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48. *Tsunami in the Vicinity of a Wave Origin [IV].*

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Abstract

Numerical calculations of the tsunamis in the near-field are carried out using Filon's method for the range $r^*=50$ to 100, where $r^*=r/H$ (r: a distance from a center of the wave origin, H: a sea depth).

We then discover a very important fact that the tsunamis which occurred in the surrounding seas of Japan must be discussed under the weight of the long wave approximation and that the asymptotic theory cannot be applied to such tsunamis.

1. Introduction

In a series of papers[1),2),3)] entitled "Tsunami in the Vicinity of a Wave Origin", the behaviors of tsunamis in the near-field have been inquired into by use of an electronic computer. Simpson's method of integration was adopted for the first two papers and Filon's for the third. In this paper, further calculations are carried out by Filon's method using an electronic computer.

2. Numerical Calculation and Discussion

When a circular portion of the sea bottom is upheaved instantaneously, the wave heights of the generated tsunamis are expressed as follows[1)]:—

$$\zeta_R=a^*\int_0^\infty \frac{\cos \omega^* t^*}{\cosh k^*} J_0(k^* r^*) J_1(k^* a^*) dk^* , \tag{1}$$

where the same notations are used as those in the previous study[1)].

The actual calculations of the integration (1) were made for the

1) T. MOMOI, *Bull. Earthq. Res. Inst.*, **42** (1964), 133-146.
2) T. MOMOI, *Bull. Earthq. Res. Inst.*, **42** (1964), 369-381.
3) T. MOMOI, *Bull. Earthq. Res. Inst.*, **43** (1965), 53-93.

range $r^*=50\sim100$ based on Filon's method, of which the technical procedure was detailed in the third work[3] of the foregoing papers. The computed values are tabulated in Table 1 and these variations are visualized figuratively in Fig. 1 (then a^* is set equal to 10).

In solving the integration (1) analytically, we have two methods available[4]. One is a method involving a long wave approximation which is carried through the approximation

$$k^*(=kH)\ll 1$$

and the other is made by use of an asymptotic expression of the Bessel function, i.e.

$$J_n(z)\approx\sqrt{\frac{2}{\pi z}}\cos\left(z-\frac{2n+1}{4}\pi\right).$$

If one uses the former approximation (a shallow water approximation), the first crest only is seen to appear[4], the other crest being suppressed. On the other hand, the use of the latter approximation yields a result[4] such that the second crest instead of the first one is the most significant in height among the crests appearing.

Passing through all the figures in Fig. 1, it is readily seen that the first crest is more remarkable in height than any other crest succeeding it. In the previous studies[1),2),3)], a similar fact (a predominance of the first crest) was observed, of which the paper treated the tsunamis in the nearer distance from a wave origin than the present work.

The depths of the wave origins of the near-field tsunamis, which occurred in the surrounding seas of Japan, might be considered to be about 4000 m or less, with radial size of the origins being about 50 to 100 km. Hence the value of a^* (equal to the ratio of the radial size (a) and the sea depth (H) of the wave origin) is interpreted to be about 10 to 25. In our model, the calculations were carried out for the specified value of $a^*=10$. Therefore, the scale of the wave source in the calculation is considered to be rather small than in the actual tsunamis. For the values larger than $a^*=10$, a characteristic feature of predominance of the first crest is expected to begin being more remarkable than that seen in the figures presented so far[1),2),3)].

Though we take the simplest model here so far as such a model does not destroy its consistency with an actual situation, the results obtained in a series of studies are considered to be still in use for the

4) R. Takahashi, *Bull. Earthq. Res. Inst.*, **20** (1942), 375.

explanation of the fundamental characteristics of the waves in the near-field tsunamis. Computations have been made for positions up to the range $r^*(=r/H)=100$, of which the distance is ten times the radius of the wave origin, i.e., $r=10a$. Supposing that a half horizontal size of the actual tsunamis is 100 km, the above upper range of the distance corresponds to 1000 km. It must be noticed here that the near-field tsunamis that occurred in the surrounding seas of Japan in the past are located so close to the coasts that the distances of the centers of the wave origins from the coasts fall in the range less than 1000 km.

From the fact mentioned above and the result obtained after numerical calculations, we have come to the very important conclusion that, *for the near-field tsunamis that occurred around the Japan Islands, a theory of a long wave approximation is more useful and superior than that derived under the approximation by use of an asymptotic expression of the Bessel functin.*

Table 1. Variation of the tsunami heights ζ_R in the near-field*).

r^* \ t^*	41	42	43	44	45	46
50.0	0.0982	0.1313	0.1655	0.1955	0.2154	0.2199
52.5	0.0371	0.0561	0.0807	0.1104	0.1429	0.1744
55.0	0.0110	0.0183	0.0293	0.0450	0.0660	0.0921
57.5	0.0027	0.0048	0.0085	0.0143	0.0233	0.0361
60.0	0.0005	0.0011	0.0020	0.0037	0.0066	0.0112
62.5	0.0000	0.0002	0.0004	0.0008	0.0016	0.0029
65.0	0.0000	0.0000	0.0001	0.0002	0.0003	0.0006
70.0	0.0000	0.0000	0.0000	0.0000	0.0001	0.0001
72.5	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

r^* \ t^*	47	48	49	50	51	52
50.0	0.2061	0.1753	0.1344	0.0939	0.0640	0.0503
52.5	0.1998	0.2132	0.2106	0.1906	0.1565	0.1157
55.0	0.1221	0.1533	0.1815	0.2016	0.2085	0.1993
57.5	0.0537	0.0763	0.1034	0.1331	0.1623	0.1865
60.0	0.0183	0.0288	0.0435	0.0629	0.0868	0.1143
62.5	0.0051	0.0088	0.0145	0.0230	0.0351	0.0515
65.0	0.0012	0.0022	0.0040	0.0069	0.0114	0.0183
67.5	0.0002	0.0005	0.0009	0.0018	0.0031	0.0054
70.0	0.0000	0.0001	0.0002	0.0004	0.0007	0.0014
72.5	0.0000	0.0000	0.0000	0.0001	0.0002	0.0003
75.0	0.0000	0.0000	0.0000	0.0000	0.0000	0.0001

r^* \ t^*	53	54	55	56	57	58
50.0	0.0508	0.0558	0.0521	0.0303	−0.0092	−0.0561
52.5	0.0785	0.0535	0.0442	0.0464	0.0497	0.0421
55.0	0.1742	0.1378	0.0982	0.0648	0.0446	0.0390
57.5	0.2010	0.2015	0.1863	0.1571	0.1195	0.0820
60.0	0.1431	0.1696	0.1894	0.1980	0.1924	0.1719
62.5	0.0724	0.0973	0.1247	0.1519	0.1751	0.1900
65.0	0.0283	0.0421	0.0601	0.0822	0.1076	0.1343
67.5	0.0090	0.0146	0.0228	0.0343	0.0496	0.0691
70.0	0.0024	0.0042	0.0071	0.0116	0.0183	0.0278
72.5	0.0006	0.0010	0.0019	0.0033	0.0056	0.0092
75.0	0.0002	0.0002	0.0005	0.0009	0.0015	0.0026

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r^* \ t^*	59	60	61	62	63	64
50.0	−0.0953	−0.1168	−0.1217	−0.1203	−0.1230	−0.1307
52.5	0.0165	−0.0245	−0.0698	−0.1052	−0.1225	−0.1239
55.0	0.0421	0.0431	0.0314	0.0025	−0.0393	−0.0824
57.5	0.0528	0.0372	0.0345	0.0376	0.0358	0.0202
60.0	0.1397	0.1021	0.0673	0.0425	0.0311	0.0305
62.5	0.1928	0.1814	0.1565	0.1223	0.0856	0.0542
65.0	0.1593	0.1786	0.1884	0.1855	0.1689	0.1405
67.5	0.0921	0.1175	0.1429	0.1651	0.1801	0.1846
70.0	0.0408	0.0577	0.0783	0.1019	0.1267	0.1503
72.5	0.0147	0.0226	0.0335	0.0479	0.0661	0.0876
75.0	0.0044	0.0074	0.0118	0.0182	0.0273	0.0397

r^* \ t^*	65	66	67	68	69	70
50.0	−0.1330	−0.1164	−0.0773	−0.0285	0.0067	0.0173
52.5	−0.1197	−0.1193	−0.1229	−0.1207	−0.0974	−0.0593
55.0	−0.1137	−0.1265	−0.1243	−0.1174	−0.1163	−0.1147
57.5	−0.0116	−0.0537	−0.0939	−0.1205	−0.1292	−0.1243
60.0	0.0328	0.0279	0.0084	−0.0257	−0.0659	−0.1027
62.5	0.0338	0.0261	0.0268	0.0275	0.0191	−0.0038
65.0	0.1054	0.0704	0.0427	0.0265	0.0207	0.0223
67.5	0.1762	0.1551	0.1242	0.0891	0.0568	0.0328
70.0	0.1691	0.1796	0.1788	0.1654	0.1415	0.1087
72.5	0.1113	0.1351	0.1562	0.1712	0.1761	0.1706
75.0	0.0555	0.0748	0.0968	0.1201	0.1418	0.1600

r^* \ t^*	71	72	73	74	75	76
50.0	0.0059	−0.0132	−0.0276	−0.0352	−0.0409	−0.0461
52.5	−0.0159	0.0144	0.0198	0.0037	−0.0189	−0.0343
55.0	−0.1067	−0.0836	−0.0454	−0.0045	0.0213	0.0218
57.5	−0.1149	−0.1082	−0.1036	−0.0934	−0.0697	−0.0333
60.0	−0.1251	−0.1297	−0.1215	−0.1096	−0.1007	−0.0935
62.5	−0.0395	−0.0797	−0.1124	−0.1290	−0.1279	−0.1156
65.0	0.0216	0.0103	−0.0153	−0.0522	−0.0908	−0.1196
67.5	0.0203	0.0177	0.0187	0.0151	−0.0001	−0.0288
70.0	0.0737	0.0435	0.0232	0.0144	0.0141	0.0150
72.5	0.1534	0.1261	0.0929	0.0599	0.0331	0.0165
75.0	0.1712	0.1725	0.1622	0.1405	0.1104	0.0768

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r^* \ t^*	77	78	79	80	81	82
50.0	−0.0435	−0.0266	−0.0010	0.0153	0.0104	−0.0171
52.5	−0.0393	−0.0397	−0.0398	−0.0357	−0.0213	0.0015
55.0	0.0011	−0.0248	−0.0412	−0.0439	−0.0398	−0.0348
57.5	0.0035	0.0246	0.0207	−0.0028	−0.0306	−0.0468
60.0	−0.0808	−0.0559	−0.0210	0.0116	0.0282	0.0194
62.5	−0.1015	−0.0912	−0.0829	−0.0692	−0.0448	−0.0118
65.0	−0.1312	−0.1256	−0.1099	−0.0936	−0.0818	−0.0721
67.5	−0.0663	−0.1012	−0.1245	−0.1301	−0.1201	−0.1021
70.0	0.0090	−0.0097	−0.0410	−0.0781	−0.1095	−0.1275
72.5	0.0103	0.0105	0.0096	0.0004	−0.0219	−0.0538
75.0	0.0458	0.0228	0.0104	0.0073	0.0076	0.0042

r^* \ t^*	83	84	85	86	87	88
50.0	−0.0406	−0.0410	−0.0219	−0.0027	0.0031	−0.0010
52.5	0.0163	0.0087	−0.0175	−0.0411	−0.0420	−0.0213
55.0	−0.0285	−0.0157	0.0021	0.0134	0.0060	−0.0181
57.5	−0.0467	−0.0375	−0.0282	−0.0207	−0.0107	0.0022
60.0	−0.0078	−0.0364	−0.0509	−0.0475	−0.0342	−0.0216
62.5	0.0172	0.0282	0.0151	−0.0139	−0.0418	−0.0538
65.0	−0.0574	−0.0332	−0.0032	0.0209	0.0265	0.0098
67.5	−0.0848	−0.0721	−0.0614	−0.0462	−0.0230	0.0037
70.0	−0.1278	−0.1138	−0.0937	−0.0755	−0.0624	−0.0511
72.5	−0.0886	−0.1162	−0.1287	−0.1239	−0.1063	−0.0845
75.0	−0.0087	−0.0331	−0.0656	−0.0980	−0.1210	−0.1279

r^* \ t^*	80	81	82	83	84	85
75.0	0.0073	0.0076	0.0042	−0.0087	−0.0331	−0.0656
77.5	0.0343	0.0145	0.0049	0.0033	0.0037	−0.0011
80.0	0.1117	0.0798	0.0488	0.0238	0.0081	0.0017
82.5	0.1607	0.1488	0.1270	0.0978	0.0657	0.0362
85.0	0.1456	0.1565	0.1597	0.1534	0.1373	0.1127
87.5	0.0968	0.1163	0.1342	0.1483	0.1562	0.1558
90.0	0.0502	0.0671	0.0858	0.1052	0.1237	0.1393
92.5	0.0213	0.0306	0.0426	0.0573	0.0743	0.0928
95.0	0.0082	0.0115	0.0168	0.0245	0.0353	0.0488
97.5	0.0028	0.0046	0.0071	0.0103	0.0147	0.0210
100.0	0.0005	0.0016	0.0029	0.0043	0.0059	0.0082

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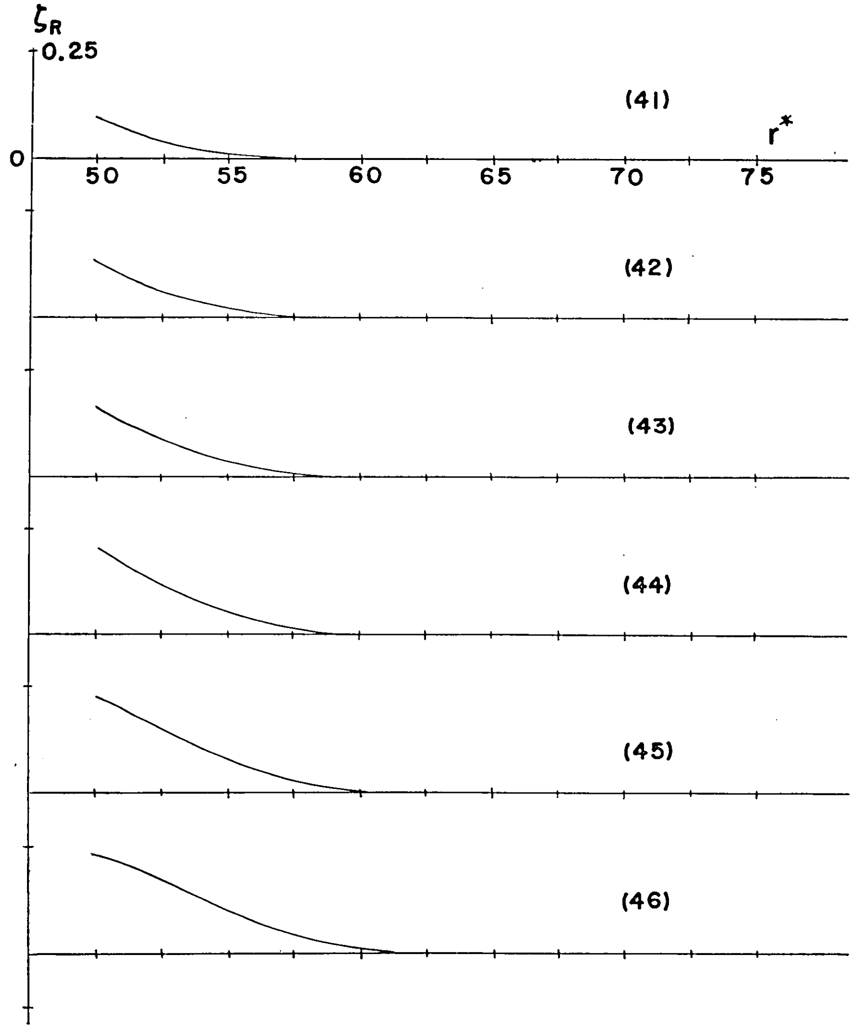
r^* \ t^*	86	87	88	89	90	91
75.0	−0.0980	−0.1210	−0.1279	−0.1176	−0.0964	−0.0731
77.5	−0.0165	−0.0432	−0.0764	−0.1069	−0.1254	−0.1265
80.0	0.0011	0.0000	−0.0079	−0.0267	−0.0552	−0.0872
82.5	0.0140	0.0016	−0.0023	−0.0019	−0.0041	−0.0146
85.0	0.0828	0.0521	0.0255	0.0069	−0.0025	−0.0050
87.5	0.1458	0.1262	0.0991	0.0682	0.0386	0.0148
90.0	0.1500	0.1538	0.1491	0.1354	0.1133	0.0852
92.5	0.1117	0.1289	0.1427	0.1507	0.1511	0.1424
95.0	0.0649	0.0827	0.1010	0.1185	0.1334	0.1441
97.5	0.0296	0.0409	0.0551	0.0715	0.0895	0.1076
100.0	0.0117	0.0169	0.0244	0.0346	0.0476	0.0628

r^* \ t^*	92	93	94	95	96	97
75.0	−0.0551	−0.0436	−0.0339	−0.0204	−0.0022	0.0150
77.5	−0.1113	−0.0872	−0.0631	−0.0455	−0.0345	−0.0255
80.0	−0.1135	−0.1260	−0.1210	−0.1018	−0.0762	−0.0530
82.5	−0.0359	−0.0655	−0.0962	−0.1187	−0.1257	−0.1153
85.0	−0.0054	−0.0099	−0.0232	−0.0465	−0.0757	−0.1033
87.5	−0.0002	−0.0065	−0.0072	−0.0081	−0.0149	−0.0312
90.0	0.0552	0.0276	0.0066	−0.0056	−0.0101	−0.0106
92.5	0.1248	0.0998	0.0706	0.0414	0.0165	−0.0007
95.0	0.1485	0.1453	0.1334	0.1134	0.0871	0.0578
97.5	0.1243	0.1375	0.1454	0.1462	0.1388	0.1231
100.0	0.0795	0.0969	0.1137	0.1282	0.1389	0.1439

r^* \ t^*	98	99
75.0	0.0221	0.0103
77.5	−0.0133	0.0023
80.0	−0.0371	−0.0276
82.5	−0.0922	−0.0650
85.0	−0.1206	−0.1219
87.5	−0.0565	−0.0856
90.0	−0.0127	−0.0216
92.5	−0.0096	−0.0120
95.0	0.0298	0.0071
97.5	0.1003	0.0728
100.0	0.1417	0.1314

*) The precision of the integrated values is four numerals below the decimal point, of which the examination is made by integrations with a doubled number of divisions.

Fig. 1. Variations of the wave heights of the near-field tsunamis.
(the value stated in the brackets stands for the time parameter t*).



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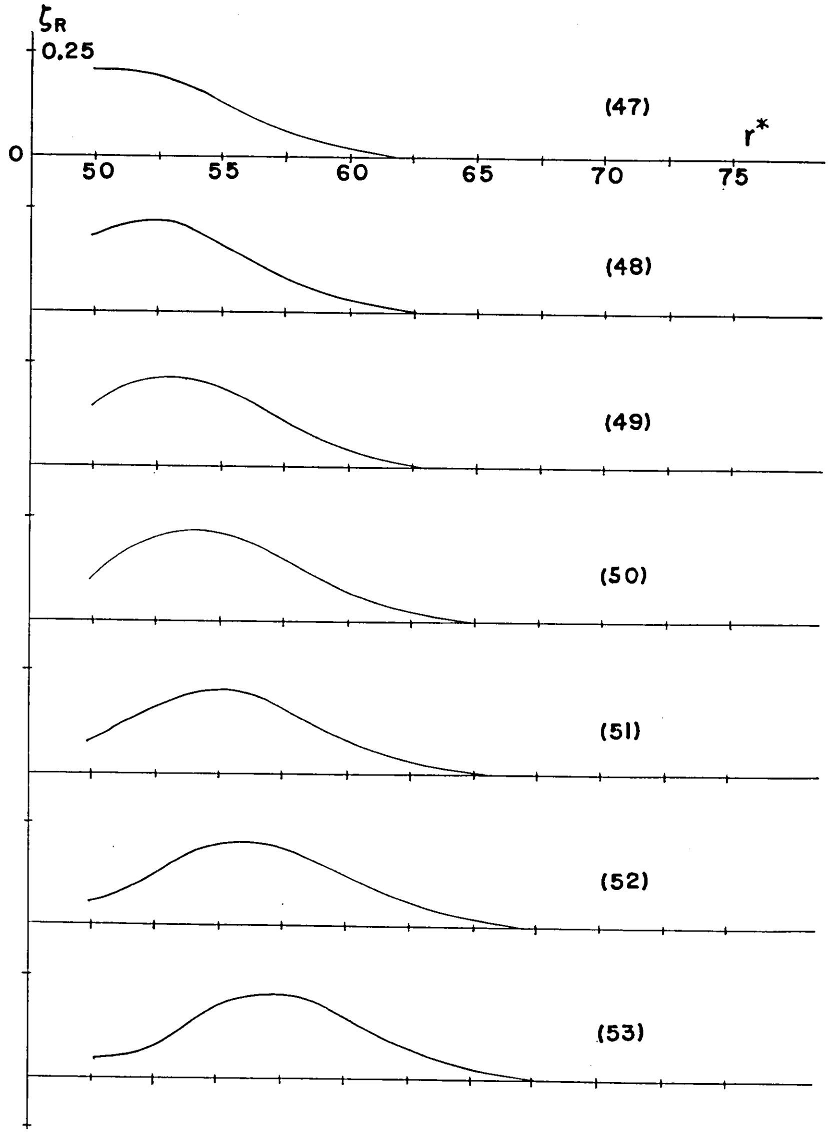

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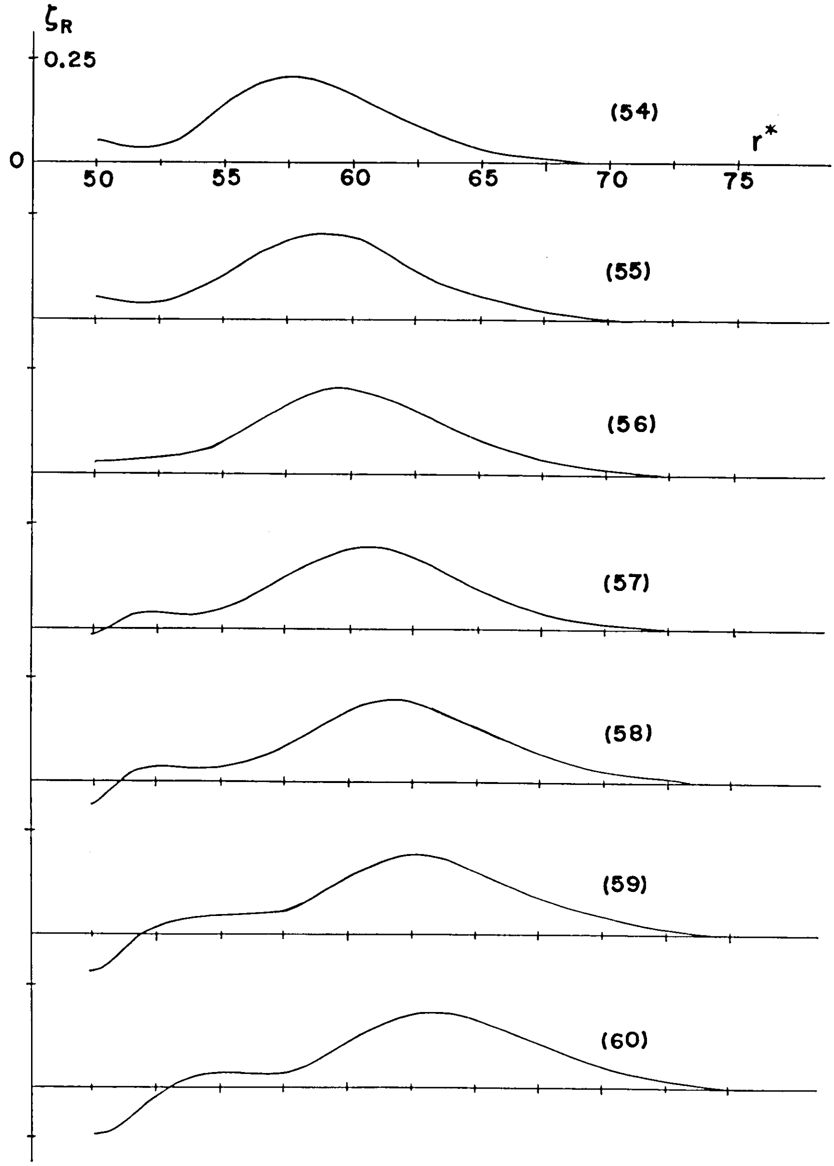

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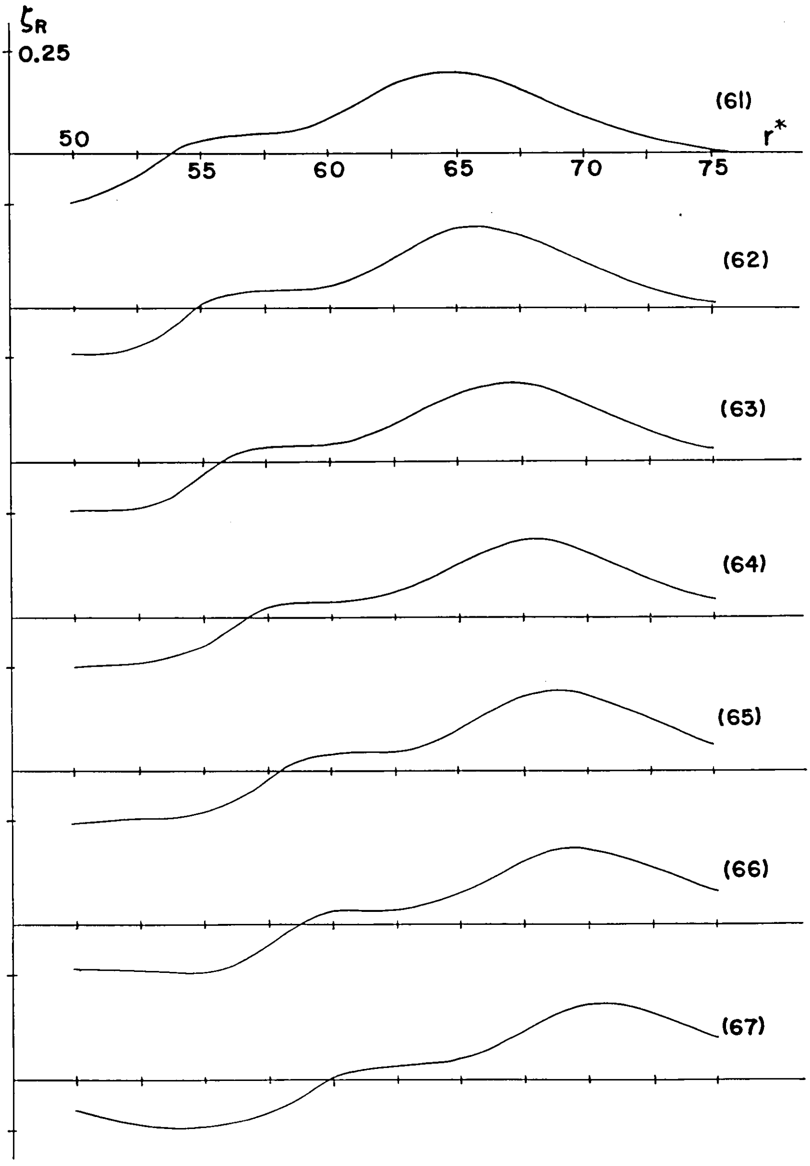

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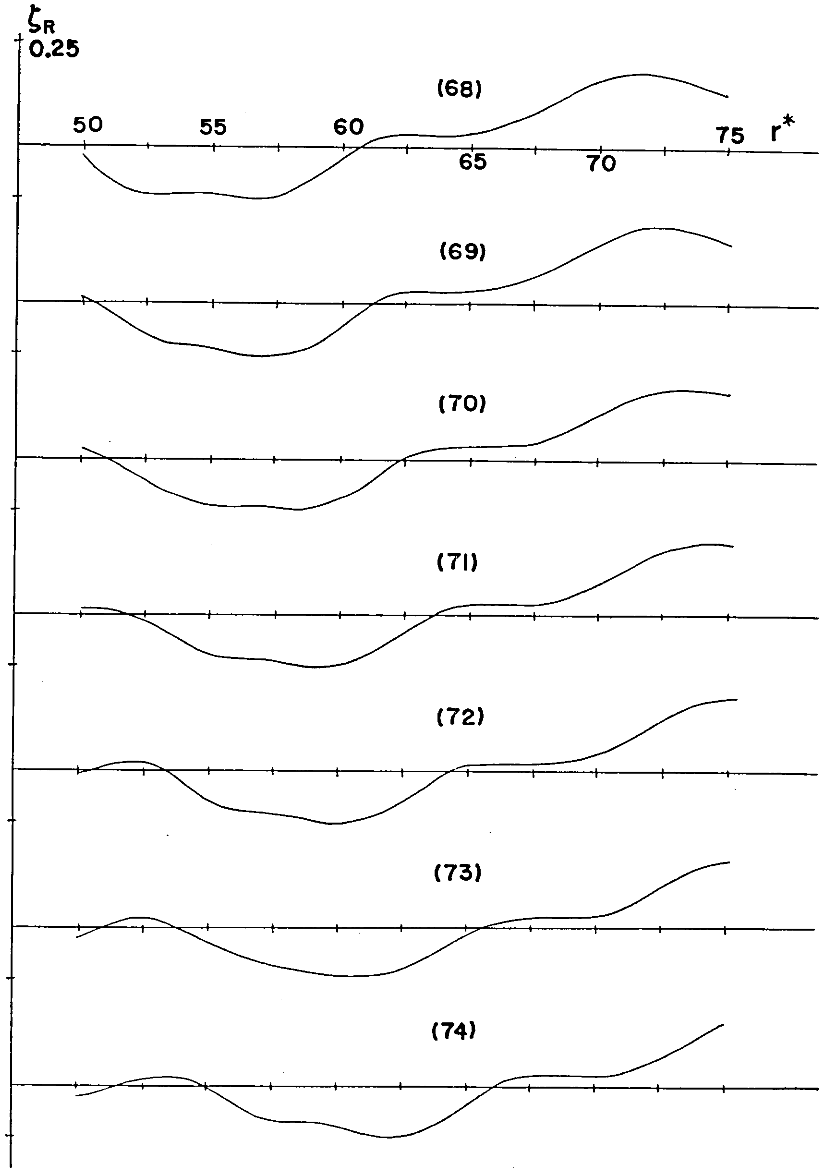

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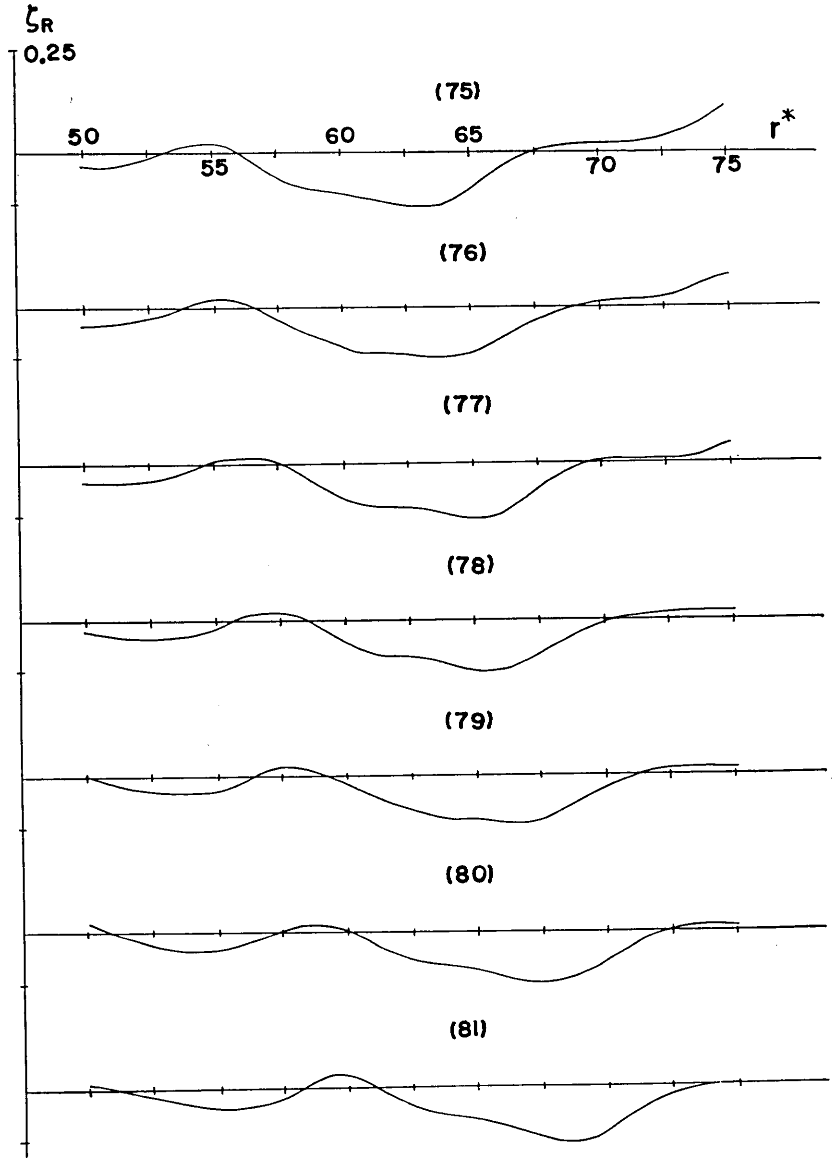

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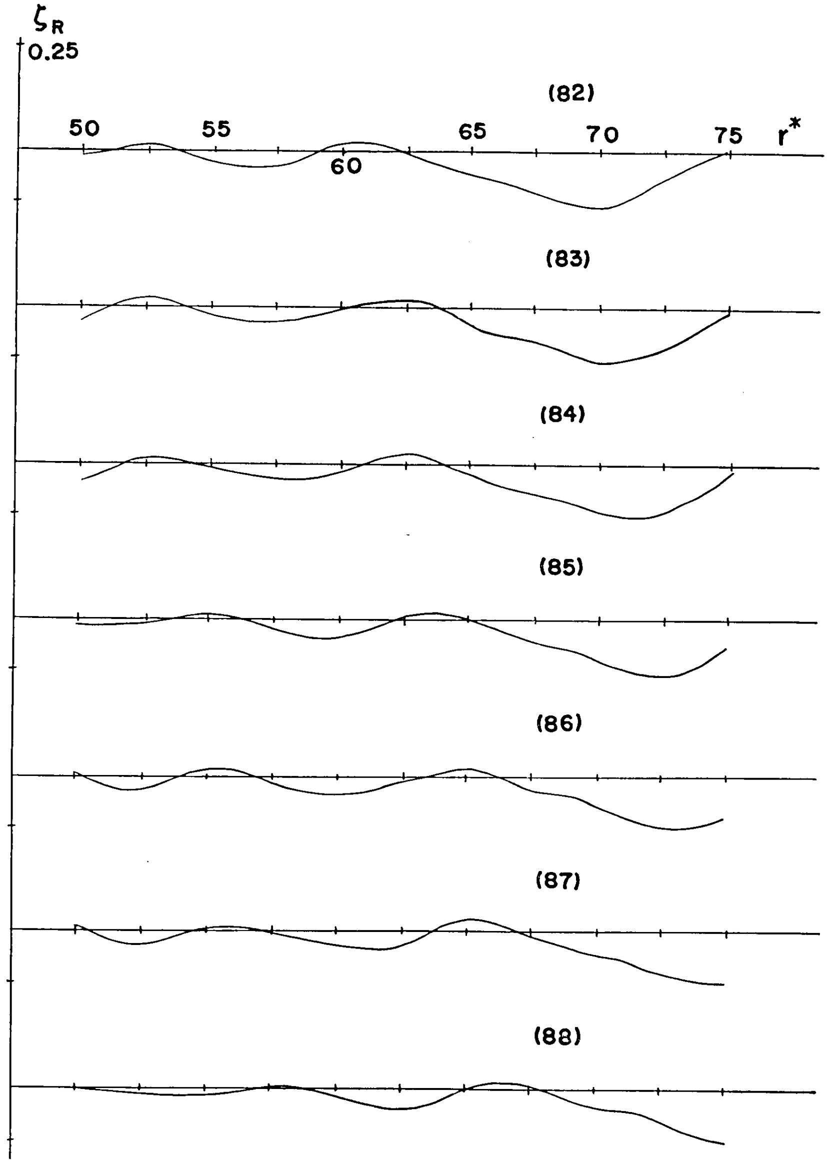

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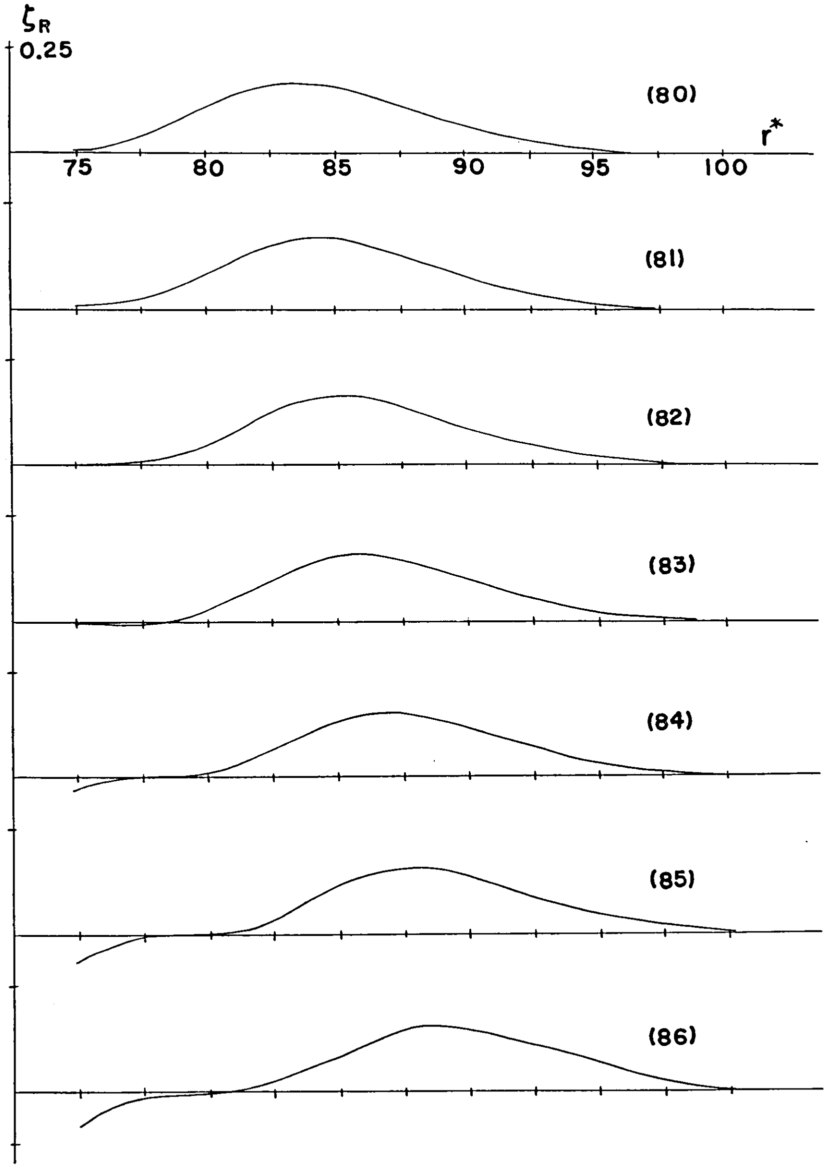

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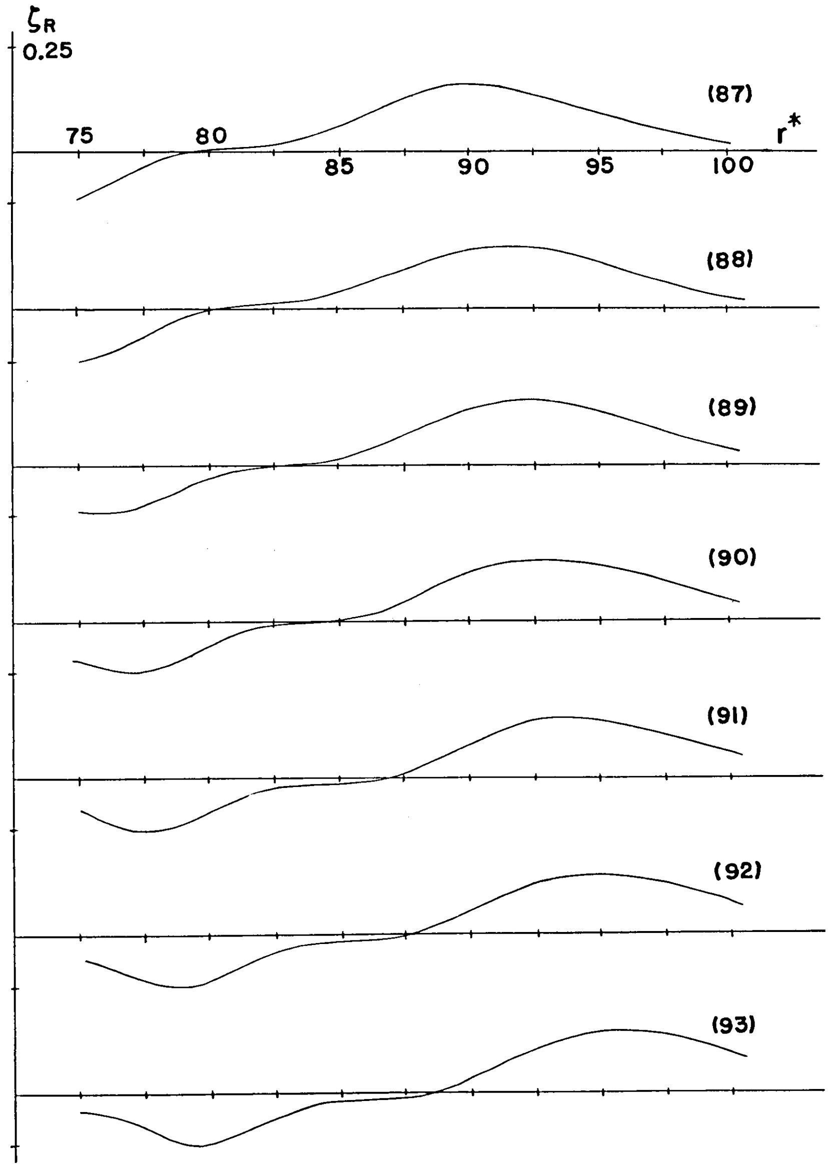

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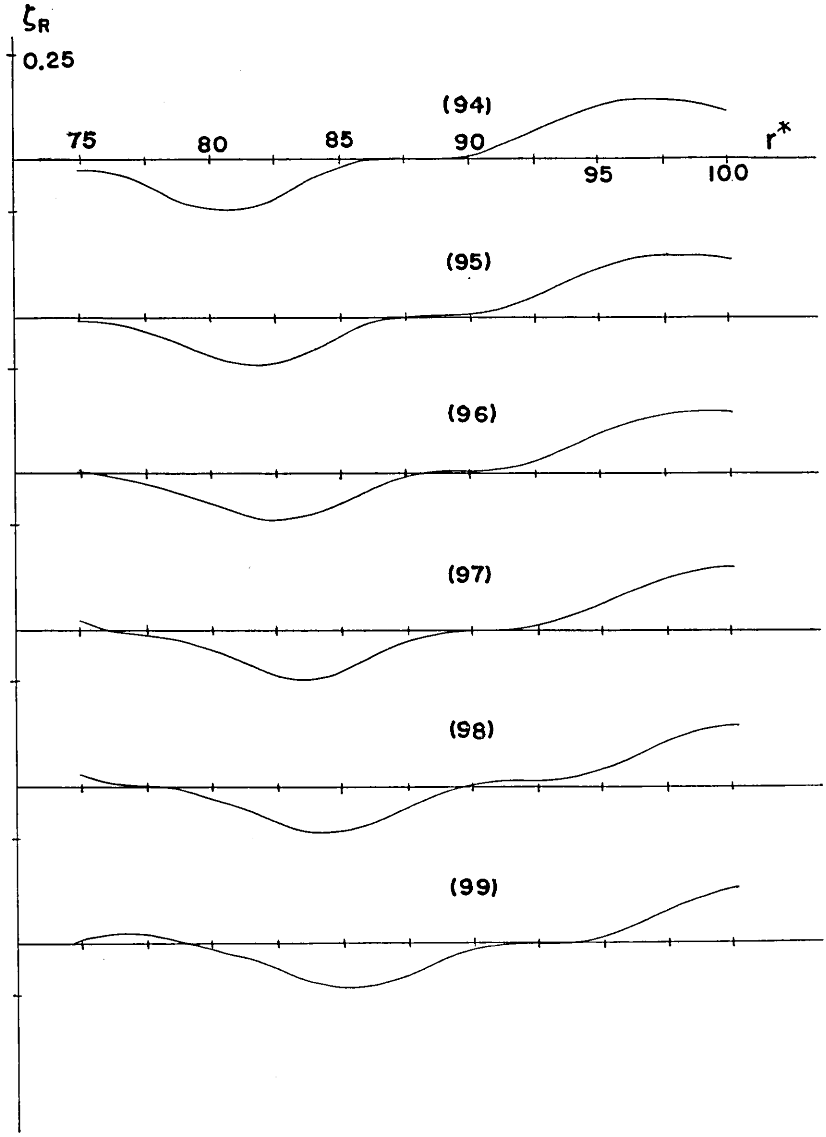

48. 波源域における津波 [IV]

地震研究所 桃 井 高 夫

本報告においては，r^* ($=r/H$, r: 波源の中心からの距離，H: 水深) が 50 から 100 の範囲に対して近地領域における津波の波高を計算した．用いられた積分方法は Filon の方法である．そして1つの重要な結論を得た．すなわち，日本近海においておこる近地津波は長波近似 (long wave approximation) の重み (weight) をかけて議論しなければならないということである．