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Preliminary report

MINIMUM DISTANCES BETWEEN ORBITS OF MINOR PLANETS

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SUMMARY: Minimum mutual distances with upper limits of 0.001, 0.01, and 0.05 AU were determined for 3859 osculating orbits of numbered minor planets. The 21 pairs were found with the minimum distance less than 150 km, among which three with 7, 12, and 13 km only. The minimum distance distribution reveals that pairs with small minimum distance are more numerous than those with large minimum distance. The distribution by longitude is bimodal, with almost identical maxima, but somewhat different minima.

1. INTRODUCTION

The minor planet belt, as a unique structure in the solar system, is in the state of permanent evolution. Study of the features of the distributions of contemporary orbits of minor planets can, therefore, contribute to understanding the origin of these bodies and developing models of future changes on the cosmogonic time scales. Distributions of orbital elements of minor planets possess a number of common characteristics, but there are specific individual orbits and peculiar groups of orbits, too. In order to analyse in more detail some special kinematic characteristics of the minor planet belt, in this paper the mutual distances between orbits of 3859 numbered minor planets (epoch $JD2447400.5$) have been computed in a systematic way. The determination of minimum distances was performed by means of the procedure described in Lazović (1967), which has already been successfully applied for the determination of minimum distances of the quasicoplanar minor planets (Lazović and Kuzmanoski, 1978; 1979). The total of 26 990 pairs with minimum distance $\rho \leq 0.001\,AU$ was found, as well as 259 139 pairs with $\rho \leq 0.01\,AU$, and 1 097 459 pairs with $\rho \leq 0.05\,AU$.

2. MINIMUM DISTANCES

Orbits of minor planets are continuously changing due to the major planets perturbations, but it is nevertheless interesting to see what are the current minimum distances of these orbits determined by their contemporary osculating elements. The smallest so far known mutual distance of two orbits of $0.000004\,AU$ has been found by Lazović and Kuzmanoski (1978) for the pair (215, 1851). It was, hence, somewhat surprising to find in this analysis as much as 92 pairs of orbits with minimum distance of

Table 1.

j	k	ρ(AU)	ρ(km)	I	$\Delta\Omega$
319	1525	.00000059	88	12.377	92.819
321	2155	.00000028	42	.089	1.585
486	3062	.00000020	31	3.179	16.361
643	1118	.00000100	150	15.137	66.640
666	3037	.00000057	85	22.439	107.616
755	2452	.00000069	103	15.026	174.067
770	1858	.00000094	141	5.640	132.467
805	3458	.00000033	50	13.618	10.220
842	885	.00000100	150	17.371	143.105
900	1375	.00000058	86	15.937	129.975
960	1666	.00000073	109	.772	13.994
1165	2740	.00000088	131	3.600	5.512
1169	1810	.00000066	98	.071	.975
1216	3057	.00000068	102	5.838	46.244
1523	2575	.00000005	7	.682	5.823
1814	2693	.00000020	29	4.818	39.505
2122	2850	.00000023	34	.093	.615
2168	2928	.00000037	55	4.804	3.233
2198	3652	.00000008	12	1.768	22.329
2316	3336	.00000088	132	2.061	94.014
2519	3183	.00000082	122	1.773	44.923
2620	3409	.00000044	66	4.238	138.338
3174	3380	.00000009	13	1.321	20.702
3239	3520	.00000097	145	2.430	28.928

Table 2.

j	k	ρ_1(AU)	ρ_2(AU)	I	$\Delta\Omega$
68	464	.0000133	.0004771	9.004	58.250
78	1426	.0000331	.0000707	.456	1.730
158	2555	.0005952	.0000848	.135	5.401
171	2039	.0000053	.0002773	.203	4.583
187	3238	.0000606	.0001687	2.318	10.528
364	1449	.0000061	.0006537	.855	5.236
376	3517	.0000079	.0009643	7.334	114.893
505	521	.0000243	.0002306	.785	1.079
637	2882	.0000402	.0004726	.194	39.795
664	3189	.0000213	.0008127	.474	1.969
669	1410	.0009498	.0000357	.435	.436
707	1147	.0002976	.0000242	1.247	16.717
767	3276	.0000561	.0004297	.472	8.863
846	2524	.0002974	.0000743	.083	16.582
857	1663	.0002083	.0000575	.071	.348
988	3832	.0009115	.0000125	.605	13.450
993	1635	.0000696	.0002257	.040	.225
1153	3397	.0000665	.0005377	23.091	105.304
1259	3174	.0003396	.0000691	.115	2.763

Tabele 2. (continue)

j	k	ρ_1(AU)	ρ_2(AU)	I	$\Delta\Omega$
1446	3034	.0000410	.0000465	.689	6.811
1486	3356	.0000348	.0005021	4.149	134.827
1699	3732	.0003260	.0000525	.440	4.702
1762	3516	.0001487	.0000535	.061	1.086
1896	3005	.0006527	.0000779	.231	4.622
1929	3006	.0006168	.0000346	6.623	56.946
2156	3221	.0000671	.0002576	4.825	61.483
2197	2657	.0005748	.0000438	.387	6.670
2225	3032	.0003164	.0000304	.041	.254
2283	3385	.0007984	.0000399	.128	.877
2458	3010	.0001398	.0000775	.057	1.363
2528	2534	.0006153	.0000901	.304	5.403
3218	3331	.0001605	.0000825	1.174	15.015
3291	3785	.0000832	.0006807	.083	.444
3589	3739	.0000973	.0007243	.227	2.022
3777	3840	.0000921	.0009054	.409	4.280

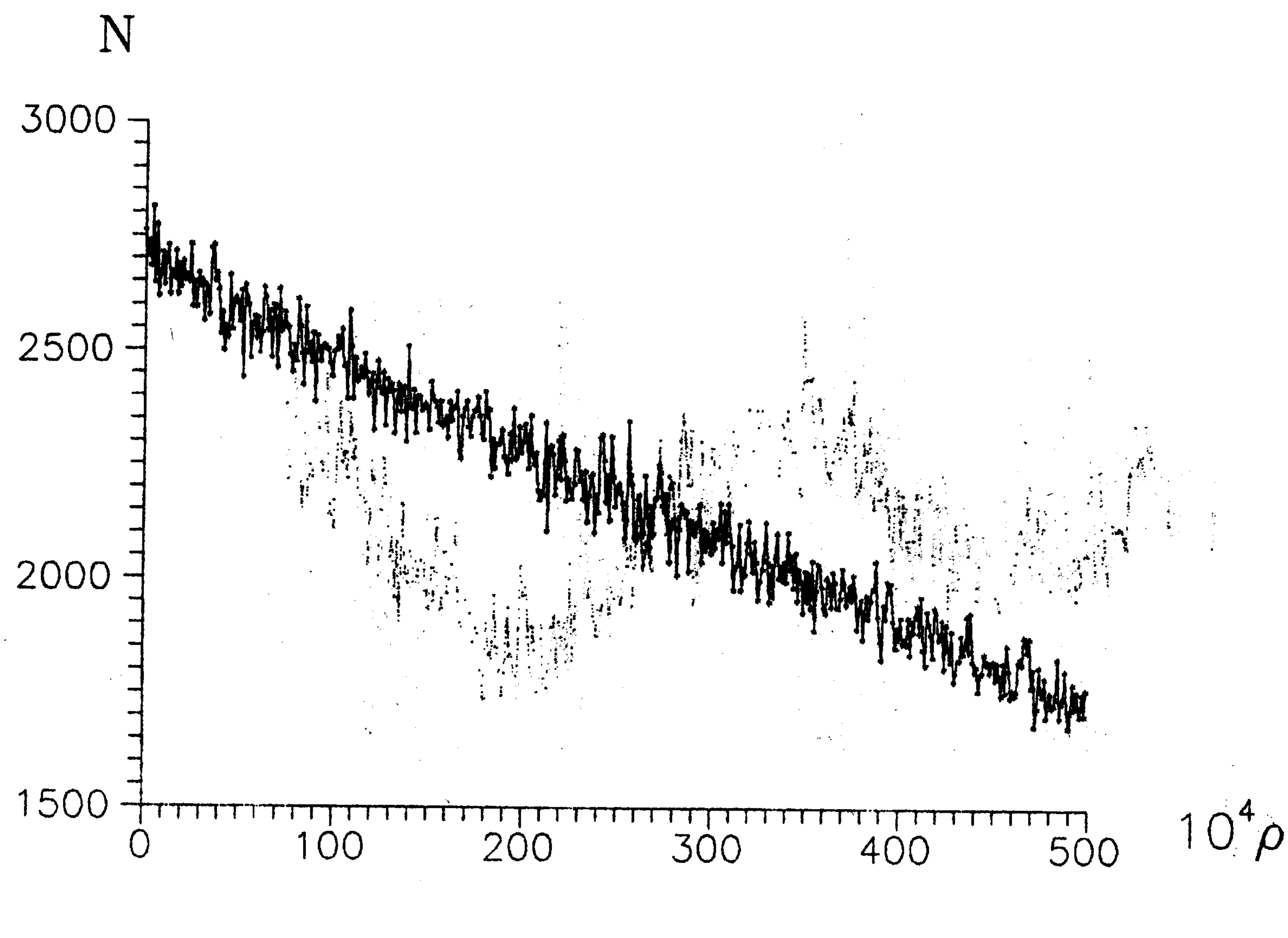
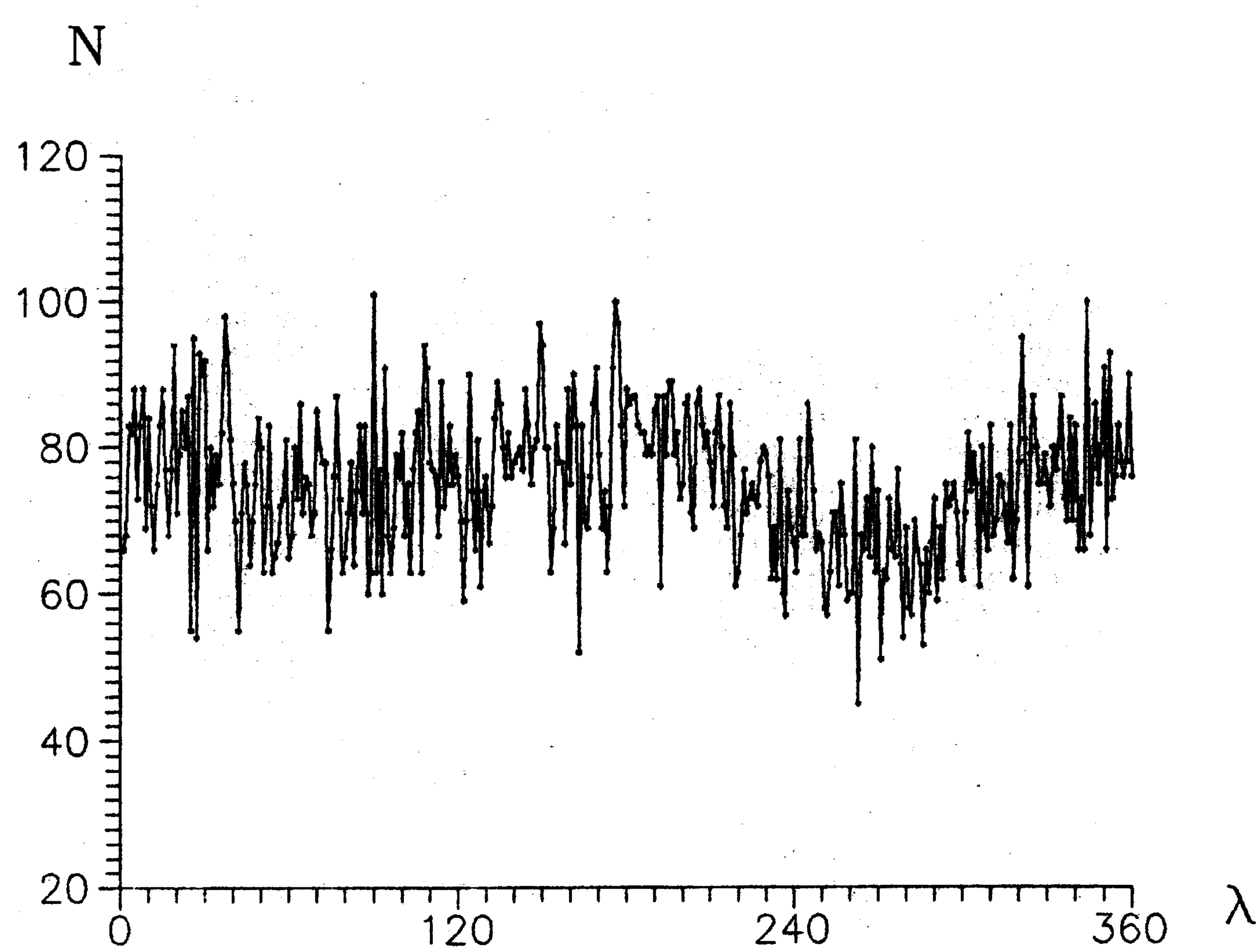


Fig. 1.


N
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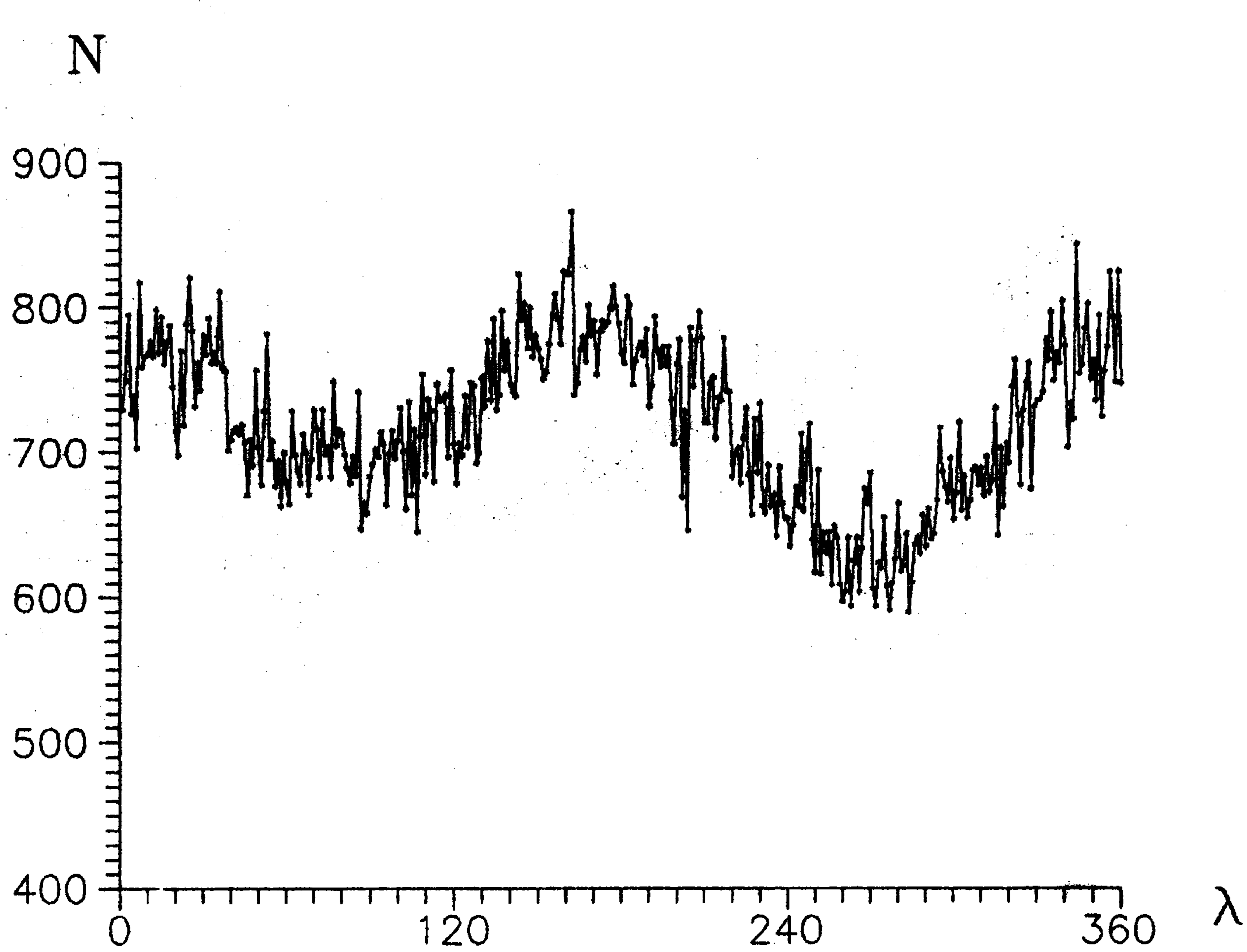
100
80
60
40
20
0
120
240
360
λ

Fig. 2.


N
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800
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600
500
400
0
120
240
360
λ

Fig. 3.

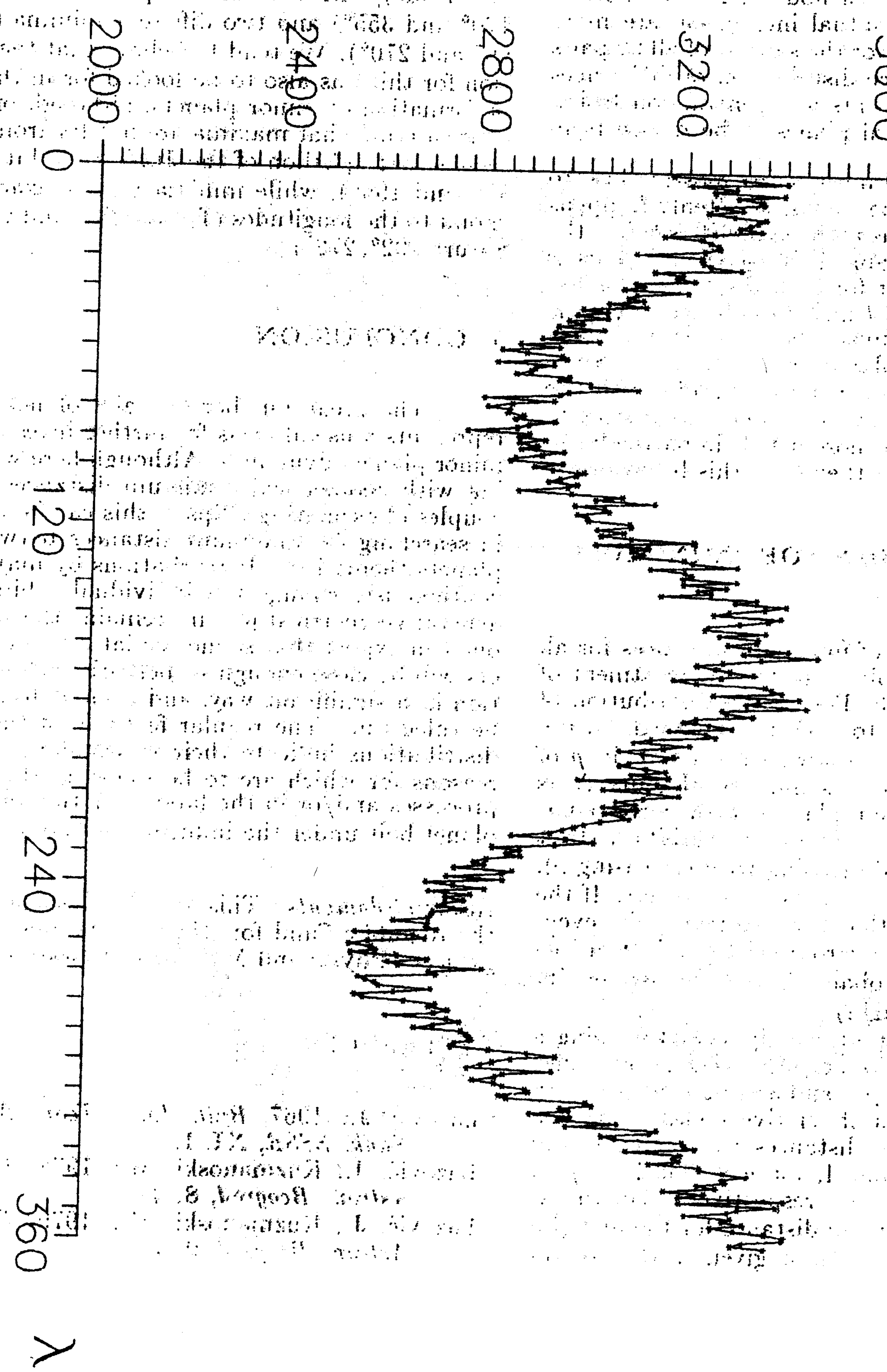

Fig. 4.

7 km only, (2198, 3652) with 12 km, and (3174, 3380) with 13 *km*. In the table are besides given the mutual inclination of the orbital planes I and the difference of the longitudes of node $\Delta\Omega$. One notices that pairs with small mutual inclination are more frequent, and this holds for the sample of all 92 pairs as well. However, chance distribution of differences of nodal longitudes prevents any general conclusion on the position of orbital planes to be drawn from these data.

As minimum distances occur mostly close to the relative nodes of the orbits, it oftenly happens that a particular pair has both proximities below the given upper limit. In Table 2 list of 35 such pairs is shown, with upper limit for both distances of 0.001 AU. From the values of I and $\Delta\Omega$ one can conclude that having both proximities below a given limit is typical of the quasicoplanar minor planets. Since the number of such pairs increases rapidly with the increase of the upper limit, it could be interesting to investigate such pairs in more detail, in particular to find out for how long do they keep this behaviour.

3. DISTRIBUTION OF MINIMUM DISTANCES

A great number of minimum distances for all three upper limits enables a statistical treatment of the obtained results. In Fig. 1 the distribution of minimum distances up to $0.05\,AU$ is shown; on the x-axis $\rho \cdot 10^4$ values are shown with a step in ρ of $0.0001\,AU$, while on y-axis number of pairs N is given of orbits of minor planets with corresponding minimum distances. The plot exhibits a strict linear dependence (N decreasing with increasing ρ), which is, at first sight, an unexpected result. If the future analyses prove that the observed pairs eventually form some distinct groups (let's call them "arrays"), this fact will probably have to be ascribed to cosmogonic causes (origin).

Longitudes of points on the orbits forming a pair, that correspond to a minimum distance, differ very little due to small ρ's, and are, in principle, very close to the longitudes of relative nodes. The distributions of minimum distances by longitudes are shown on Figs. 2,3 and 4, for $\rho \leq 0.001\,AU, \rho \leq 0.01\,AU,$ and $\rho \leq 0.05\,AU$, respectively. On the x-axes longitude of minimum distance for the first (lower number) orbit in a pair is given, with a corresponding number of pairs on the y-axes. The bimodal distribution is clearly seen in all the plots (that for $\rho \leq 0.001\,AU$ having a somewhat smaller amplitude), with two almost equal maxima (at about 170° and 355°) and two different minima (at about 90° and 270°). We tend to believe that the explanation for this has also to be looked for in the process of formation of minor planets, although one should bear in mind that maxima are not far from the perihelion and aphelion of the Jupiter's orbit (being at 15° and 195°), while minima almost exactly correspond to the longitudes of perihelion and aphelion of Saturn (92°, 272°).

4. CONCLUSION

The great number of pairs of nearby orbits represents a useful basis for further investigations of minor planets dynamics. Although here we are dealing with geometrical minimum distances between couples of osculating ellipses, this can be a first step in searching for minimum distances between minor planets themselves. Perturbations by major planets continuously change the individual orbits, but the general geometrical picture remains the same; thus, one can expect that sooner or later two minor planets will be close enough to perturb each other's motion in a significant way, and even collisions cannot be ruled out. The regular features of the obtained distributions indicate their nonrandom nature, the reasons for which are to be found in the formation processes and/or in the later evolution of the minor planet belt under the influence of major planets.

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REFERENCES:

Lazović, J.: 1967, *Bull. Inst. Teor. Astr. Akad. Nauk. SSSR*, **XI**, 1, 57.

Lazović, J., Kuzmanoski, M.: 1978, *Publ. Dept. Astron. Beograd*, **8**, 47.

Lazović, J., Kuzmanoski, M.: 1979, *Publ. Dept. Astron. Beograd*, **9**, 49.

МИНИМАЛНЕ ДАЉИНЕ ИЗМЕЂУ ПУТАЊА МАЛИХ ПЛАНЕТА

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УДК 521.4
Претходно саопштење

За 3859 оскулаторних путања малих планета одређене су њихове међусобне минималне даљине са горњим границама од 0.001, 0.01 и 0.05AU. Нађен је 21 пар са међусобним растојањима мањим од 150km, од којих три пара са 7, 12 и 13km. Расподела минималних даљина показује да је број парова путања са мањим међусобним даљинама већи од броја парова путања са већим међусобним даљинама. Лонгитудинална расподела минималних даљина је бимодална, са два скоро идентична максимума и два нешто различита минимума.