A computing program derived from Chree's method

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Summary. — A computing program has been actived for having information from stationary time series.

The technique utilized is that of superposed epochs (Chree's method), adapted by using large computers.

This technique gives evidence for a phenomenon and statistical consistency is provided.

The program described elaborates unlimited numbers of data and epochs the maximum length of which is 2000 numerical data.

Riassunto. — È stato fatto un programma di calcolo per ottenere informazioni da serie temporali stazionarie.

La tecnica usata è quella di sovrapposizione di epoche (metodo di Chree), di cui se ne propone una modifica per essere utilizzata con grandi calcolatori.

Si mette in evidenza un fenomeno e se ne discute la consistenza statistica.

Il programma descritto elabora un numero illimitato di dati e di epoche la cui lunghezza massima è fissata in 2000 dati numerici.

Introduction.

In graphic registrations, or tabulations of some quantities, that constitute a stationary time series, the problem that arises is that of testing the consistency of certain particular phenomenon that are noticed in correspondence with determinate physical events (1) (2).

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The graphed or tabulated quantities correspond in some way to these physical events that, by other methods, can be localized in time.

A tipical example is constituted by the oscillations observed in recorded cosmic radiation in correspondence with the sudden commencement of magnetic storms, whose position in time can be found by observing the magnetograms.

The phenomenon we must test can be approximated to the order of the statistical fluctuation (or a little better) of the data series whose registration is examined, and therefore necessitates a particular analysis for determining the characteristics.

In this work we propose a solution to the problem by using the technique of Chree of superposed epochs (3) for using electronic computers and completing it by an ulterior analysis for proving the statistical consistency of the results regarding the width and the duration of the phenomena. Besides, the maximum temporal position is localized which allows us to visualize the bond between the registrated phenomena and the physical events which are bound to it.

METHOD.

A stationary time series can be thought of as a linear combination of type:

$$I(t) = A(t) + \varepsilon\,,$$

being $A(t)$ the systematic part and ε the random one of the series. The aim of pointing out the phenomena according to the type of series which we want to separate, we must utilize a preventive filter operation (1) of which a computing program (5) already exists.

In the numerical filtering steps the reduction of the influences by the random part in the residual series allows to note the phenomenon without modifying the structure.

Let us call $q_r(r = 1,2,\ldots\ldots,n)$ the corresponding values in the recording of the physical events which we consider responsible for the phenomenon that we must examine.

Let us construct the matrix:

$$\left\| \begin{matrix} p_{1,1} & p_{1,2} & p_{1,3} \cdots\cdots p_{2,l} & q_1 & d_{1,1} & d_{1,2} \cdots\cdots d_{1,m} \\ p_{2,1} & p_{2,2} & p_{3,3} \cdots\cdots p_{2,1} & q_2 & d_{2,1} & d_{2,2} \cdots\cdots d_{2,m} \\ - - - - & - - - - & - - - - & - - & - - - - & - - - - \\ - - - - & - - - - & & - - & - - - - & - - - - \\ p_{n,1} & p_{n,2} & p_{n,3} \cdots\cdots p_{n,l} & q_n & d_{n,1} & d_{n,2} \cdots\cdots d_{n,m} \end{matrix} \right\|$$

being $p_{s,r}(s = 1,2,\ldots\ldots l)$ the numerical values of the l positions preceeding the position of the event q_r and $d_{t,r}$ the values of the m positions following.

Each row of the matrix, $n \times R$ $(R = l + m + 1)$, contains the elements of each one of the n epochs (3).

As for random part, between the variance of $y_i(i = 1,2,\ldots\ldots,r)$ (obtained by adding and by averaging per columns the elements of the matrix:

$$y_i = \frac{1}{n}\sum_{r=1}^{n} p_{r,i} \qquad (i = 1,2,\ldots\ldots l)$$

$$y_{l+1} = \frac{1}{n}\sum_{r=1}^{n} q_r$$

$$y_{i+l+1} = \frac{1}{n}\sum_{r=1}^{n} d_{r,i} \qquad (i = 1,2,\ldots\ldots m)$$

of which S_e^2 is the estimate) and the mean variance of each of the n epochs (of which S^2 constitues the estimate) is the relation

$$\bar{S}^2 = n\, S_e^2\,.$$

The standard deviation S_e^2 is

$$s.\,d.\,(S^2) = S_e^2 \sqrt{\frac{2}{R-1}} = \frac{S^2}{n}\sqrt{\frac{2}{R-1}}\,.$$

Finally:

$$S = \sqrt{\frac{R-1}{2}}\left(n\,\frac{S_e^2}{S^2} - 1\right). \qquad [1]$$

Being n the number of the superposed epochs, represents, in standard deviation units the true shift of the data series from random behaviour, and S is the significance level of the phenomenon in the series.

The lenght R of the epoch depends from the physical problem examined. The preceding $(p_{s,r})$ and successive $(d_{t,r})$ data of the event may be equally populated $(l = m)$.

Since the effects of a certain physical event are generally allayed in the recordings, whether for the inertia of the system on which it acts or by the recorder that smooths the various phenomena exploring them in a large width, a time contraction of the elements forming the epoch is elaborated. Such an operation permits a better localisation of the phenomenon studied and ulteriorly decreases that statistical fluctuation of the series.

The problem studied will guide the choice of such a contraction. The relation (1) is modified:

$$S(k) = \sqrt{\frac{\frac{R}{k} - 1}{2}\left(n\, k \cdot \frac{S_{ek}^2}{\bar{S}^2} - 1\right)} \qquad \left(\frac{R}{k} \text{ integer}\right)$$

being k the order of the temporal contraction S_{ek}^2 the variance of the contracted mean epoch.

A rigth representation of $S(k)$ will permits useful considerations on the localisation and duration of the phenomena studied.

Description of the program.

The program has been carried out at " Centro di Calcolo del CNEN " in Bologna using the FORTRAN IV language versione 13 under the IBSYS 7094/7040 DCS monitor control.

The data number that can be elaborated is pratically unlimited; the maximum allowed number of elements of the epoch is 2000. This number is extremely sufficient for many problems but it can also be increased by modifying the appropriate statements.

The number n of superposed epochs is 200. This number may be increased by modifying the appropriate statement, but attention must be made in order of the approximation due to the machine representation of the value of the elements, that arises when mean epoch is computed.

The program allows also to group, k by k, the set of elements in the mean epoch for giving an epoch whose variance is k times less than that of the original mean epoch.

This procedure allows a better accuracy in the computing of the average width of the studied event without phase changes, because, if k is odd, y_{i+1} will always be in the middle of the interval of the obtained epoch.

The program can also be informed to ignore the not good elements of the series without modifying the input data series cards.

It is useful to note $\bar{S}^2$ is computed not using the mean of the variances of each row, but the mean of the variances concerning the consecutive epochs, each R elements long, obtained considering all the time data series (except the not good elements); the variance computed in this way tends to the true variance of the series.

OUTPUT.

Normally we can obtain a following list:

a) input tape (NTPI)
b) number of data per input card (NDS)
c) input FORMAT (FR1)
d) print FORMAT (FR2)
e) punch FORMAT (FR3)
f) number of superposed epochs or q (NKPO)
g) number of p (NOPR)
h) number of d (NODO)
i) index of q positions in time-series (KPO)
j) number of utilized data
k) number of consecutive epochs
l) mean epoch information:
 1) mean variance (ISGR2)
 2) standard deviation (SE)
 3) variance (SIGMA)
 4) significance level (S)
 5) $\text{DIFVER} = \text{SIGMA} - \dfrac{\text{SIGR2}}{\text{NKPO}}$
m) length of mean epoch (R)
n) elements of mean epoch (ELM)
o) grouped epoch information:
 1) number of elements (R)
 2) GROUPS
 3) SIGMA
 4) S
 5) DIFVER
p) local maxima of S are computed and the following information are listed:
 1) S
 2) SIGMA
 3) type of groupping (GROUPS)
 4) R

If the restart procedure is required, the normal list is like the proceeding from *l*) to *p*).

If the program recognizes errors during his flow appropriate diagnostics are printed.

ORDER OF DATA CARDS DECK SET-UP.

All cards must be included in the order shown below,

a) *Start procedure* (Fig. 1)

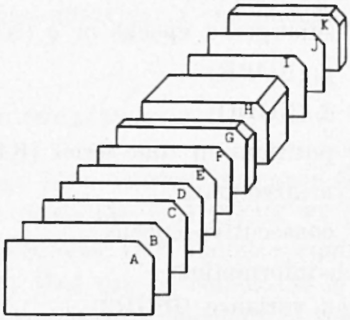

Fig. 1

A Parameter card for starting and groupping
B Variable format card for time series input data
C Variable format card for printout mean epoch
D Variable format card for punched input epoch
E Time series data parameter card
F Epoch parameter card
G q_i index card
H Time series data
I END punched in col. 1 — 3
J Number of groups to be discarded
K Index of group to be discarded

b) *Restart procedure* (Fig. 2)

A Parameter card for restarting and groupping
B Blank card

C Like in a)

D Like in a)

L Mean epoch parameter card

M Mean epoch elements.

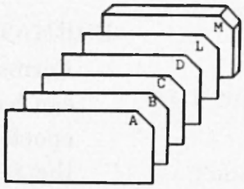

Fig. 2

CARD PREPARATION.

Card columns	Corresponding variable	Description
**A* card*		FORMAT (4I3)
1-2	KTEST	— = 1 if restart procedure is required ≠ 1 if start procedure is required
3-4	KRAI	— Initial groupping. Must always be KRAI > 1.
5-6	KRAF	— Last groupping. Must always be KRAF ⩾ KRAI.
7-8	KRAP	— Step for executing intermediate grouppings.
**B* card*		FORMAT (20A4)
1-80	FRI	— Format of time series input data. It must be like (A3, specifications for input data). Columns 1-3 cannot be used. This restriction is used to allow an indefinite number of time series input data cards, the end of which is reached when the program read the *I* card.

Card columns	Corresponding variable	Description
**C* card*		FORMAT (20A4)
1-80	FR2	— Format of output data to be put on standard output tape.
**D* card*		FORMAT (20A4)
1-80	FR3	— Format according which one can have the elements of mean epoch on logical tape 8, from the second record on.
**E* card*		FORMAT (4I3)
1-2	NDS	— Number of time series data contained in each input card.
3-4	NTPI	— Logical tape number of input (5 if input is from punched cards).
5-6	KE	— Number of decimal figures if conversion is used (*).
7-8	IT	— > 0 if input conversion is required (*)
		— $\leqslant 0$ if input conversion not required (*).
**F* card*		FORMAT (3I3)
1-2	NKPO	— Number of superposed epochs
3-4	NOPR	— Number of elements preceding q_i in the epoch
5-6	NODO	— Number of elements successive to q_i in the epoch.

(*) One must use conversion when time series input data are punched as integer constants having the sign (hole zone) over the less significant figure of the number. In this case each field of width w containing the number, is considered like it were formed of two sequential fields: the 1st of integer-type of width w-*1*, the 2nd of alphanumeric-type of width *1*. i.e.: if number 12.125 is punched according to the format specification *F*7.3 no conversion is required, being a Fortran number (in this case $IT = O$). The character string 1212N (where N means holes 5 and 11, minus sign overpunched) columns of the card, punched in a field of width $w = 5$ for having the same value as the above one, must be read according to the format specification I4, A1 and *must* be $KE = 3$ (decimal figures of the number) and $IT \neq 0$.

Card columns	Corresponding variable	Description
**G* card*		FORMAT (16I5)
1-n	KPO	— Index of q_i in the time series input (*H* card).
($n \leqslant 80$)		
**H* card*		FR1 format (see *B* card)
4-n	EL	
($n \leqslant 80$)	(KA, KB)	— Time series input data.
**I* card*		FORMAT (A3)
1-3	KEND	— The work END *must* be punched in the corresponding columns. This card notifies the program that all the cards containing time series input data have been read.
**J* card*		FORMAT (I3)
1-3	NGRU	— Number of groups of elements to be discarded. If no groups be discarded NGRU = O or blank.
**K* card*		FORMAT (8(2I5, 3X))
	NGRUI, NGRUF...	— Index of the initial and last elements for each group to be discarded among the time series input data. — If NGRU = O or blank this card must be omitted.
**L* card*		FORMAT (I4, 2I3, 5E14.6)
	This card may be punched from the first record on logical tape 8.	
1-4	LEPO	— Number of elements of the mean epoch.
5-7	NOPR	— See *F* card.
8-10	NKPO	— See *F* card.

Card columns	Corresponding variable	Description
**L* card* (cont.)		
11-24	SIGMA (1)	— Variance of the mean epoch.
25-38	S (1)	— Significance level of the mean epoch.
39-52	SIGR2	— Mean variance of data series.
53-66	SE	— Standard deviation of data series.
67-80	DIFVER (1)	SIGMA (1) – SIGR2/NKPO
**M* card*		FR3 format (see *D* card)
	ELM	— Elements of mean epoch. They may be punched from the second record on from logical tipe 8.

Comment.

In the following pages it has been reproduced the list of the described program.

The authors have mainly contributed each in their activity field.

Timing.

1) It takes 7″ to elaborate 1000 elements of stationary time series, the length of the epoch being 100, corresponding to $n = 10$, to group from 1 to 10 step 1, and to find the local maxima.

2) It takes 1″ to elaborate the restart procedure groupping from 4 to 9.

Acknowledgement.

Prof. E. Clementel made easy the IBM 7094/7040 DCS computers utilisation at the Centro di Calcolo del CNEN in Bologna (SHARE Installation BI).

```
$IBFTC EPO      M94,XR7,LIST
C
C=================================================================
C                         E P O C H S
C=================================================================
C
      DIMENSIGN FR1(20),FR2(20),FR3(20),KPO(100),KA(80),KB(80),EL(80),
     1          NGRUI(100),NGRUF(100), LEFF(2000), ELM(2000),KDIV(2000),
     2          LEPOM(100),SIGMA(100), S(100),ELM1(2000),DIFVER(100)
      DATA KALT/3HEND/
      WRITE(6,901)
C
C=================================================================
C  INPUT OF PARAMETERS
C=================================================================
C
      READ(5,5) KTEST,KRAI,KRAF,KRAP
      READ(5,15) FR1,FR2,FR3
      IF(KTEST.EQ.1) GO TO 440
      READ(5,5) NDS,NTPI,KE,IT
      KE=10**KE
      READ(5,5) NKPO,NOPR,NODO
      REAC(5,25) (KPO(I),I=1,NKPO)
      WRITE(6,902) NTPI,NDS,FR1,FR2,FR3,NKPO,NOPR,NODO
      WRITE(6,903)(KPO(I),I=1,NKPO)
C
C=================================================================
C  INPUT OF DATA (NDS PER CARD) AND RECORDING ON BINARY TAPE 3 (NDS PER
C  RECORD
C=================================================================
C
      REWIND 3
      NREC=0
      IF(IT.LE.0)GO TO 500
  501 READ(NTPI,FR1)KFIN,(KA(J),KB(J),J=1,NDS)
      IF(KFIN.EQ.KALT)GO TO 502
      DO 503 J=1,NDS
      KB(1)=MOD(KB(J)/KIFT,16)
  503 EL(J)=ISIGN(KA(J)*10+IABS(MOD(KB(1),10)),KB(1))/KE
      NREC=NREC+1
      WRITE(3)(EL(J),J=1,NDS)
      GO TO 501
  500 READ(NTPI,FR1)KFIN,(EL(J),J=1,NDS)
      IF(KFIN.EQ.KALT)GO TO 502
      NREC=NREC+1
      WRITE(3)(EL(J),J=1,NDS)
      GC TO 500
  502 NTOT=NREC*NDS
      REWIND 3
C
C=================================================================
C  COMPUTATION OF VARIANCE CONCERNING EACH EPOCH
C=================================================================
C
      LEPO=NOPR+NODO+1
      NTEPO=NTOT/LEPO
      NTOTAL=NTEPO*LEPO
      WRITE(6,904)NTOTAL,NTEPO
```

```
      READ(5,4)NGRU
      IF(NGRU.EQ.0)GO TO 720
      READ(5,6)(NGRUI(I),NGRUF(I),I=1,NGRU)
      WRITE(6,905)NGRU
      WRITE(6,906)(NGRUI(I),NGRUF(I),I=1,NGRU)
  720 DO 701 I=1,NTEPO
  701 LEFF(I)=LEPO
      SIG2=0.
      TOT=0.
      SIGR=0.
      K=0
      JJ=1
      II=1
      NC=0
      DO 400 L=1,NREC
      READ(3)(EL(J),J=1,NDS)
      DO 401 I=1,NDS
      IF(II.GT.NGRU)GO TO 704
      NC=NC+1
      IF(NC.GE.NGRUI(II).AND.NC.LE.NGRUF(II))GO TO 702
      IF(NC.GT.NGRUF(II))II=II+1
  704 TOT=TOT+EL(I)
      SIG2=SIG2+EL(I)*EL(I)
  703 K=K+1
      IF(K.NE.LEPO)GO TO 401
      SIG2=(SIG2-TOT*TOT/FLOAT(LEFF(JJ)))/(FLOAT(LEFF(JJ))-1.)
      SIGR=SIGR+SIG2
      TOT=0.
      SIG2=0.
      K=0
      JJ=JJ+1
      GO TO 401
  702 LEFF(JJ)=LEFF(JJ)-1
      GO TO 703
  401 CONTINUE
  400 CONTINUE
      SIGR2=SIGR/FLOAT(NTEPO)
C
C======================================================================
C  COMPUTATION OF MEAN EPOCH
C======================================================================
C
      DO 411 I=1,LEPO
      KDIV(I)=NKPO
  411 ELM(I)=0.
      DO 412 I=1,NKPO
      LEPOM(I)=LEPO
      KPO(I)=KPC(I)-NOPR
      IF(KPC(I).GT.0) GO TO 412
      KF=IABS(KPO(I))+1
      DO 732 K=1,KF
  732 KDIV(K)=KDIV(K)-1
      LEPOM(I)=LEPOM(I)-KF
      KPO(I)=KPO(I)+KF
  412 CONTINUE
      DO 413 L=1,NKPO
      REWIND 3
      I=1
```

```
      II=1
      I2=1
      J=LEPO -LEPOM(L)
      IF(NGRU.GT.0)GO TO 711
      I=2
      I2=2
  711 DO 414 L1=1,NREC
      READ(3) (EL(L2),L2=1,NDS)
      KT=NDS*(L1-1)
      DO 414 L2=1,NDS
      KI=KT+L2
      IF(KI.LT.KPO(L)) GO TO 414
      J=J+1
      IF(J.GT.LEPO) GO TO 413
      GO TO (705,706),I
  705 DO 710 IG=1,NGRU
      IF(KI.LE.NGRUI(II).OR.KI.LE.NGRUF(II)) GO TO 708
  710 II=II+1
      I2=2
  706 GO TO (708,709),I2
  708 IF(KI.GE.NGRUI(II).AND.KI.LE.NGRUF(II))GO TO 707
      IF(KI.GT.NGRUF(II)) II=II+1
      IF(II.GT.NGRU) I2=2
  709 ELM(J)=ELM(J)+EL(L2)
      GO TO 414
  707 KDIV(J)=KDIV(J)-1
      I=2
  414 CONTINUE
      IF(J.GT.LEPO) GO TO 413
      J1=J+1
      DO 416 K=J1,LEPO
      KDIV(K)=KDIV(K)-1
  416 CONTINUE
  413 CONTINUE
C
C=======================================================================
C  COMPUTATION OF STANDARD DEVIATION
C=======================================================================
C
      TSIGR2=SIGR2/FLOAT(NKPO)
      SE-TSIGR2*SQRT(2./FLOAT(LEPO-1))
C
C=======================================================================
C  LINEAR INTERPOLATION
C=======================================================================
C
      IZF=0
      DO 415 I=1,LEPO
      IF(KDIV(I).EQ.0)GO TO 733
      ELM(I)=ELM(I)/FLOAT(KDIV(I))
      GO TO 415
  733 IF(IZF.EQ.0)WRITE(6,909)
      IZF=1
      WRITE(6,417)I
  415 CONTINUE
      J=1
      IN=1
      IF=1
```

```
      DO 421 I=1,LEPO
      IF(KDIV(I).NE.0)GO TO 422
      IF(J.EQ.2)GO TO 423
      J=2
      IN=I
  423 IF=I
      GO TO 421
  422 IF(J.EQ.1)GO TO 421
      J=1
      IF(IN.EQ.1)GO TO 426
      IF(IF.EQ.LEPO)GO TO 428
      IF(IN.EQ.LEPO)GO TO 429
      EME=(ELM(IF+1)-ELM(IN-1))/FLOAT(IF-IN+2)
  427 DO 425 IM=IN,IF
      IM1=IM
  425 ELM(IM)=ELM(IM1-1)+EME
      GO TO 421
  426 IF(IF.EQ.LEPO)GO TO 431
      IN=1
      EME=ELM(IF+1)
  432 DO 430 IM=IN,IF
  430 ELM(IM)=EME
      GO TO 421
  431 WRITE(6,910)
      GO TO 678
  428 EME=ELM(IN-1)
      GO TO 432
  429 ELM(LEPO)=ELM(LEPO-1)
  421 CONTINUE
      TKPO=NKPO
      CALL VAR(ELM,SIGMA,S,1,LEPO,1.,TKPO,SIGR2,DIFVER)
      I3=3
  912 WRITE(6,907)SIGR2,SE,SIGMA(1),S(1),DIFVER(1)
      WRITE(6,601)LEPO
      WRITE(6,FR2)(ELM(J),J=1,LEPO)
      WRITE(8,908)LEPO,NOPR,NKPO,SIGMA(1),S(1),SIGR2,SE,DIFVER(1)
      WRITE(8,FR3)(ELM(J),J=1,LEPO)
      KK=1
      WRITE(6,1010)LEPO,KK,SIGMA(KK),S(KK),DIFVER(KK)
      IF(KTEST.EQ.1) KK=KRAI-1
      DO 610 KRA=KRAI,KRAF,KRAP
      IF(KRA.EQ.1)GO TO 610
      KK=KK+1
      CALL RAC(ELM,ELM1,LEPO,NOPR,KRA,LEPRA,IER)
      IF(IER.EQ.1)GO TO 640
      WRITE(6,641)KK,NOPR,KRA
      KK=KK-1
      GO TO 642
  640 TKRA=KRA
      CALL VAR(ELM1,SIGMA,S,KK,LEPRA,TKRA,TKPO,SIGR2,DIFVER)
  610 CONTINUE
C
C=========================================================================
C  LOCAL MAXIMA OF SIGNIFICANCE LEVEL
C=========================================================================
C
      WRITE(6,647)
  642 IF(KK.GE.I3)GO TO 644
```

```
      WRITE(6,643)KK
      GO TO 678
C
  644 DC 645 I=I3,KK
      II=I
      IF(S(II-2).GE.S(II-1).OR.S(II-1).LE.S(I))GC TC 645
      KRA=KRAI+(II-I3)*KRAP
      IF(KTEST.EQ.1) KRA=KRA+1
      CALL RAG(ELM,ELM1,LEPO,NOPR,KRA,LEPRA,IER)
      WRITE(6,646)S(II-1),SIGMA(II-1),KRA,KRA,LEPRA
  645 CONTINUE
  678 WRITE(6,914)
      END FILE 8
      STOP
C
C==================================================================
C  IF KTEST=1  INPUT OF MEAN EPCCH TO RESTART A FCRMER COMPUTATION
C==================================================================
C
  440 READ(5,908)LEPO,NOPR,NKPO,SIGMA(1),S(1),SIGR2,SE,DIFVER(1)
      TKPO=NKPO
      I3=KRAI+2
      WRITE(6,916)
      READ(5,FR3)(ELM(I),I=1,LEPO)
      GO TO 912
C
C==================================================================
C
    4 FORMAT(I3)
    5 FORMAT(4I3)
    6 FORMAT(8(2I5,3X))
   15 FCRMAT(20A4)
   25 FORMAT(16I5)
  417 FORMAT( 15X,I6)
  601 FCRMAT(1H1,10X,15HMEAN EPCCH  R =I6/11X,10(1H-),///)
  641 FORMAT(1H1,10X,16HGROUPPING NUMBERI3,15H CANNOT BE MADE5X,6HNOPR =
     1I6,10X,5HKRA =I5)
  643 FORMAT(1H0,10X,15HTHE GROUPS ARE I2,41H . THE LOCAL MAXIMUM CANNOT
     1 BE DETERMINED)
  646 FORMAT(1HC,10X,3HS =E14.6, 8X,7HSIGMA =E14.6, 8X,8HGROUPING,I4,3H
     1BY,I3,8X,3HR =,I5)
  647 FCRMAT(1H1,10X,12HLOCAL MAXIMA/11X,12(1H-),///)
  901 FCRMAT(1H1,10X,11HE P O C H S/11X,11(1H-),///)
  902 FCRMAT(11X,10HINPUT TAPEI3/11X,13HDATA PER CARDI4/11X21HTHE INPUT
     1FCRMAT IS  20A4/11X,21HTHE PRINT FORMAT IS  20A4/11X,21HTHE PUNCH
     2FCRMAT IS  20A4///11X,21HNUMBER OF POINTS Q(I)I4/11X,34HNUMBER OF
     3THE ELEMENTS PRECEDING QI4/11X,34HNUMBER OF THE ELEMENTS FOLLOWING
     4 QI4)
  903 FORMAT(11X,31HINDEX OF SUPERPOSED PCINTS Q(I)//,(11X,16I6))
  904 FORMAT(1H0,10X,27HNUMBER OF UTILIZED ELEMENTSI8/11X,28HNUMBER OF C
     1ONSECUTIVE EPOCHSI6)
  905 FORMAT(1HC,10X,51HNUMBER OF GROUPS OF CCNSECUTIVE ELEMENTS TO DISC
     1ARDI4)
  906 FORMAT(11X,66HINDEXES OF THE FIRST AND THE LAST ELEMENT TO DISCARD
     1 IN EACH GROUP//,(11X,5(2I6,3H * )))
  907 FORMAT(1HC,10X,21HMEAN VARIANCE    SIGR2E15.6/
     1 11X,23HSTANDARD DEVIATION   SEE15.6/
     2 11X,30HVARIANCE OF MEAN EPOCH   SIGMAE15.6/
```

```
     3 11X,22HSIGNIFICANCE LEVEL    SE15.6/
     4 11X,64HVARIANCE OF MEAN EPOCH - MEAN VARIANCE/NUMBER OF EPOCHS
     5DIFVERE15.6////)
  908 FORMAT(I4,2I3,5E14.6)
  909 FORMAT(1H0,10X,48HINDEX OF INTERPOLATED ELEMENTS IN THE MEAN EPOCH
     1)
  910 FORMAT(1H1,10X,40HTHE ELEMENTS OF MEAN EPOCH ARE ALL ZEROS)
  914 FORMAT(1H0,10X,10HEND OF JOB/11X,10(1H=))
  916 FORMAT(1H1,///,11X,31HRESTART OF A FORMER COMPUTATION/11X,31(1H-),
     1///)
 1010 FORMAT(1H0/1H0, 7X,1HR,7X,6HGROUPS,10X,5HSIGMA,17X,1HS,16X,6HDIFVE
     1R//2I10,3E20.6)
C
C=======================================================================
C
      END
$IBFTC VRI     M94,XR7,LIST
      SUBROUTINE VAR(EPO,SIGMA,S,KK,LUP,TKRA,TKPO,SIGR2,DIFVER)
C
C=======================================================================
      DIMENSION EPO(1),SIGMA(1),S(1),DIFVER(1)
C=======================================================================
C
      TL=LUP
      DIF=SIGR2/TKPO
      TOT=0.
      SIGMA(KK)=0.
      DO 1 I=1,LUP
      TOT=TOT+EPO(I)
      SIGMA(KK)=SIGMA(KK)+EPO(I)*EPO(I)
    1 CONTINUE
      SIGMA(KK)=(SIGMA(KK)-TOT*TOT/TL)/(TL-1.)
      S(KK)=SQRT((TL-1.)/2.)*(TKPO*TKRA*SIGMA(KK)/SIGR2-1.)
      DIFVER(KK)=SIGMA(KK)-DIF
      IF(KK.EQ.1) RETURN
      WRITE(6,2) LUP,KK,SIGMA(KK),S(KK),DIFVER(KK)
      RETURN
    2 FORMAT(2I10,3E20.6)
      END
$IBFTC RGR     M94,XR7,LIST
      SUBROUTINE RAG(EPOR,EPKK,LEPO,NOPR,KRA,LEPRA,IER)
C
C=======================================================================
      DIMENSION EPOR(1),EPKK(1)
C=======================================================================
C
      IER=1
      NO=NOPR-KRA/2
      IF(NO.LT.KRA)GO TO 1
      IN=MOD(NO,KRA)+1
      GO TO 2
    1 IF(NO.LT.0)GO TO 7
      IN=NO+1
    2 I1=IN
      I2=IN+KRA-1
      LEPRA=(LEPO-IN+1)/KRA
      DO 3 I=1,LEPRA
      EPKK(I)=EPOR(I1)
```

```
  I1=I1+1
  DO 4 J=I1,I2
4 EPKK(I)=EPKK(I)+EPOR(J)
  I1=I2+1
  I2=I2+KRA
3 CONTINUE
  DO 5 I=1,LEPRA
5 EPKK(I)=EPKK(I)/FLOAT(KRA)
  RETURN
7 IER=2
  RETURN
  END
```

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