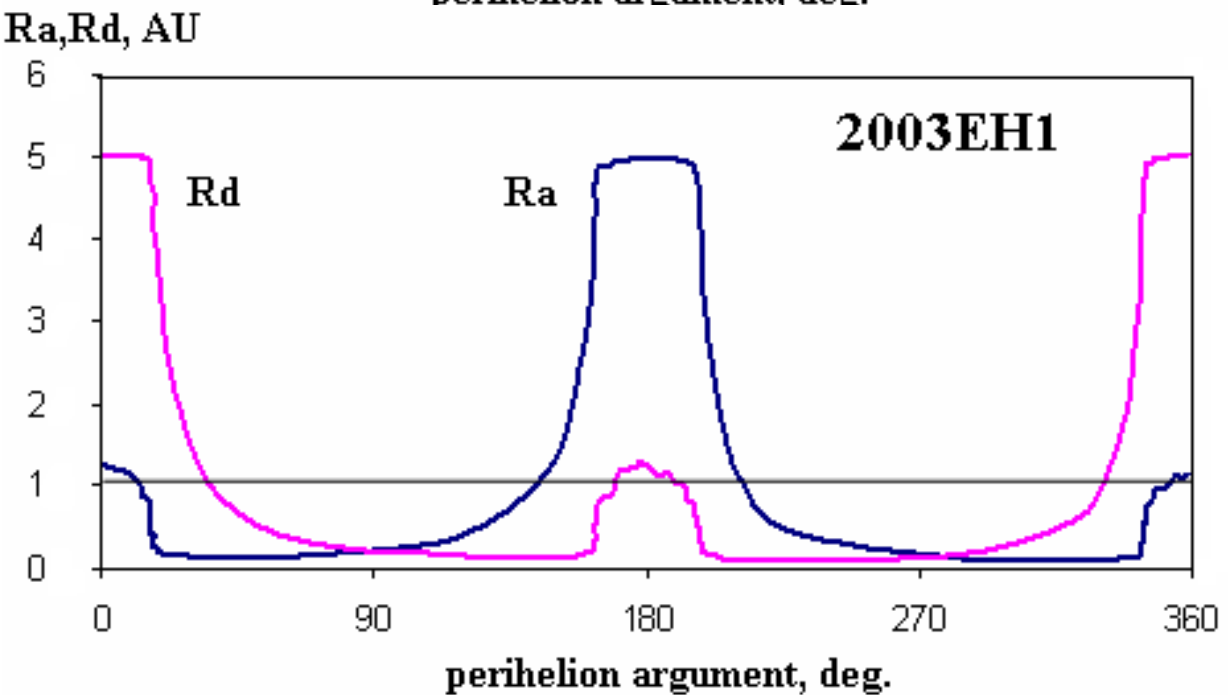
Variations of the objects' nodal heliocentric distances versus time

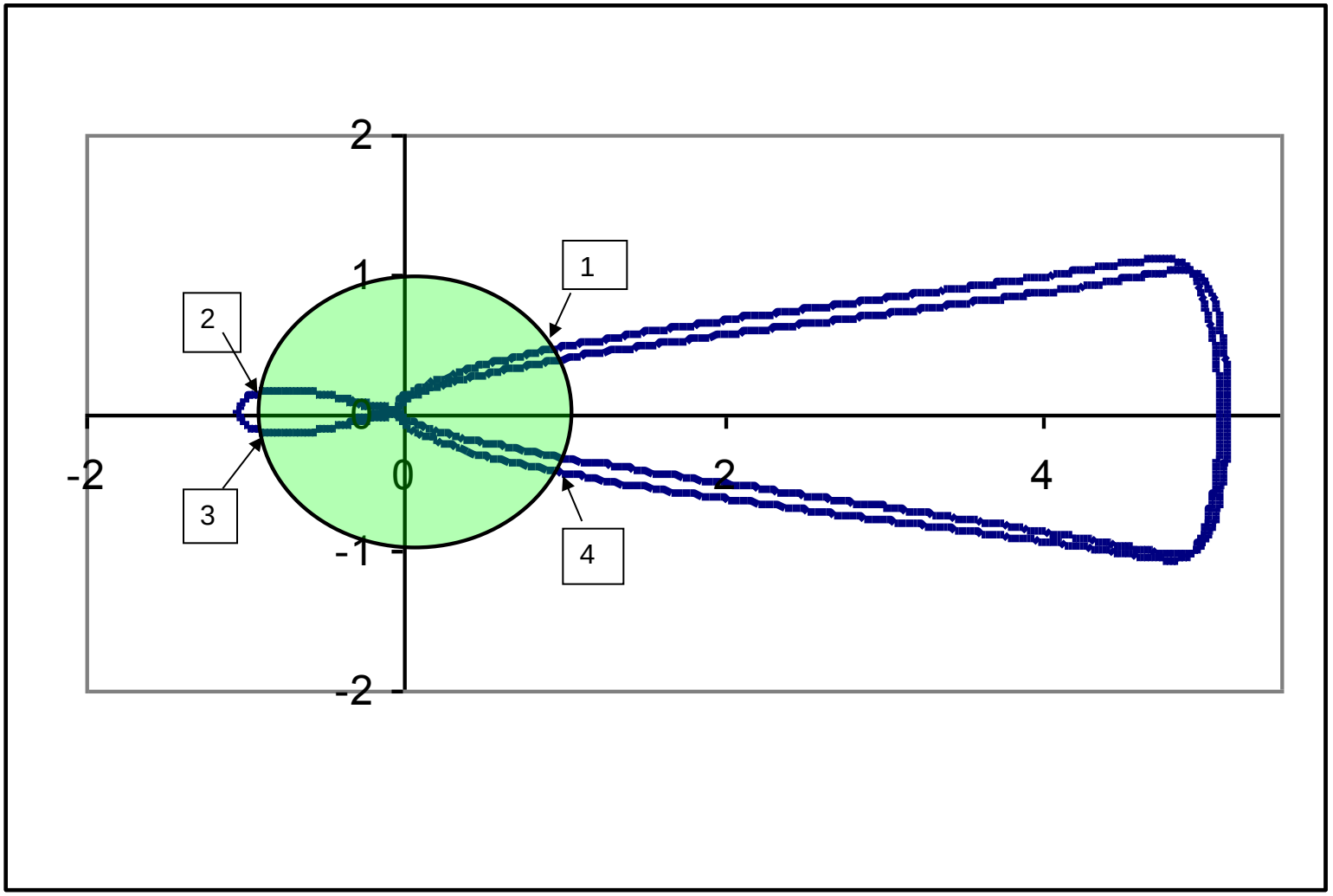




Variations of the objects' nodal heliocentric distances versus ω







One cycle of secular trajectory of the radii-vectors to the ascending and descending nodes of 96P/Machholz and 2003EH1 in ecliptic plane. Green zone - the Earth's orbit

Criteria of orbital similarity

$$D_{S-H}{}^2 = (e_2 - e_1)^2 + (q_2 - q_1)^2 + (2\sin\frac{i_2 - i_1}{2})^2 + \sin i_1 \sin i_2 (2\sin\frac{\Omega_2 - \Omega_1}{2})^2$$

$$+\left[(\frac{e_1 + e_2}{2})2\sin\frac{(\Omega_2 + \omega_2) - (\Omega_1 + \omega_1)}{2}\right]^2,$$

Southworth & Hawkins (1963).

$D_{SH} \leq 0.20$

$$D_r^2 = \left(\frac{e_1 - e_2}{e_1 + e_2} \right)^2 + \left(\frac{q_1 - q_2}{q_1 + q_2} \right)^2 + \left(\frac{I_{1,2}}{180^o} \right)^2 + \left(\frac{e_1 + e_2}{2} \right)^2 \left(\frac{\Theta_{1,2}}{180^o} \right)^2,$$

Drummond (1979, 1981).

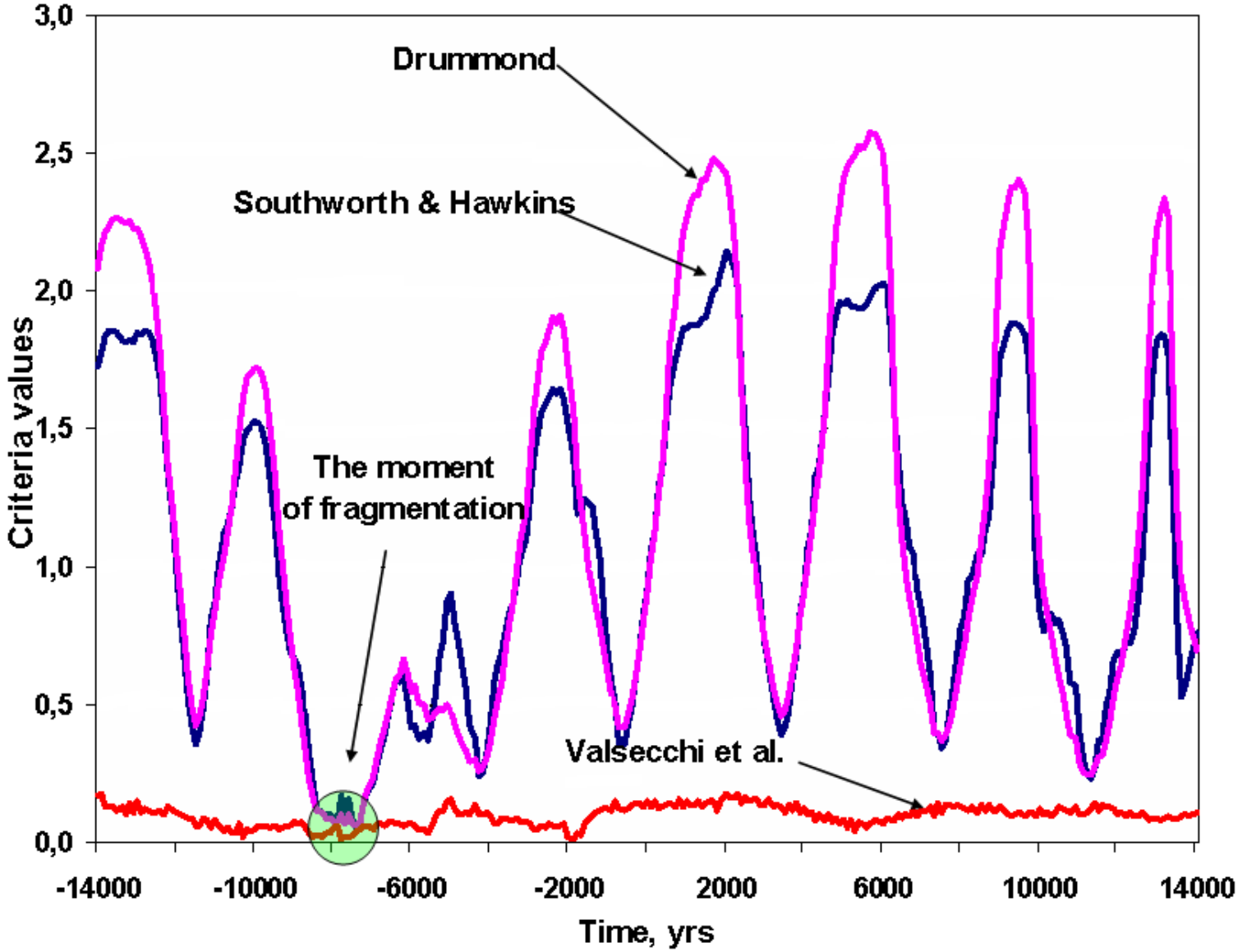
$D_r \leq 0.20$

$$D_N^2 = \left(U_1 - U_2\right)^2 + w_1\left(\cos\theta_1 - \cos\theta_2\right)^2 + \Delta\xi^2$$

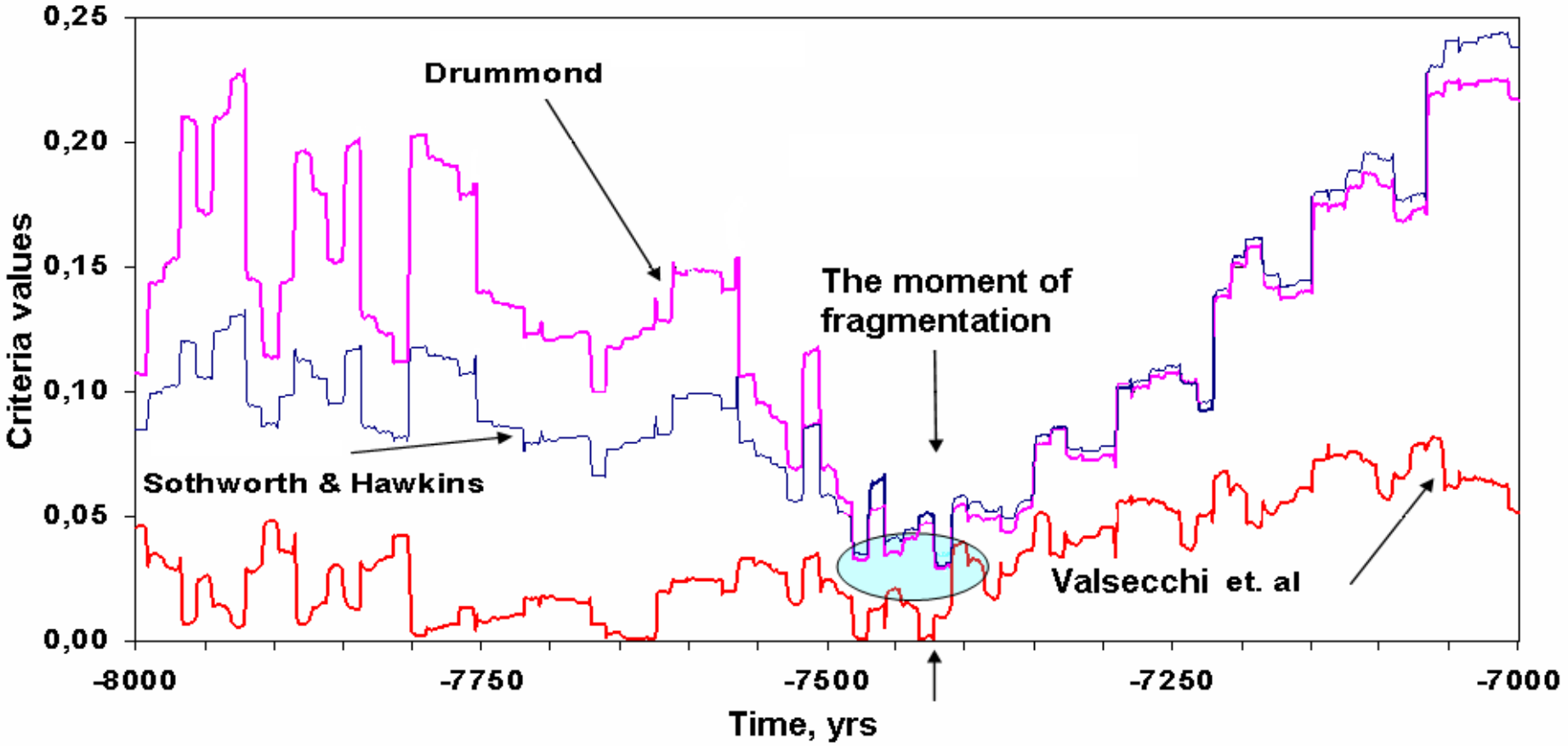
Valsecchi et al (1999)

$$D_R^2 = \left(U_1 - U_2\right)^2 + w_1\left(\cos\theta_1 - \cos\theta_2\right)^2$$

On orbital similarity of comet 96P/Machholz 1 and the object 2003EH1



Variations of the criteria of orbital similarity of comet 96P/Machholz 1 and the object 2003EH1 during 28 kyrs



Large scale variations of criteria in vicinity of their minima at the time interval of 1000 yrs

Orbital elements of comet 96P/Machholz 1 and the object 2003EH1 at 7415 BC (J2000.0)

Object	*a* *(AU)*	*e*	*q (AU)*	*i* *(deg)*	*ω* *(deg)*	Ω *(deg)*	T_j	*DSH*	*Dr*	*DR*
96P/ Machholz1	3.037	0.795	0.622	65.82	13.28	98.56	1.94	0.029	0.059	0.015
2003EH1	3.039	0.798	0.615	65.03	15.55	97.78	1.96			

Conclusions

- Comet 96P/Machholz 1 and NEA 2003EH1 have a common origin.

- A decay of the comet-progenitor of the Quadrantid meteoroid complex into these two large fragments has occurred about 9.5 kyrs backward.

- Asteroid 2003EH1 is in effect an extinct remnant of the parent comet.

- The Quadrantid complex consists of active comet 96P/Machholz 1, inactive comet (186256) 2003EH1 and the Quadrantid meteoroid stream with its eight meteor showers observable on the Earth.

THANKS a LOT for ATTENTION!