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On non–gravitational acceleration in Harrington–Abell comet motion due to Jupiter

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The problem of the tidal forces influence on the cometary nucleus in vicinity of Jupiter is considered. Two effects of particular interest are as follows:

i) The additional warming of the nucleus and, as a consequence, the appearance of the new non–gravitational accelerations in addition to the known Sun–generated effects of this kind;

ii) Partial disintegration of the nucleus and, as a consequence, the instant displacing of the centre of inertia of the latter.

The comet Harrington–Abell is chosen as an object of study. It had the close approach to Jupiter in 1974 and was observed during 3 apparitions before this approach and 4 apparitions after that. The perturbations from eight major planets, the Sun, the second zonal harmonic of the Jovian gravitational field, and from Gallilean satellites of Jupiter when the comet approached Jupiter were taken into account. When numerically integrating the comet equations of motion, the Everhart 11th–order procedure was used. We employed the Encke's transformation. It has been supposed that there exists some additional non–gravitational acceleration in the cometary motion inversely proportional to the squared Jupiter–comet distance:

$$a_i = A_i^J \cdot 1/r_J^2, \quad i = 1, 2.$$

A linkage of the five apparitions within 1968–1999 has been performed. The results of computations are presented in the Table. Here the components of position X, Y, Z (in a.u.), the velocity components V_x, V_y, V_z (in $a.u./day$), and non–gravitational parameters of Style II in Marsden's model [1], A_1, A_2 (in $10^8 a.u./day^2$), the coefficients of proportionality of the additional acceleration A_1^J, A_2^J (in $10^8 a.u./day^2$) are given. The epoch for these parameters is 1.0 December 1978 TDT. The set of parameters obtained allows to represent the positional observations for 5 apparitions with the mean unit weight errors $\sigma = 0.84''$.

Orbital parameters	Values	Errors
$X, a.u.$	0.507251454	.669E-05
Y	−4.638083407	.131E-05
Z	−2.953283821	.149E-05
$V_x, a.u./day$	0.005306157	.245E-08
V_y	−0.001485409	.426E-08
V_z	−0.000530134	.299E-08
$A_1 \cdot 10^8 a.u./day^2$	0.1240	.940E-02
A_2	0.05324	.286E-02
A_1^J	0.04567	.458E-02
A_2^J	−0.07204	.419E-02

Correlation coefficients:

X	Y	Z	V_x	V_y	V_z	A_1	A_2	A_1^J	A_2^J
1.00									
−0.75	1.00								
−0.67	0.58	1.00							
−0.74	0.86	0.88	1.00						
0.98	−0.78	−0.56	−0.67	1.00					
0.96	−0.77	−0.79	−0.81	0.92	1.00				
−0.26	0.11	−0.20	−0.23	−0.39	−0.25	1.00			
0.62	−0.48	−0.78	−0.75	0.45	0.72	0.27	1.00		
0.77	−0.66	−0.87	−0.90	0.63	0.84	0.26	0.94	1.00	
−0.63	0.51	0.79	0.76	−0.47	−0.74	−0.19	−0.99	−0.93	1.00

The coefficients of proportionality as obtained from observations are $(4.75 \pm 0.46) \cdot 10^{-10}$ au/day^2 for the Jupiter–centre radial component of the acceleration and $(-7.20 \pm 0.42) \cdot 10^{-10}$ au/day^2 for the transversal one.

The hypothesis of the partial disintegration of the cometary nucleus at the approach to Jupiter had resulted in displacing the nucleus centre of inertia in the direction of Jupiter at -1.83 ± 0.75 km. It means that the exterior part of cometary nucleus has been broken during approach and went off the nucleus.

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References

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