j25
7/22/64

MASTER

EIGENVALUE SPACING DISTRIBUTIONS FOR COMPARISON WITH EXPERIMENTAL DATA

A SERIES OF COMPUTER PROGRAMS

K. FUCHEL, J.D. GARRISON, AND LOURDES R. ZAVITSAS

May 1964

BROOKHAVEN NATIONAL LABORATORY
ASSOCIATED UNIVERSITIES, INC.

under contract with the

UNITED STATES ATOMIC ENERGY COMMISSION

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

EIGENVALUE SPACING DISTRIBUTIONS FOR COMPARISON WITH EXPERIMENTAL DATA

A SERIES OF COMPUTER PROGRAMS

K. FUCHEL, J.D. GARRISON, AND LOURDES R. ZAVITSAS

May 1964

**BROOKHAVEN NATIONAL LABORATORY
UPTON, NEW YORK**

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

PRINTED IN USA

PRICE \$1.00

Available from the
Office of Technical Services
Department of Commerce
Washington 25, D.C.

June 1964

1000 copies

ABSTRACT

A series of computer programs are described which utilize the output eigenvalues of the Random Matrix Diagonalization code [see BNL 760 (T-282)] to obtain eigenvalue spacing distributions and their moments. These distributions and moments have been used for comparison with nuclear level spacing distributions obtained from neutron cross section measurements, and also for providing corrections for the nuclear level spacing distributions and moments for the weak levels which have been missed experimentally and for the extra levels which may be erroneously included.

THIS PAGE
WAS INTENTIONALLY
LEFT BLANK

CONTENTS

ABSTRACT	iii
INTRODUCTION	1
INPUT DATA	3
PROGRAM I	4
PROGRAM II	10
PROGRAM III	15
PROGRAM IV	19
SUBROUTINE PBAR	21
SUBROUTINE RANUN	24
TYPICAL OUTPUT	25

INTRODUCTION

This report describes four computer programs which have been developed for the comparison of the level spacing distributions predicted by statistical theory with the level spacing distributions obtained from low energy neutron cross section measurements. The applications of these programs and references to the theory may be found in the paper by J. D. Garrison in the proceedings of the symposium on Statistical Properties of Atomic and Nuclear Spectra, held at the State University of New York at Stony Brook on May 3, 1963.

The input for these programs consists of sets of eigenvalues obtained by diagonalizing randomly generated, real, symmetric matrices with elements normally distributed about mean zero. The diagonal elements have standard deviation $\sqrt{2}$, the off diagonal elements have standard deviation one. The generation and diagonalization of these matrices is described in the report "Random Matrix Diagonalization - A Computer Program," BNL 760 (T-282), September 1962, by K. Fuchel, Rita J. Greibach, and C. E. Porter.

All four programs obtain a distribution of the spacings between certain eigenvalues. The difference lies in what is done to the original sets of eigenvalues before the spacing distributions are obtained.

If $\lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \dots \leq \lambda_n$ are ordered eigenvalues, then the nearest-neighbor spacing, (no levels in between which we denote by a zero superscript) are $\delta_i^0 = \lambda_{i+1} - \lambda_i$. The next-nearest neighbor spacings (one level in between) are $\delta_i^1 = \lambda_{i+2} - \lambda_i$, and, in general, the n^{th} neighbor relation spacings are $\delta_i^n = \lambda_{i+n+1} - \lambda_i$.

In the first program the eigenvalues of two matrices are overlapped (i.e.) combined into one set) edge eigenvalues are removed, and if the spacing between two eigenvalues falls below a preset value, then one of them is

removed. There is also provision for inserting an arbitrary number into the combined set.

In the second program, there is a random removal of one eigenvalue per matrix before the eigenvalues of two matrices are overlapped. An eigenvalue is removed from the combined set if the spacing between it and a neighbor is less than a given value.

In the third program there is no overlapping. The options are: insertion of an arbitrary number into the set of eigenvalues, removal of edge eigenvalues, and removal of an eigenvalue that is too close to a neighboring one.

The fourth program provides for a random removal of one eigenvalue per matrix. There is no overlapping.

All four programs use subroutine PBAR which calculates and prints the frequency distributions and the moments.

INPUT DATA

A. Magnetic Tape

Sets of eigenvalues previously obtained from diagonalization of matrices of dimension NE are stored on magnetic tape. Each set of eigenvalues is ordered ascendingly: $\lambda_1^j \leq \lambda_2^j \leq \dots \leq \lambda_{NE}^j$. The superscript, j, indicates λ 's coming from the j^{th} matrix.

B. Control Cards

Two control cards are required for Programs I, II, and III; Program IV requires only one card. The first card is similar for all four programs. It is read with FORMAT (6I5) and contains the following parameters:

	<u>Card</u> <u>Column</u>	
JTAPE:	1-5	tape on which the sets of eigenvalues are already written
KTAPE:	6-10	scratch tape used to temporarily store the spacings between the eigenvalues
NM:	11-15	number of sets of eigenvalues to be read from JTAPE
NGHB:	16-20	highest neighbor relation to be treated (e.g. if NGHB = 1, only nearest-neighbor spacings are obtained, if NGHB = 2, one obtains both nearest and next-nearest neighbor spacings, etc.)
IPBAR:	21-25	= 0 if the distributions are not to be printed = 1 if the distributions are to be printed
NE:	26-30	dimension of matrix

PROGRAM I

2nd Input Card: FORMAT (3F5.0, 2I5)

	<u>Card Column</u>	
PN:	1-5	relative scale of two sets of spacings (before overlapping two sets of eigenvalues, one of the sets is multiplied by this number)
TOL:	6-10	if the nearest neighbor spacing between two eigenvalues is less than this number, the smaller of the two eigenvalues will be deleted from the set
XLEV:	11-15	extra level (after two sets of eigenvalues are overlapped, this number may or may not be inserted in the overlapped set, depending on the contents of IXLEV)
IXLEV:	16-20	= 0 if no extra level is to be inserted = 1 if extra level (XLEV) is to be inserted
NR:	21-25	number of eigenvalues to be removed from each end of every set of eigenvalues

PART A

The input is read.

PART B

1. REMOVAL OF EIGENVALUES AT BOTH ENDS OF SPECTRUM.

The first set of NE eigenvalues is read from the tape. The first NR eigenvalues and the last NR eigenvalues are deleted and the resulting set is multiplied by PN. The second set of eigenvalues is read from the tape. The first NR and the last NR eigenvalues are omitted from this set also.

2. OVERLAPPING.

The eigenvalues coming from two consecutive matrices $\lambda_i^j, \lambda_i^{j+1}$,
 $i = 1, 2, \dots, M$ are combined into one set, $\lambda_i^j, i = 1, 2, \dots, 2M$

and ordered ascendingly, Call this new set C. The program keeps track of which λ 's came from the j^{th} matrix, and which came from the $j+1^{\text{th}}$.

3. INSERTION OF EXTRA LEVEL.

If IXLEV equals zero this part of the program is skipped. If IXLEV equals one then the number XLEV is inserted in its proper place in the ordered set C.

4. EDGE EFFECT.

To eliminate an undesirable edge effect, certain elements of C are discarded. At each end of the spectrum of λ 's, λ 's are discarded until we reach two successive λ 's coming from different sets; at this point the outer one is discarded and the one lying nearer the center of the spectrum is retained. For example, in the spectrum of K eigenvalues coming from the j^{th} matrix and the $j+1^{\text{th}}$

$$\lambda_1 \leq \lambda_2 \leq \lambda_3 \leq \dots \leq \lambda_{K-1} \leq \lambda_K$$

the underlined elements would be discarded. Call this new set C'. C' will have at least two elements less than C.

5. DELETION OF CLOSELY SPACED EIGENVALUES

If TOL equals zero, this part of the program is skipped. If TOL is greater than zero, the differences between successive eigenvalues (nearest-neighbor spacings) are compared to the number TOL. If the difference between any two successive eigenvalues is less than TOL, the smaller of the two eigenvalues is deleted from the set.

6. CALCULATION OF SPACINGS.

The nearest-neighbor spacings are temporarily stored on the scratch tape. The sum of these spacings as well as the number of spacings obtained are stored. The same procedure is followed for the next neighbor spacings, all the way up to "NGHB-1" neighbor spacings.

PART C

After reading in a third set of eigenvalues, Part B is repeated using the second and third sets in linked chain fashion. The sum of the spacings are added to those obtained from the first and second sets of eigenvalues. Part B is repeated with new sets of eigenvalues NM times.

The total number of eigenvalues deleted because the spacing is less than TOL is printed. The scratch tape is rewound and subroutine PBAR is called.

ESD1 OVERLAPPED - PROGRAM I

C	OPTIONS - EXTRA LEVEL INSERTION, CLOSE SPACING AND EDGE REMOVAL	ESD10001
C	IF IXLEV=1 EXTRA LEVEL WILL BE INSERTED, IF IXLEV=0 IT WILL NOT BE	ESD10002
C	IF IPBAR=0 PBAR WILL NOT BE PRINTED, IF IPBAR=1 IT WILL BE	ESD10003
C		ESD10004
	COMMON NGH8, IPBAR, ISUM, SPACES, NM, NN, DIFR, KTAPE	ESD10005
	DIMENSION A(20), B(20), M(41), C(41), SAVEB(20), DIFR(38,19), ISUM(19),	ESD10006
	1SPACES(19), NN(19)	ESD10007
C		ESD10008
	READINPUTTAPE5,10,JTAPE,KTAPE,NM,NGH8,IPBAR,NE	ESD10009
10	FORMAT(6I5)	ESD10010
	READINPUTTAPE5,20,PN,TOL,XLEV,IXLEV,NR	ESD10011
20	FORMAT(3F5.0,2I5)	ESD10012
	REWIND JTAPE	ESD10013
	REWIND KTAPE	ESD10014
	NR1=NR+1	ESD10015
	NENR=NE-NR	ESD10016
	N2=2*(NE-2*NR)	ESD10017
	IDelet = 0	ESD10018
	DO 30 I=1,NGH8	ESD10019
	ISUM(I) = 0	ESD10020
30	SPACES(I)=0.0	ESD10021
C		ESD10022
C	OUTPUT HEADINGS FOR TITLE PAGE	ESD10023
C		ESD10024
	WRITEOUTPUTTAPE6,90,NE,NE	ESD10025
	WRITEOUTPUTTAPE6,100,NM	ESD10026
	WRITEOUTPUTTAPE6,110,PN	ESD10027
	IF (IXLEV) 50,50,40	ESD10028
40	WRITEOUTPUTTAPE6,120,XLEV	ESD10029
50	IF (NR) 70,70,60	ESD10030
60	WRITEOUTPUTTAPE6,130,NR	ESD10031
70	IF (TOL) 150,150,80	ESD10032
80	WRITEOUTPUTTAPE6,140,TOL	ESD10033
90	FORMAT(1H1,54X,I2,3H X ,I2,7H MATRIX////57X,10HOVERLAPPED////)	ESD10034
100	FORMAT(47X,I5,24H MATRICES HAVE BEEN USED////)	ESD10035
110	FORMAT(48X,25H RATIO OF LEVEL SPACING = ,F4.2////)	ESD10036
120	FORMAT(30X,16H ONE EXTRA LEVEL (F5.2,40H) PER PAIR OF MATRICES HAS BEEN	ESD10037
	INSERTED////)	ESD10038
130	FORMAT(30X,I2,60H EIGENVALUES HAVE BEEN REMOVED FROM EACH END OF EVERY	ESD10039
	MATRIX////)	ESD10040
140	FORMAT(30X,63H IF THE NEAREST NEIGHBOR SPACING BETWEEN TWO EIGENVALUES	ESD10041
	IS LESS//30X,4H THAN F5.2,52H THE SMALLER OF THE TWO EIGENVALUES	ESD10042
	2 HAS BEEN DELETED////)	ESD10043
C		ESD10044
C	READ AND STORE FIRST SET OF EIGENVALUES	ESD10045
C		ESD10046
150	READ TAPE JTAPE,(B(I),I=1,NE)	ESD10047
	DO 160 I=NR1,NENR	ESD10048
160	SAVEB(I) = B(I)	ESD10049
C	NM IS NUMBER OF MATRICES	ESD10050
	DO 520 K=1,NM	ESD10051
C		ESD10052
C	REMOVAL OF EIGENVALUES AT BOTH ENDS OF SPECTRUM	ESD10053
C		ESD10054
	DO 170 I=NR1,NENR	ESD10055

ESD1 OVERLAPPED - PROGRAM I

170	A(I) = B(I)*PN	ESD10056
	IF (K-NM) 200,180,200	ESD10057
180	DØ 190 I=NR1,NENR	ESD10058
190	B(I)=SAVEB(I)	ESD10059
	GØ TØ 210	ESD10060
200	READ TAPE JTape,(B(I),I=1,NE)	ESD10061
210	DØ 220 I=1,41	ESD10062
220	M(I)=0	ESD10063
C		ESD10064
C	OVERLAPPING	ESD10065
C		ESD10066
	I=NR1	ESD10067
	J=NR1	ESD10068
	DØ 250 L=1,N2	ESD10069
	IF (A(I)-B(J)) 230,230,240	ESD10070
230	C(L)=A(I)	ESD10071
	I=I+1	ESD10072
	IF (I-NENR) 250,250,260	ESD10073
240	C(L)=B(J)	ESD10074
	M(L)=1	ESD10075
	J=J+1	ESD10076
	IF (J-NENR) 250,250,280	ESD10077
250	CØNTINUE	ESD10078
260	DØ 270 JJ=J,NENR	ESD10079
	JJJ=NE-3*NR+JJ	ESD10080
	C(JJJ)=B(JJ)	ESD10081
270	M(JJJ)=1	ESD10082
	GØ TØ 300	ESD10083
280	DØ 290 II=I,NENR	ESD10084
	III=NE-3*NR+II	ESD10085
290	C(III)=A(II)	ESD10086
C		ESD10087
C	INSERTION ØF EXTRA LEVEL	ESD10088
C		ESD10089
	IF (IXLEV) 350,350,300	ESD10090
300	DØ 310 I=1,N2	ESD10091
	IF (C(I) - XLEV) 310,320,320	ESD10092
310	CØNTINUE	ESD10093
320	J=N2	ESD10094
330	C(J+1) = C(J)	ESD10095
	M(J+1) = M(J)	ESD10096
	J = J-1	ESD10097
	IF (J-1) 340,330,330	ESD10098
340	C(I) = XLEV	ESD10099
C		ESD10100
C	EDGE EFFECT	ESD10101
C		ESD10102
350	I=2	ESD10103
360	IF (M(I) - M(I-1)) 380,370,380	ESD10104
370	I=I+1	ESD10105
	GØ TØ 360	ESD10106
380	IF (IXLEV) 390,390,400	ESD10107
390	N=N2-1	ESD10108
	GØ TØ 410	ESD10109
400	N=N2	ESD10110
410	IF (M(N+1) - M(N)) 430,420,430	ESD10111

ESD1 OVERLAPPED - PROGRAM I

420	N = N-1	ESD10112
	GO TO 410	ESD10113
C		ESD10114
C	DELETION OF CLOSELY SPACED EIGENVALUES	ESD10115
C		ESD10116
430	IF (TOL) 500,500,440	ESD10117
440	L=I	ESD10118
450	SUB = C(L+1) - C(L)	ESD10119
	IF (SUB-TOL) 460,480,480	ESD10120
460	L1 = L + 1	ESD10121
	DO 470 J=L1,N	ESD10122
470	C(J-1) = C(J)	ESD10123
	N=N-1	ESD10124
	IDELET = IDELET + 1	ESD10125
	GO TO 490	ESD10126
480	L=L+1	ESD10127
490	IF (L-N) 450,500,500	ESD10128
C		ESD10129
C	CALCULATION OF SPACINGS	ESD10130
C		ESD10131
500	DO 510 LL=1,NGHB	ESD10132
	LLI=N-LL	ESD10133
	NN(LL) = LLI	ESD10134
	DO 510 L=I,LLI	ESD10135
	KL = L+LL	ESD10136
	DIFR(L,LL) = C(KL) - C(L)	ESD10137
	SPACES(LL) = SPACES(LL) + DIFR(L,LL)	ESD10138
510	ISUM(LL) = ISUM(LL) + 1	ESD10139
520	WRITE TAPE KTAPE,I,(NN(LL),(DIFR(L,LL),L=1,38),LL=1,NGHB)	ESD10140
C		ESD10141
	IF (TOL) 550,550,530	ESD10142
530	WRITEOUTPUTTAPE6,540,IDELET	ESD10143
540	FORMAT(IH0,29X,I3,56H EIGENVALUES HAVE BEEN DELETED BECAUSE OF CLOSE SPACINGS)	ESD10144
550	REWIND KTAPE	ESD10145
	UNLOAD JTAPE	ESD10146
C		ESD10147
	CALL PBAR	ESD10148
C	SUBROUTINE PBAR DOES NOT RETURN TO MAIN PROGRAM	ESD10149
	STOP	ESD10150
	END	ESD10151

PROGRAM II

2nd Input Card: FORMAT (2F5.0)

	<u>Card Column</u>	
PN:	1-5	relative scale of two sets of spacings (before overlapping two sets of eigenvalues, one of the sets is multiplied by this number)
TOL:	6-10	if the nearest neighbor spacing between two eigenvalues is less than this number, the smaller of the two eigenvalues will be deleted from the set

PART A

The input is read.

PART B

1. RANDOM REMOVAL OF ONE EIGENVALUE PER MATRIX.

The first set of eigenvalues is read from the tape. A random integer I is generated such that $1 \leq I \leq 10$. The I^{th} eigenvalue of this set is then deleted and the resulting set is multiplied by PN. A second set is read from the tape and another random integer is generated so as to remove one eigenvalue from this second set.

2. OVERLAPPING.

The eigenvalues from these two sets are combined into one set and ordered ascendingly as in Program I.

3. EDGE EFFECT.

See Program I.

4. DELETION OF CLOSELY SPACED EIGENVALUES.

See Program I.

5. CALCULATION OF SPACINGS.

See Program I.

PART C

See Program I.

ESD2 OVERLAPPED-PROGRAM II

C	OPTIONS-RANDOM REMOVAL, CLOSE SPACINGS REMOVAL	ESD20001
C	IF IPBAR=0 PBAR WILL NOT BE PRINTED, IF IPBAR=1 IT WILL BE	ESD20002
C		ESD20003
	COMMON NGHB, IPBAR, ISUM, SPACES, NM, NN, DIFR, KTAPE	ESD20004
	DIMENSION A(19), B(20), M(38), C(38), SAVEB(19), SPACES(19), ISUM(19),	ESD20005
	IDIFR(38, 19), NN(19)	ESD20006
C		ESD20007
	READINPUTTAPE5, 10, JTAPE, KTAPE, NM, NGHB, IPBAR, NE	ESD20008
10	FORMAT(6I5)	ESD20009
	READINPUTTAPE5, 20, PN, TOL	ESD20010
20	FORMAT(2F5.0)	ESD20011
	REWIND JTAPE	ESD20012
	REWIND KTAPE	ESD20013
	IDelet = 0	ESD20014
	NE1 = NE - 1	ESD20015
	NE2 = 2 * NE1	ESD20016
C		ESD20017
	DO 30 I=1, NGHB	ESD20018
	ISUM(I) = 0	ESD20019
30	SPACES(I)=0.0	ESD20020
C		ESD20021
C	OUTPUT HEADINGS FOR TITLE PAGE	ESD20022
C		ESD20023
	WRITEOUTPUTTAPE6, 60, NE, NE	ESD20024
	WRITEOUTPUTTAPE6, 70, NM	ESD20025
	WRITEOUTPUTTAPE6, 80, PN	ESD20026
	IF (TOL) 50, 50, 40	ESD20027
40	WRITEOUTPUTTAPE6, 90, TOL	ESD20028
50	WRITEOUTPUTTAPE6, 100	ESD20029
60	FORMAT(1H1, 54X, 12, 3H X, 12, 7H MATRIX////57X, 10H OVERLAPPED////)	ESD20030
70	FORMAT(47X, 15, 24H MATRICES HAVE BEEN USED////)	ESD20031
80	FORMAT(48X, 25H RATIO OF LEVEL SPACING = , F4.2////)	ESD20032
90	FORMAT(30X, 63H IF THE NEAREST NEIGHBOR SPACING BETWEEN TWO EIGENVALUES	ESD20033
	IS LESS//30X, 4H THAN F5.2, 52H THE SMALLER OF THE TWO EIGENVALUES	ESD20034
	2 HAS BEEN DELETED////)	ESD20035
100	FORMAT(30X, 60H RANDOM INTEGERS BETWEEN 1 AND 10 HAVE BEEN GENERATED	ESD20036
	1 AND THE //30X, 58H CORRESPONDING EIGENVALUE HAS BEEN DELETED FROM	ESD20037
	2ACH MATRIX////)	ESD20038
C		ESD20039
C	READ AND STORE FIRST SET OF EIGENVALUES	ESD20040
C		ESD20041
	READ TAPE JTAPE, (B(I), I=1, NE)	ESD20042
	CALL RANUN(ETA)	ESD20043
	INT=XFIXF(10.0*ETA) + 1	ESD20044
	IF (INT-NE) 110, 130, 110	ESD20045
110	DO 120 I = INT, NE1	ESD20046
120	B(I)=B(I+1)	ESD20047
130	DO 140 I=1, NE1	ESD20048
140	SAVEB(I)=B(I)	ESD20049
C	NM IS NUMBER OF MATRICES	ESD20050
	DO 450 K=1, NM	ESD20051
	DO 150 I=1, NE1	ESD20052
150	A(I)=B(I)*PN	ESD20053
	IF (K-NM) 180, 160, 180	ESD20054
160	DO 170 I=1, NE1	ESD20055

ESD2 OVERLAPPED-PROGRAM II

170 B(I)=SAVEB(I)	ESD20056
GO TO 210	ESD20057
180 READ TAPE JTAPE,(B(I),I=1,NE)	ESD20058
C	ESD20059
C RANDOM REMOVAL OF ONE EIGENVALUE PER MATRIX	ESD20060
C ETA IS UNIFORMLY DISTRIBUTED ON (0,1)	ESD20061
CALL RANUN(ETA)	ESD20062
INT=XFIXF(10.0*ETA) + 1	ESD20063
IF (INT-NE) 190,210,190	ESD20064
190 DO200 I=INT,NE1	ESD20065
200 B(I)=B(I+1)	ESD20066
210 DO220I=1,NE2	ESD20067
220 M(I) = 0	ESD20068
C	ESD20069
C OVERLAPPING	ESD20070
C	ESD20071
I=1	ESD20072
J=1	ESD20073
DO 250 L=1,NE2	ESD20074
IF (A(I)-B(J)) 230,230,240	ESD20075
230 C(L) = A(I)	ESD20076
I=I+1	ESD20077
IF (I-NE1) 250,250,260	ESD20078
240 C(L) = B(J)	ESD20079
M(L)=1	ESD20080
J=J+1	ESD20081
IF (J-NE1) 250,250,280	ESD20082
250 CONTINUE	ESD20083
260 DO270JJ=J,NE1	ESD20084
JJN = JJ+NE1	ESD20085
C(JJN) = B(JJ)	ESD20086
270 M(JJN) = 1	ESD20087
GO TO 300	ESD20088
280 DO290II=1,NE1	ESD20089
IIIN=II+NE1	ESD20090
290 C(IIIN) = A(II)	ESD20091
C	ESD20092
C EDGE EFFECT	ESD20093
C	ESD20094
300 I=2	ESD20095
310 IF (M(I) - M(I-1)) 330,320,330	ESD20096
320 I=I+1	ESD20097
GO TO 310	ESD20098
330 N = NE2-1	ESD20099
340 IF (M(N+1) - M(N)) 360,350,360	ESD20100
350 N=N-1	ESD20101
GO TO 340	ESD20102
360 N=N-1	ESD20103
C	ESD20104
C DELETION OF CLOSELY SPACED EIGENVALUES	ESD20105
C	ESD20106
IF (TOL) 430,430,370	ESD20107
370 L=1	ESD20108
380 SUB=C(L+1)-C(L)	ESD20109
IF(SUB-TOL) 390,410,410	ESD20110
390 DO400 J=L,N	ESD20111

ESD2 OVERLAPPED-PROGRAM II

400 C(J)=C(J+1)	ESD20112
N=N-1	ESD20113
IDELET = IDELET + 1	ESD20114
GO TO 420	ESD20115
410 L=L+1	ESD20116
420 IF(L-N) 380,380,430	ESD20117
C	ESD20118
C CALCULATION OF SPACINGS	ESD20119
C	ESD20120
430 D0440 LL=1,NGHB	ESD20121
ELI=N+1-LL	ESD20122
NN(LL) = LLI	ESD20123
D0440 L=1,LLI	ESD20124
KL = L+LL	ESD20125
DIFR(L,LL) = C(KL) - C(L)	ESD20126
SPACES(LL) = SPACES(LL) + DIFR(L,LL)	ESD20127
440 ISUM(LL) = ISUM(LL) + 1	ESD20128
450 WRITE TAPE KTAPE,I,(NN(LL),(DIFR(L,LL),L=1,38),LL=1,NGHB)	ESD20129
IF (TOL) 480,480,460	ESD20130
460 WRITE OUTPUT TAPE 6,470,IDELET	ESD20131
470 FORMAT(1H0,29X,I3,56H EIGENVALUES HAVE BEEN DELETED BECAUSE OF CL	ESD20132
USE SPACINGS)	ESD20133
480 REWIND KTAPE	ESD20134
UNLOAD JTAPE	ESD20135
C	ESD20136
CALL PBAR	ESD20137
C SUBROUTINE PBAR DOES NOT RETURN TO MAIN PROGRAM	ESD20138
STOP	ESD20139
END	

PROGRAM III

2nd Input Card: FORMAT (2I5, 2F5.0)

	<u>Card</u> <u>Column</u>	
NR	1-5	number of eigenvalues to be removed from each end of every set of eigenvalues
IXLEV	6-10	= 0 if no extra level is to be inserted = 1 if extra level (XLEV) is to be inserted
XLEV	11-15	extra level (this number may or may not be inserted in the set, depending on the contents of IXLEV)
TOL	16-20	if the nearest neighbor spacing between two eigenvalues is less than this number, the smaller of the two eigenvalues will be deleted from the set.

PART A

The input is read.

PART B

1. REMOVAL OF EIGENVALUES AT BOTH ENDS OF SPECTRUM.

The first set of eigenvalues is read from the tape. The first NR eigenvalues and the last NR eigenvalues are deleted from the set.

2. INSERTION OF EXTRA LEVEL.

If IXLEV equals zero this part of the program is skipped. If IXLEV equals one then the number XLEV is inserted in its proper position in the ordered set of eigenvalues.

3. DELETION OF EIGENVALUES DUE TO CLOSE NEAREST NEIGHBOR SPACINGS.

See Program I.

4. CALCULATION OF SPACINGS.

See Program I.

PART C

After reading in a second set of eigenvalues, Part B is repeated using this new set. The sum of the spacings obtained from this second set as

well as the number of spacings obtained are added to those of the first set.

Part B is repeated with new sets of eigenvalues NM times. Subroutine PBAR is then called.

ESD3 NO OVERLAPPING - PROGRAM III

```

C  OPTIONS - EXTRA LEVEL INSERTION, CLOSE SPACINGS AND EDGE REMOVAL ESD30001
C  IF IXLEV=1 EXTRA LEVEL WILL BE INSERTED, IF IXLEV=0 IT WILL NOT BE ESD30002
C  IF IPBAR=0 PBAR WILL NOT BE PRINTED, IF IPBAR=1 IT WILL BE ESD30003
C  ESD30004
C  COMMON NGHB,IPBAR,ISUM,SPACES,NM,NN,DIFR,KTAPE ESD30005
C  DIMENSION B(21),NN(19),DIFR(38,19),SPACES(19),ISUM(19) ESD30006
C  READINPUTTAPE5,10,JTAPE,KTAPE,NM,NGHB,IPBAR,NE ESD30007
10  FORMAT(6I5) ESD30008
C  READINPUTTAPE5,20,NR,IXLEV,XLEV,TOL ESD30009
20  FORMAT(2I5,2F5.0) ESD30010
C  REWIND JTAPE ESD30011
C  REWIND KTAPE ESD30012
C  IDELET = 0 ESD30013
C  DO 30 I=1,NGHB ESD30014
C  ISUM(I) = 0 ESD30015
30  SPACES(I)=0.0 ESD30016
C  ESD30017
C  OUTPUT FOR TITLE PAGE ESD30018
C  ESD30019
C  WRITEOUTPUTTAPE6,90,NE,NE ESD30020
C  WRITEOUTPUTTAPE6,100,NM ESD30021
C  IF(IXLEV) 50,50,40 ESD30022
40  WRITEOUTPUTTAPE6,110,XLEV ESD30023
50  IF (NR) 70,70,60 ESD30024
60  WRITEOUTPUTTAPE6,120,NR ESD30025
70  IF (TOL) 140,140,80 ESD30026
80  WRITEOUTPUTTAPE6,130,TOL ESD30027
90  FORMAT(1H1,54X,12,3H X ,12,7H MATRIX////55X,14HN0 OVERLAPPING////) ESD30028
100  FORMAT(47X,15,24H MATRICES HAVE BEEN USED////) ESD30029
110  FORMAT(30X,16H0NE EXTRA LEVEL(F5.2,30H) PER MATRIX HAS BEEN INSERTED ESD30030
110  ESD30031
120  FORMAT(30X,12,60H EIGENVALUES HAVE BEEN REMOVED FROM EACH END OF ESD30032
120  ESD30033
130  FORMAT(30X,63HIF THE NEAREST NEIGHBOR SPACING BETWEEN TWO EIGENVALES ESD30034
130  ESD30035
130  ESD30036
130  ESD30037
140  DO 340 K=1,NM ESD30038
C  NM IS NUMBER OF MATRICES ESD30039
C  READ TAPE JTAPE,(B(I), I=1,NE) ESD30040
C  ESD30041
C  REMOVAL OF EIGENVALUES AT BOTH ENDS OF SPECTRUM ESD30042
C  ESD30043
C  N=NE-2*NR ESD30044
C  IF (NR) 170,170,150 ESD30045
150  DO 160 I=1,N ESD30046
C  NRI = NR + I ESD30047
160  B(I) = B(NRI) ESD30048
C  ESD30049
C  INSERTION OF EXTRA LEVEL ESD30050
C  ESD30051
170  IF (IXLEV) 230,230,180 ESD30052
180  DO 190 I=1,N ESD30053
C  IF (B(I) - XLEV) 190,200,200 ESD30054
190  CONTINUE ESD30055

```

ESD3 NO OVERLAPPING - PROGRAM III

200 J=N	ESD30056
210 B(J+1)=B(J)	ESD30057
J=J-1	ESD30058
IF (J-I) 220,210,210	ESD30059
220 B(I) = XLEV	ESD30060
N = N+1	ESD30061
C	ESD30062
C DELETION OF CLOSELY SPACED EIGENVALUES	ESD30063
C	ESD30064
230 IF (TOL) 300,300,240	ESD30065
240 L=1	ESD30066
250 SUB = B(L+1) - B(L)	ESD30067
IF (SUB-TOL) 260,280,280	ESD30068
260 L1 = L+1	ESD30069
DO 270 J=L1,N	ESD30070
270 B(J-1) = B(J)	ESD30071
N=N-1	ESD30072
IDELET = IDELET + 1	ESD30073
GO TO 290	ESD30074
280 L = L+1	ESD30075
290 IF (L-N) 250,300,300	ESD30076
C	ESD30077
C CALCULATION OF SPACINGS	ESD30078
C	ESD30079
300 DO 330 LL=1,NGHB	ESD30080
LLI = N-LL	ESD30081
NN(LL) = LLI	ESD30082
IF (LLI) 330,330,310	ESD30083
310 DO 320 L=1,LLI	ESD30084
KL = L+LL	ESD30085
DIFR(L,LL) = B(KL) - B(L)	ESD30086
SPACES(LL) = SPACES(LL) + DIFR(L,LL)	ESD30087
320 ISUM(LL) = ISUM(LL) + 1	ESD30088
330 CONTINUE	ESD30089
I=1	ESD30090
340 WRITE TAPE KTAPE,I,(NN(LL),(DIFR(L,LL),L=1,38),LL=1,NGHB)	ESD30091
C	ESD30092
IF (TOL) 370,370,350	ESD30093
350 WRITE OUTPUT TAPE 6,360,IDELET	ESD30094
360 FORMAT(1H0,29X,13,56H EIGENVALUES HAVE BEEN DELETED BECAUSE OF CLOSE SPACINGS)	ESD30095
370 REWIND KTAPE	ESD30096
UNLOAD JTAPE	ESD30097
C	ESD30098
CALL PBAR	ESD30099
C SUBROUTINE PBAR DOES NOT RETURN TO MAIN PROGRAM	ESD30100
STOP	ESD30101
END	ESD30102

PROGRAM IV

PART A

The input is read.

PART B

1. RANDOM REMOVAL OF ONE EIGENVALUE PER MATRIX.

The first set of eigenvalues is read from the tape. A random integer I is generated such that $1 \leq I \leq 10$. The I^{th} eigenvalue of this set is then deleted.

2. CALCULATION OF SPACINGS.

See Program I.

PART C

See Program III.

ESD4 NØ ØVERLAPPING - PRØGRAM IV

C	ØPTIONS-RANDØM REMØVAL	ESD40001
C		ESD40002
	CØMMØN NGHØ,IPBAR,ISUM,SPACES,NM,NN,DIFR,KTAPE	ESD40003
	DIMENSION B(20),NN(19),ISUM(19),DIFR(38,19),SPACES(19)	ESD40004
	DØ 10 I=1,NGHØ	ESD40005
	ISUM(I) = 0	ESD40006
	10 SPACES(I)=0.0	ESD40007
	READINPUTTAPE5,20,JTAPE,KTAPE,NM,NGHØ,IPBAR,NE	ESD40008
	20 FØRMAT(6I5)	ESD40009
	NE1=NE-1	ESD40010
	REWIND JTAPE	ESD40011
	REWIND KTAPE	ESD40012
C		ESD40013
C	ØUTPUT FØR TITLE PAGE	ESD40014
C		ESD40015
	WRITEØUTPUTTAPE6,30,NE,NE	ESD40016
	WRITEØUTPUTTAPE6,40,NM	ESD40017
	WRITEØUTPUTTAPE6,50	ESD40018
	30 FØRMAT(11H1,54X,12,3H X ,12,7H MATRIXA////55X,14HNN ØVERLAPPING////)	ESD40019
	40 FØRMAT(47X,15,24H MATRICES HAVE BEEN USED////)	ESD40020
	50 FØRMAT(30X,60HRANDØM INTEGERS BETWEEN 1 AND 10 HAVE BEEN GENERATED	ESD40021
	1 AND THE //30X,58HCØRRESPØNDING EIGENVALUE HAS BEEN DELETED FROM	ESD40022
	24CH MATRIX////)	ESD40023
C		ESD40024
C	NM IS THE NUMBER ØF MATRICES	ESD40025
	DØ 100 K=1,NM	ESD40026
	READ TAPE JTAPE,(B(I),I=1,NF1	ESD40027
C		ESD40028
C	RANDØM REMØVAL ØF ØNE EIGENVALUE PER MATRIX	ESD40029
C	ETA IS UNIFØRMLY DISTRIBUTED ØN (0,1)	ESD40030
	CALL RANUN(ETA)	ESD40031
	INT=XFIXF(10.0*ETA) + 1	ESD40032
	IF (INT-NE) 60,80,60	ESD40033
	60 DØ 70 I=INT,NE1	ESD40034
	70 B(I)=B(I+1)	ESD40035
C		ESD40036
C	CALCULATION ØF SPACINGS	ESD40037
C		ESD40038
	80 DØ 90 LL=1,NGHØ	ESD40039
	LLI = NE1-LL	ESD40040
	NN(LL) = LLI	ESD40041
	DØ 90 L=1,LLI	ESD40042
	KL = L+LL	ESD40043
	DIFR(L,LL) = B(KL) D(L)	ESD40044
	SPACES(LL) = SPACES(LL) + DIFR(L,LL)	ESD40045
	90 ISUM(LL) = ISUM(LL) + 1	ESD40046
	I=1	ESD40047
	100 WRITE TAPE KTAPE,I,(NN(LL),(DIFR(L,LL),L=1,38),LL=1,NGHØ)	ESD40048
	REWIND KTAPE	ESD40049
	UNLØAD JTAPE	ESD40050
C		ESD40051
	CALL PBAR	ESD40052
C	SUBRØUTINE PBAR DØES NØT RETURN TØ MAIN PRØGRAM	ESD40053
	STØP	ESD40054
	END	

SUBROUTINE PBAR

CALCULATION OF MEAN SPACINGS

The average nearest neighbor spacing is calculated by dividing the previously obtained sum of all the nearest neighbor spacings by the total number of nearest neighbor spacings. In the same manner, the average one-neighbor, two-neighbor, etc. spacings are calculated up to "NGHB-1" neighbor spacings.

DISTRIBUTION OF SPACINGS

The spacings which were stored temporarily on the scratch tape in Part B are read. For each neighbor relation, the spacings are divided by the appropriate $A^{(K)}/(K+1)$ where $A^{(K)}$ = average spacing calculated above, K = number of eigenvalues between the two eigenvalues whose spacing is obtained. These normalized spacings are sorted into grids of width $\text{DELTA}X = .1$, putting spacings greater than 20 into the last grid box.

CALCULATION OF PBAR AND MOMENTS

For each neighbor relation the following are calculated:

$$\text{PBAR}_i = \frac{S_i}{N \cdot \text{DELTA}X} \quad \text{where } S_i = \text{number of spacings in } i^{\text{th}} \text{ grid box}$$

N = total number of spacings

If $\text{IPBAR} = 1$, these PBAR's are printed along with the midpoint of the grid interval (XMIDPT_i) and the actual count in the grid box. If $\text{IPBAR} = 0$, none of this is printed.

The following moments are calculated and printed:

$$M_n^{(K)} = \text{DELTA}X * \sum_{i=1}^L (\text{PBAR}_i) * (\text{XMIDPT}_i)^n$$

where L = total number of intervals

n = moment order = 0, 1, 2, 3, 4

SUBROUTINE PBAR	PBAR0001
	PBAR0002
	PBAR0003
COMMON NGHB,IPBAR,ISUM,SPACES,NM,NN,DIFR,KTAPE	PBAR0004
DIMENSION SMEAN(19),SUMDEL(19),SUM(19),JMAX(19),IBOX(200,19),PX(4,	PBAR0005
1,PM(4),ISUM(19),SPACES(19),NN(19),DIFR(38,19),AVRG(19)	PBAR0006
	PBAR0007
DO 10 I = 1,NGHB	PBAR0008
JMAX(I) = 0	PBAR0009
DO 10 J=1,200	PBAR0010
10 IBOX(J,I) = 0	PBAR0011
	PBAR0012
CALCULATION OF MEAN SPACINGS	PBAR0013
	PBAR0014
DO 20 LL=1,NGHB	PBAR0015
SUM(LL) = ISUM(LL)	PBAR0016
SMEAN(LL) = SPACES(LL)/SUM(LL)	PBAR0017
20 AVRG(LL) = SMEAN(LL)/FL0ATF(LL)	PBAR0018
	PBAR0019
DISTRIBUTION OF SPACINGS	PBAR0020
	PBAR0021
DO 80 K=1,NM	PBAR0022
READ TAPE KTAPE, I.(NN(LL).(DIFR(I,11),I=1,38),11=1,NGHB)	PBAR0023
DO 80 LL=1,NGHB	PBAR0024
N=NN(LL)	PBAR0025
IF (N) 80,80,30	PBAR0026
30 DO 70 L=1,N	PBAR0027
J = XFIXF(DIFR(L,LL)/(AVRG(LL) * .1)) + 1	PBAR0028
IF (J-200) 50,50,40	PBAR0029
40 J = 200	PBAR0030
50 IF (J-JMAX(LL)) 70,70,60	PBAR0031
60 JMAX(LL) = J	PBAR0032
70 IBOX(J,LL) = IBOX(J,LL) + 1	PBAR0033
80 CONTINUE	PBAR0034
REWIND KTAPE	PBAR0035
	PBAR0036
CALCULATION OF PBAR AND MOMENTS	PBAR0037
	PBAR0038
DO 200 LL=1,NGHB	PBAR0039
X = .05	PBAR0040
LM = LL - 1	PBAR0041
WRITEOUTPUTTAPE6,90,LM,SMEAN(LL)	PBAR0042
90 F0RMA1(1H1,54X,10HNEIGHB0R ,12///40X,12HDELTAX = 0.1,6X,14HMEAN	PBAR0043
1PACING =,1PE10.3////)	PBAR0044
IF (IPBAR) 120,120,100	PBAR0045
100 WRITEOUTPUTTAPE6, 110	PBAR0046
110 F0RMA1(45X,7HX MIDPT,6X,5HC0UNT,8X,5HP-BAR//)	PBAR0047
120 SUMDEL(LL) = SUM(LL) * .1	PBAR0048
SUMP = 0.0	PBAR0049
DO 130 J=1,4	PBAR0050
130 PX(J) = 0.0	PBAR0051
MAX = JMAX(LL)	PBAR0052
DO 180 I = 1,MAX	PBAR0053
PBAR = FL0ATF(1BOX(I,LL))/SUMDEL(LL)	PBAR0054
IF (IPBAR) 160,160,140	PBAR0055

PBAR CALCULATES SPACINGS AND MØMENTS

140 WRITEØUTPUTTAPE6,150,X,IBØX(I,LL),PBAR	PBAR0056
150 FØRMAT(46X,F5.2,I12,1PE18.4)	PBAR0057
160 SUMP = SUMP + PBAR	PBAR0058
DØ 170 J=1,4	PBAR0059
170 PX(J) = PX(J) + PBAR * X**J	PBAR0060
180 X = X + .1	PBAR0061
PMØ = .1 * SUMP	PBAR0062
DØ 190 J=1,4	PBAR0063
190 PM(J) = .1 * PX(J)	PBAR0064
200 WRITEØUTPUTTAPE6,210,ISUM(LL),PMØ,PM	PBAR0065
210 FØRMAT(1HØ,29X,27HTØTAL NUMBER ØF SPACINGS = ,16,//// 3ØX,2HMØ,12X	PBAR0066
1,2HM1,12X,2HM2,12X,2HM3,12X2HM4//25X,1PE11.4,4E14.4)	PBAR0067
CALL EXIT	PBAR0068
END	

SUBROUTINE RANUN

This subroutine is called by the statement:

CALL RANUN (ETA)

It returns with ETA a random number, uniformly distributed on the interval (0,1).

*	FAP			RANUN000
	COUNT	20		RANUN001
*RANUN		PRODUCES A UNIFORMLY DISTRIBUTED RANDOM NUMBER ON (0,1)		RANUN002
	ENTRY	RANUN	CALLED BY CALL RANUN(ETA)	RANUN003
RANUN	LDQ	RA		RANUN004
	MPY	RB		RANUN005
	LLS	5		RANUN006
	ZAC			RANUN007
	LRS	5		RANUN008
	STQ	RA		RANUN009
	LLS	32		RANUN010
	ORA	CH		RANUN011
	FAD	CH		RANUN012
	STO*	1,4		RANUN013
	TRA	2,4		RANUN014
CH	TWU	0		RANUN015
RA	OCT	005343277245		RANUN016
RB	OCT	005343277245		RANUN017
	END			RANUN018

T Y P I C A L
O U T P U T
(FOR PROGRAM I)

INPUT USED

Card 1

```

JTAPE = 12
KTAPE = 3
NM = 200
NGHB = 4
IPBAR = 1
NE = 20

```

Card 2

```

PN      = 3.0
TOL     = .04
XLEV    = 3.0
IXLEV   = 1
NR      = 4

```

20 X 20 MATRIX

OVERLAPPED

200 MATRICES HAVE BEEN USED

RATIO OF LEVEL SPACING = 3.00

ONE EXTRA LEVEL(3.00) PER PAIR OF MATRICES HAS BEEN INSERTED

4 EIGENVALUES HAVE BEEN REMOVED FROM EACH END OF EVERY MATRIX

IF THE NEAREST NEIGHBOR SPACING BETWEEN TWO EIGENVALUES IS LESS
THAN 0.04 THE SMALLER OF THE TWO EIGENVALUES HAS BEEN DELETED

116 EIGENVALUES HAVE BEEN DELETED BECAUSE OF CLOSE SPACINGS

NEIGHBOR 0

DELTA X = 0.1

MEAN SPACING = 5.315E-01

X MIDPT	COUNT	P-BAR
0.05	31	1.0194E-01
0.15	153	5.0312E-01
0.25	195	6.4124E-01
0.35	203	6.6754E-01
0.45	196	6.4452E-01
0.55	209	6.8727E-01
0.65	195	6.4124E-01
0.75	187	6.1493E-01
0.85	167	5.4916E-01
0.95	156	5.1299E-01
1.05	157	5.1628E-01
1.15	159	5.2285E-01
1.25	140	4.6037E-01
1.35	124	4.0776E-01
1.45	130	4.2749E-01
1.55	91	2.9924E-01
1.65	94	3.0911E-01
1.75	83	2.7294E-01
1.85	64	2.1046E-01
1.95	78	2.5649E-01
2.05	40	1.3154E-01
2.15	47	1.5455E-01
2.25	25	8.2210E-02
2.35	33	1.0852E-01
2.45	17	5.5903E-02
2.55	18	5.9191E-02
2.65	19	6.2479E-02
2.75	6	1.9730E-02
2.85	5	1.6442E-02
2.95	3	9.8652E-03
3.05	3	9.8652E-03
3.15	4	1.3154E-02
3.25	2	6.5768E-03
3.35	3	9.8652E-03
3.45	0	0.
3.55	2	6.5768E-03
3.65	1	3.2884E-03
3.75	0	0.
3.85	1	3.2884E-03

TOTAL NUMBER OF SPACINGS = 3041

M0	M1	M2	M3	M4
10.0000E-01	1.0004E 00	1.4051E 00	2.4179E 00	4.7854E 00

NEIGHBOR 1

DELTA X = 0.1 MEAN SPACING = 1.052E 00

X MIDPT	COUNT	P-BAR
0.05	0	0.
0.15	0	0.
0.25	6	2.1119E-02
0.35	4	1.4080E-02
0.45	15	5.2798E-02
0.55	36	1.2672E-01
0.65	52	1.8303E-01
0.75	51	1.7951E-01
0.85	65	2.2879E-01
0.95	74	2.6047E-01
1.05	94	3.3087E-01
1.15	116	4.0831E-01
1.25	113	3.9775E-01
1.35	100	3.5199E-01
1.45	115	4.0479E-01
1.55	131	4.6111E-01
1.65	135	4.7518E-01
1.75	121	4.2591E-01
1.85	132	4.6463E-01
1.95	135	4.7518E-01
2.05	148	5.2094E-01
2.15	129	4.5407E-01
2.25	111	3.9071E-01
2.35	111	3.9071E-01
2.45	100	3.5199E-01
2.55	96	3.3791E-01
2.65	88	3.0975E-01
2.75	83	2.9215E-01
2.85	75	2.6399E-01
2.95	68	2.3935E-01
3.05	57	2.0063E-01
3.15	39	1.3728E-01
3.25	43	1.5136E-01
3.35	30	1.0560E-01
3.45	25	8.7997E-02
3.55	28	9.8557E-02
3.65	18	6.3358E-02
3.75	30	1.0560E-01
3.85	9	3.1679E-02
3.95	10	3.5199E-02
4.05	16	5.6318E-02
4.15	11	3.8719E-02
4.25	4	1.4080E-02
4.35	4	1.4080E-02
4.45	2	7.0398E-03
4.55	2	7.0398E-03
4.65	5	1.7599E-02
4.75	3	1.0560E-02
4.85	0	0.
4.95	1	3.5199E-03

TOTAL NUMBER OF SPACINGS = 2841

M0	M1	M2	M3	M4
10.0000E-01	2.0008E 00	4.6849E 00	1.2355E 01	3.5791E 01

NEIGHBOR 2

DELTA X = 0.1

MEAN SPACING = 1.577E 00

X MIDPT	COUNT	P-BAR
0.05	0	0.
0.15	0	0.
0.25	0	0.
0.35	0	0.
0.45	0	0.
0.55	0	0.
0.65	1	3.7864E-03
0.75	0	0.
0.85	9	3.4078E-02
0.95	6	2.2719E-02
1.05	9	3.4078E-02
1.15	17	6.4370E-02
1.25	20	7.5729E-02
1.35	24	9.0875E-02
1.45	27	1.0223E-01
1.55	43	1.7039E-01
1.65	36	1.3631E-01
1.75	52	1.9690E-01
1.85	73	2.7641E-01
1.95	57	2.1583E-01
2.05	82	3.1049E-01
2.15	69	2.6126E-01
2.25	104	3.9379E-01
2.35	102	3.8622E-01
2.45	110	4.1651E-01
2.55	104	3.9379E-01
2.65	132	4.9981E-01
2.75	120	4.5437E-01
2.85	91	3.4457E-01
2.95	97	3.6729E-01
3.05	89	3.3699E-01
3.15	111	4.2030E-01
3.25	98	3.7107E-01
3.35	88	3.3321E-01
3.45	99	3.7486E-01
3.55	98	3.7107E-01
3.65	89	3.3699E-01
3.75	73	2.7641E-01
3.85	69	2.6126E-01
3.95	46	1.7418E-01
4.05	47	1.7796E-01
4.15	60	2.2719E-01
4.25	34	1.2874E-01
4.35	41	1.5524E-01
4.45	42	1.5903E-01
4.55	31	1.1738E-01
4.65	16	6.0583E-02
4.75	23	8.7088E-02
4.85	19	7.1942E-02
4.95	15	5.6797E-02
5.05	12	4.5437E-02
5.15	10	3.7864E-02

5.25	7	2.6505E-02
5.35	13	4.9224E-02
5.45	3	1.1359E-02
5.55	6	2.2719E-02
5.65	3	1.1359E-02
5.75	4	1.5146E-02
5.85	2	7.5729E-03
5.95	1	3.7864E-03
6.05	1	3.7864E-03
6.15	1	3.7864E-03
6.25	1	3.7864E-03
6.35	1	3.7864E-03
6.45	0	0.
6.55	1	3.7864E-03

TOTAL NUMBER OF SPACINGS = 2641

M0	M1	M2	M3	M4
10.0000E-01	3.0000E 00	9.8902E 00	3.5301E 01	1.3488E 02

NEIGHBOR 3

DELTA X = 0.1

MEAN SPACING = 2.112E 00

X MIDPT	COUNT	P-BAR
0.05	0	0.
0.15	0	0.
0.25	0	0.
0.35	0	0.
0.45	0	0.
0.55	0	0.
0.65	0	0.
0.75	0	0.
0.85	0	0.
0.95	0	0.
1.05	1	4.0967E-03
1.15	1	4.0967E-03
1.25	1	4.0967E-03
1.35	2	8.1934E-03
1.45	2	8.1934E-03
1.55	2	8.1934E-03
1.65	7	2.8677E-02
1.75	6	2.4580E-02
1.85	12	4.9160E-02
1.95	12	4.9160E-02
2.05	7	2.8677E-02
2.15	11	4.5063E-02
2.25	25	1.0242E-01
2.35	31	1.2700E-01
2.45	24	9.8320E-02
2.55	47	1.9254E-01
2.65	50	2.0483E-01
2.75	32	1.3109E-01
2.85	79	3.2364E-01
2.95	54	2.2122E-01
3.05	71	2.9086E-01
3.15	81	3.3183E-01
3.25	81	3.3183E-01
3.35	72	2.9496E-01
3.45	91	3.7280E-01
3.55	77	3.1544E-01
3.65	99	4.0147E-01
3.75	98	4.0147E-01
3.85	94	3.8509E-01
3.95	93	3.8099E-01
4.05	90	3.6870E-01
4.15	79	3.2364E-01
4.25	94	3.8509E-01
4.35	85	3.4822E-01
4.45	77	3.1544E-01
4.55	83	3.4002E-01
4.65	71	2.9086E-01
4.75	68	2.7857E-01
4.85	68	2.7857E-01
4.95	70	2.8677E-01
5.05	49	2.0074E-01
5.15	45	1.8435E-01

5.25	44	1.8025E-01
5.35	44	1.8025E-01
5.45	36	1.4748E-01
5.55	30	1.2290E-01
5.65	24	9.8320E-02
5.75	18	7.3740E-02
5.85	15	6.1450E-02
5.95	12	4.9160E-02
6.05	15	6.1450E-02
6.15	7	2.8677E-02
6.25	7	2.8677E-02
6.35	13	5.3257E-02
6.45	4	1.6387E-02
6.55	7	2.8677E-02
6.65	3	1.2290E-02
6.75	6	2.4580E-02
6.85	5	2.0483E-02
6.95	1	4.0967E-03
7.05	4	1.6387E-02
7.15	2	8.1934E-03
7.25	0	0.
7.35	2	8.1934E-03
7.45	0	0.
7.55	0	0.
7.65	0	0.
7.75	1	4.0967E-03

TOTAL NUMBER OF SPACINGS = 2441

M0	M1	M2	M3	M4
10.0000E-01	4.0003E 00	1.7041E 01	7.6732E 01	3.6303E 02