JH Potacki

SIMULATIONS OF DIRECTIONALLY-SPREAD WAVES

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Edinburgh Wave Power Project

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late 1976

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Contents

Introduction

The pictures which follow are designed to give a first impression of what is happening at points along the backbone of a duck string in a directionally spread sea; in particular, to look at the correlation between wave-records and instantaneous power at pairs of points at varying distances.

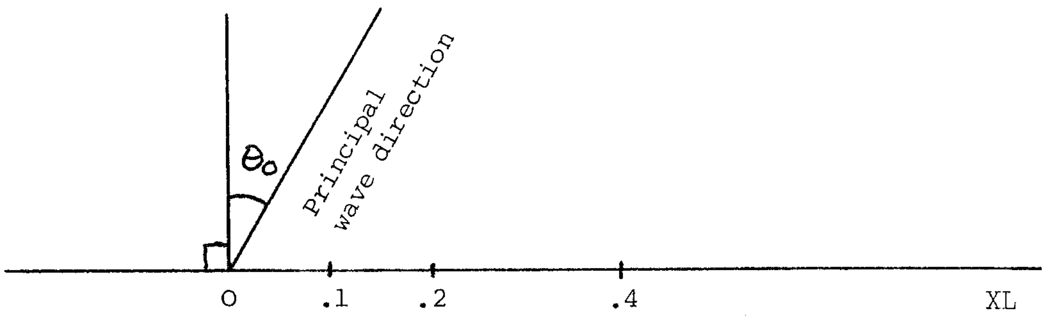
The wave records have been simulated using a Pierson-Moskowitz spectrum (with low frequency cut-off at 3 x Te), and directional spreading of both $\cos^s(\theta - \theta_o)$ form (s independent of frequency) and the Mitsuyasu form

$$\cos^{s_\omega}(\tfrac{1}{2}(\theta - \theta_o)) \quad \text{where} \quad s_\omega = 15.85 \left(\frac{\omega}{\omega_o}\right)^5 \quad \text{for } \omega < \omega_o$$

$$= 15.85 \left(\frac{\omega_o}{\omega}\right)^{2.5} \quad \text{for } \omega > \omega_o$$

Wave records and instantaneous power records (with power measured simply in terms of the vertical water movement - this is not the right phase for a real duck) are shown for just a part of the simulation period ($100 < t/Te < 110$ out of a total 204.8 Te simulation). The histograms on the right-hand page, showing the distribution of POW IN in terms of instantaneous power, were calculated over the whole simulation period.

Records are shown at an origin (first record, repeated as a dotted line on top of each subsequent record), and at distances $x = XL \times \lambda_e$ ($\lambda_e = (g/2\pi)Te^2$) along a backbone. The principal wave direction θ_o (THØ) is given relative to the perpendicular to the backbone, thus:

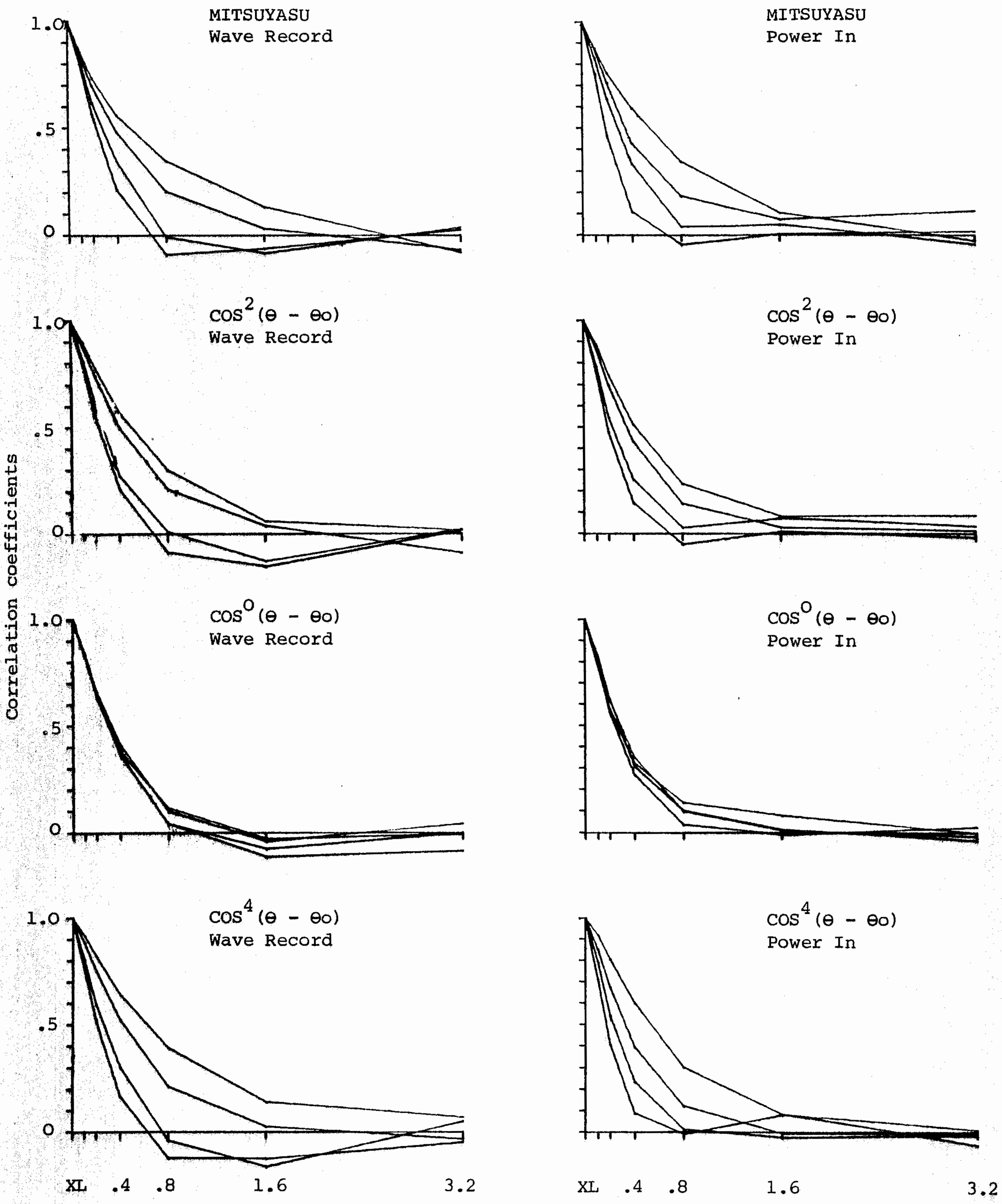


backbone

Units: time is in units of Te, height in units of H_{rms}, and power in units of average power (POW IN which is a %age of the total power POW depending on the spreading function).

Correlation coefficients between records at x and O are given for each x. Graphs of these correlation coefficients are shown on page 3.

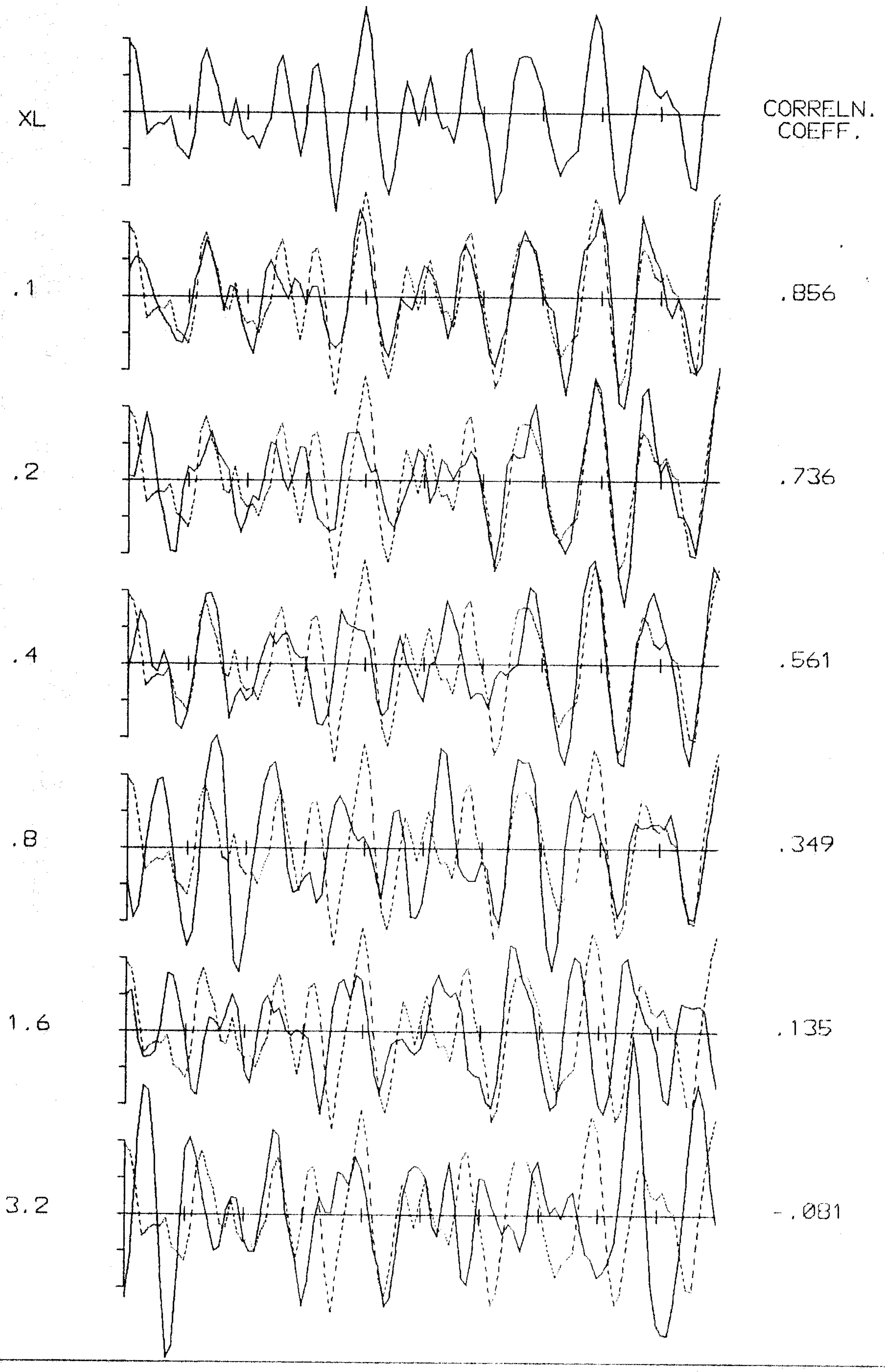
Note: The simulations decrease in reliability as θo increases, because the number of spectral components contributing to the power decreases. Thus the simulations with θo greater than about 60^o should be taken with a pinch of salt (especially the Mitsuyasu and $\cos^4\theta$ which are most directionally concentrated).

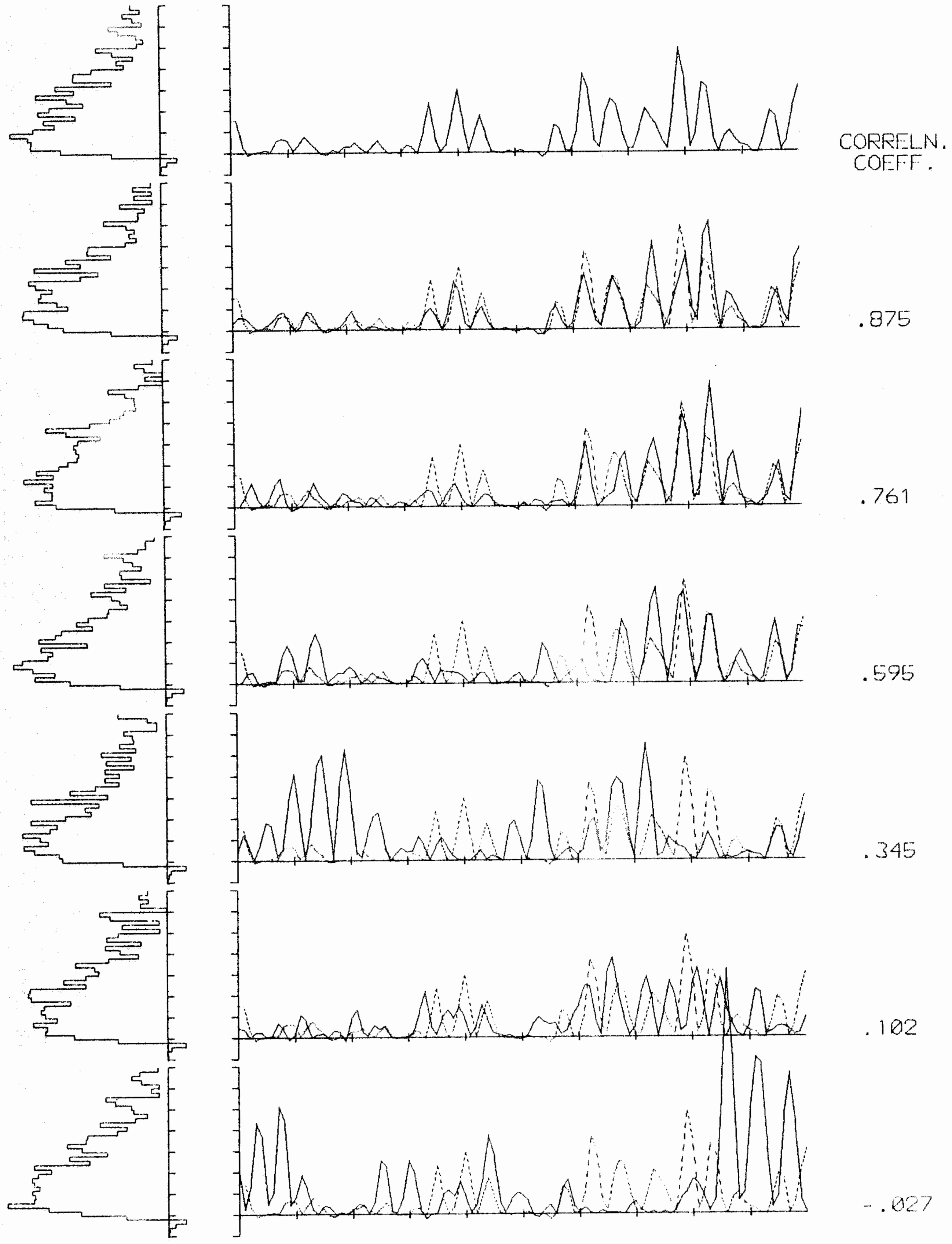


<u>CORRELATION SUMMARIES</u>

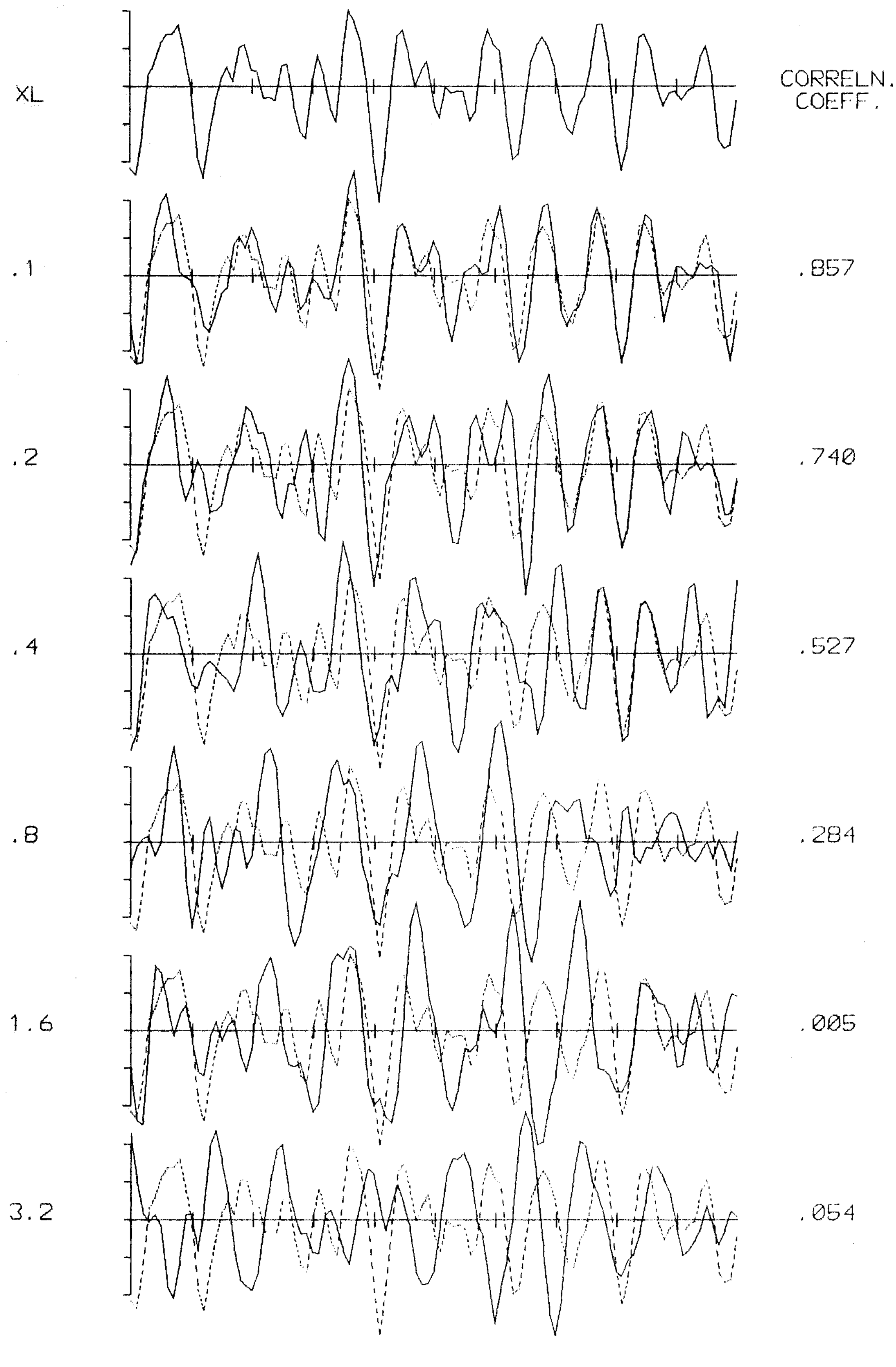
Correlation coefficients for wave-records (left) and power in (right) are plotted against XL for the four different spreading functions; in each case for (from top to bottom) $\theta o = 0^{\circ}, 30^{\circ}, 80^{\circ}$ and 90°.

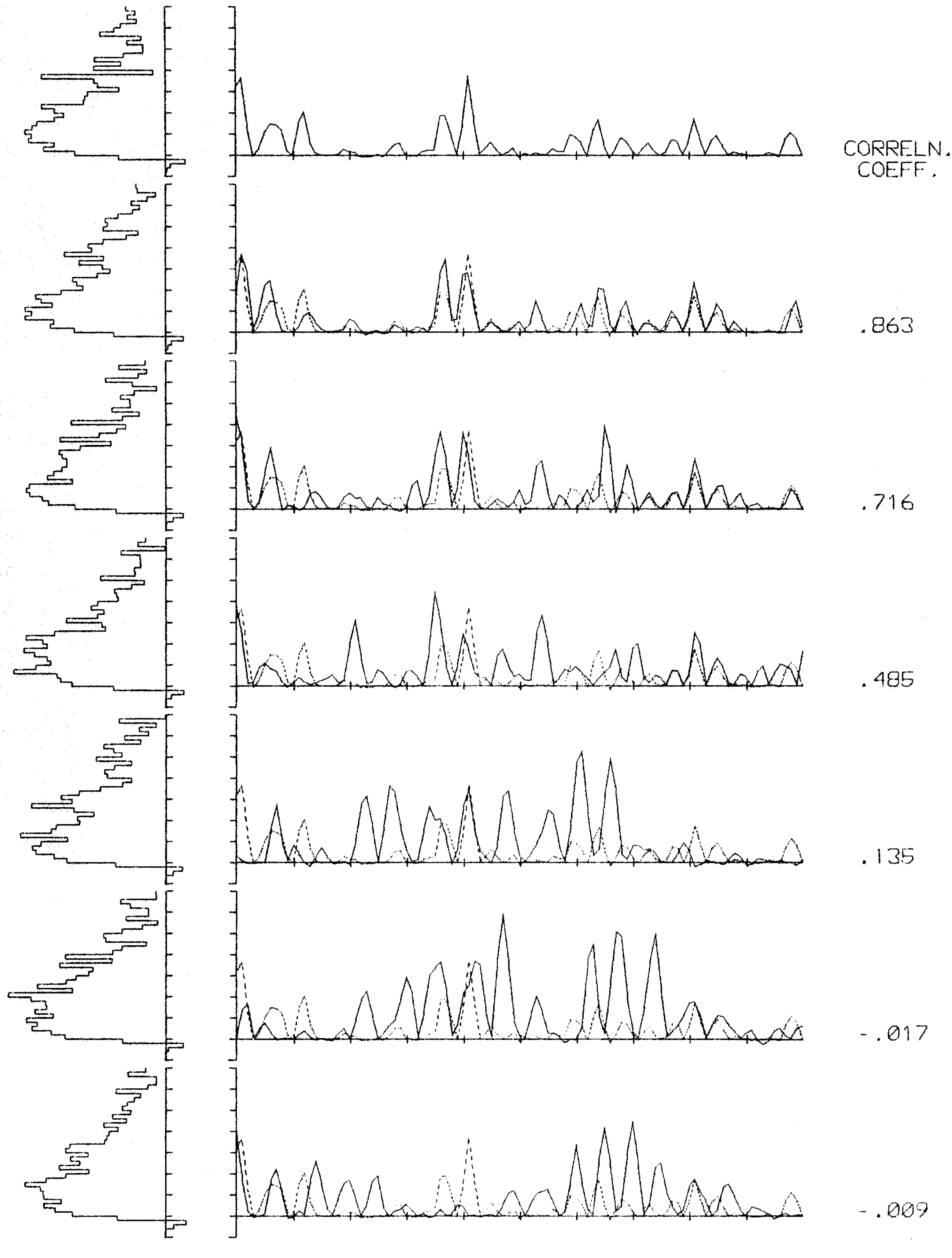
```
THØ   NL   IR
 Ø     6   1342
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE   =  9.998
HRMS=`  1.ØØØ
POW IN = 61.27(  78.4 % OF POW)
```



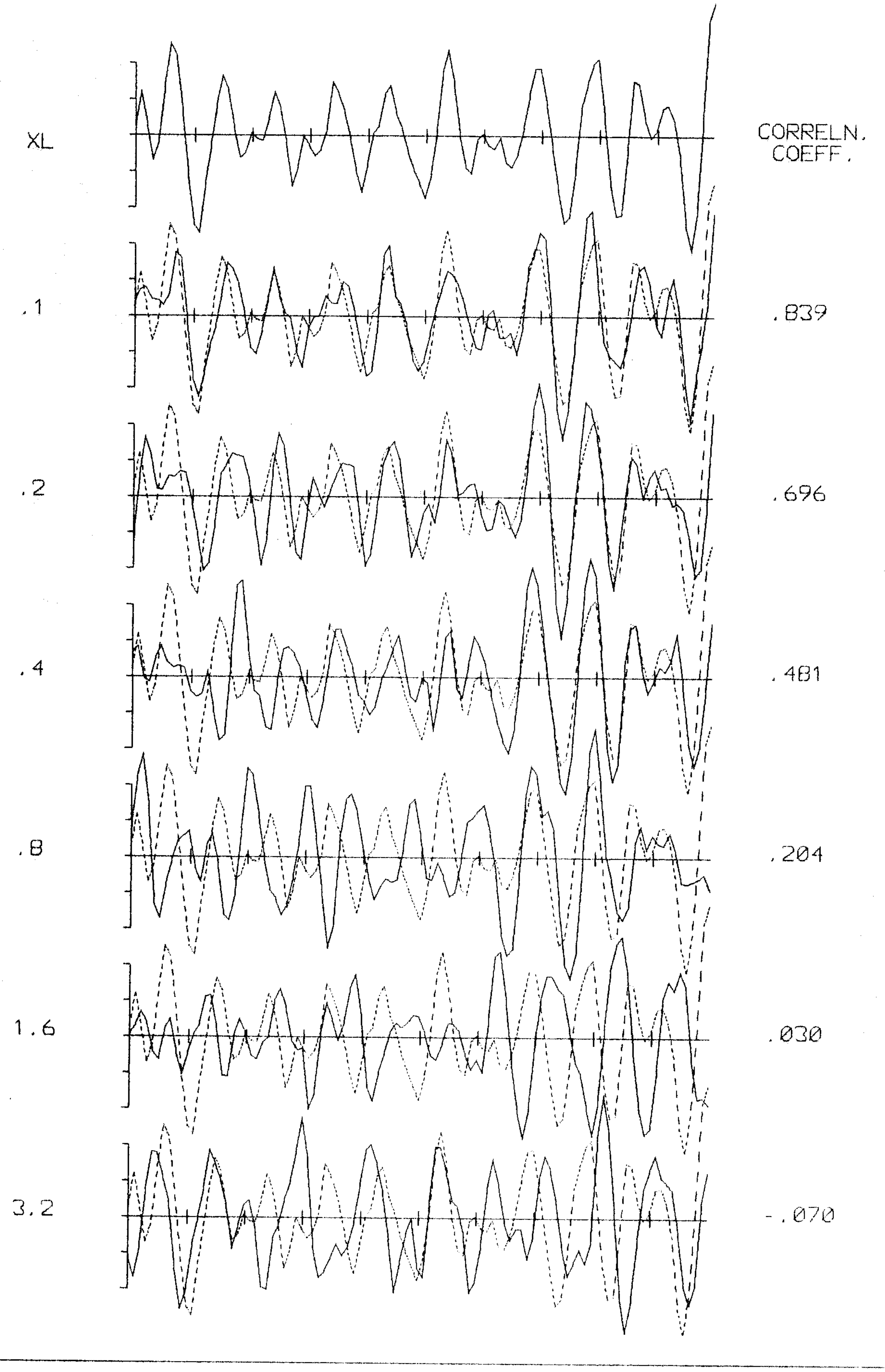

CORRELN.
COEFF.
.875
.761
.595
.345
.102
-.027

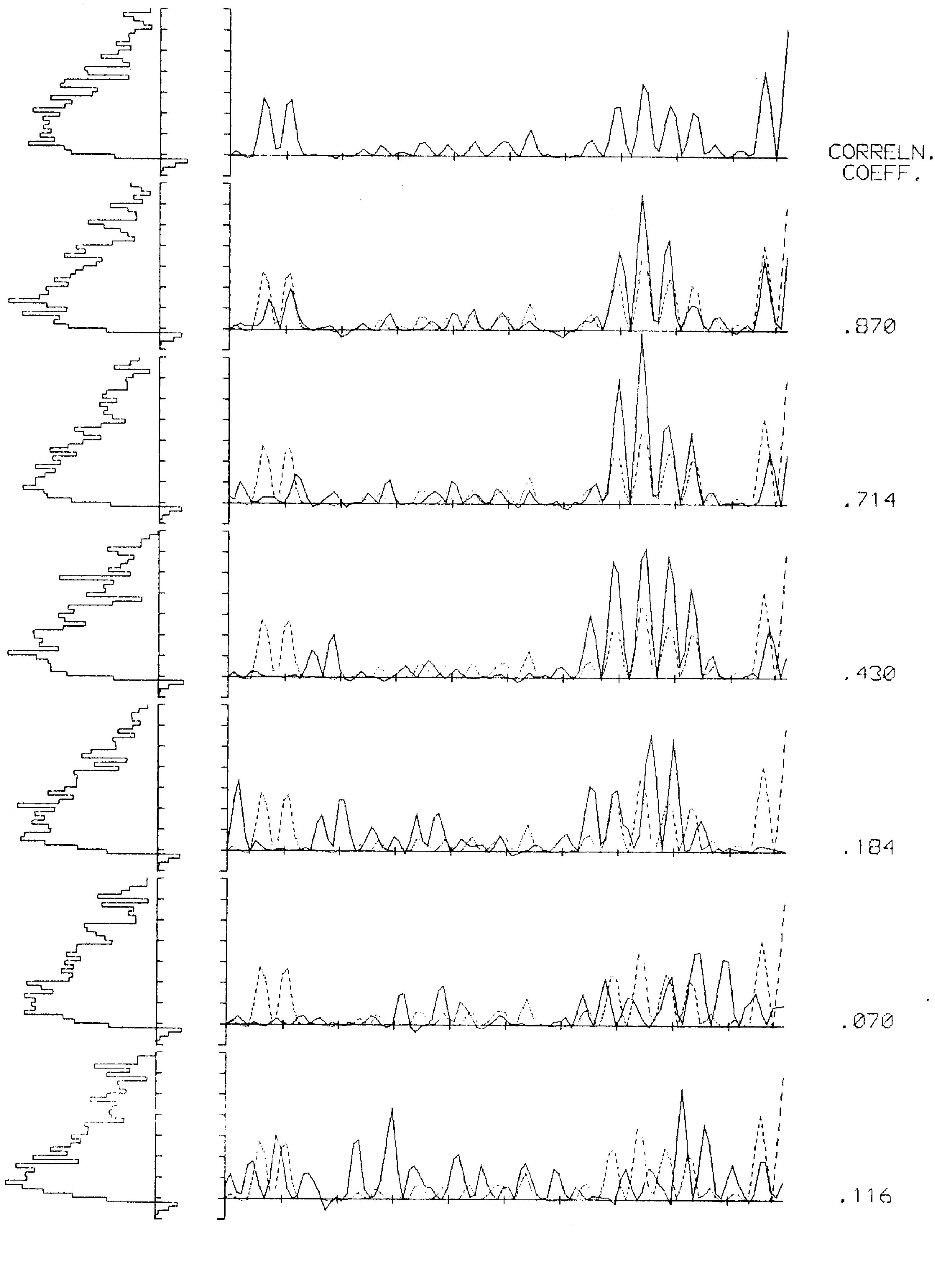
```
 TH0  NL   IR
  15   6  1432
XL( 1-NL)  = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE  =   9.998
HRMS=   1.000
POW IN = 59.19( 75.8 % OF POW)
```



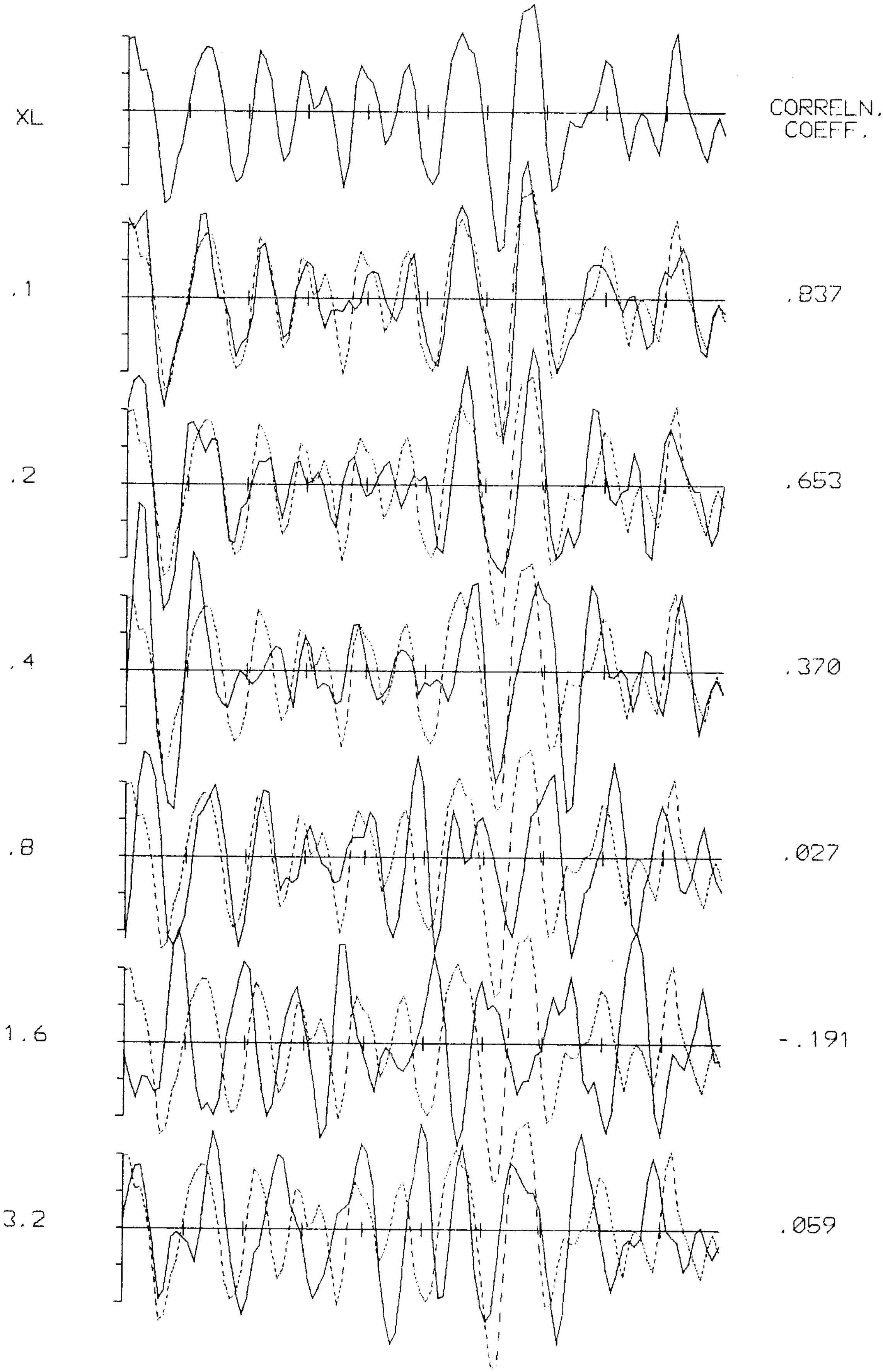

CORRELN.
COEFF.
.863
.716
.485
.135
-.017
-.009

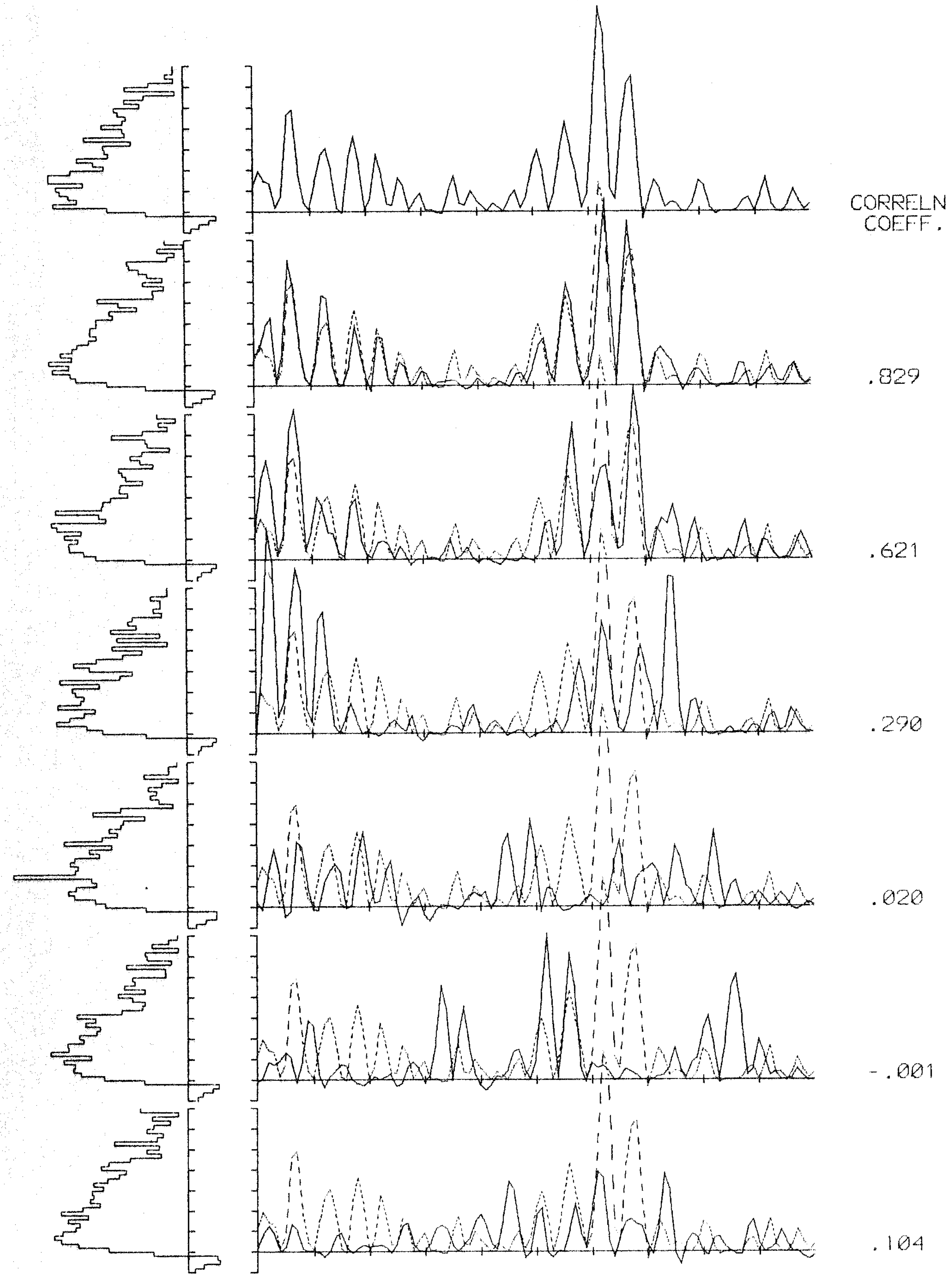
```
TH0   NL   IR
 30    6   1058
XL(1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE   =   9.998
HRMS=   1.000
POW IN = 54.78( 70.1 % OF POW)
```



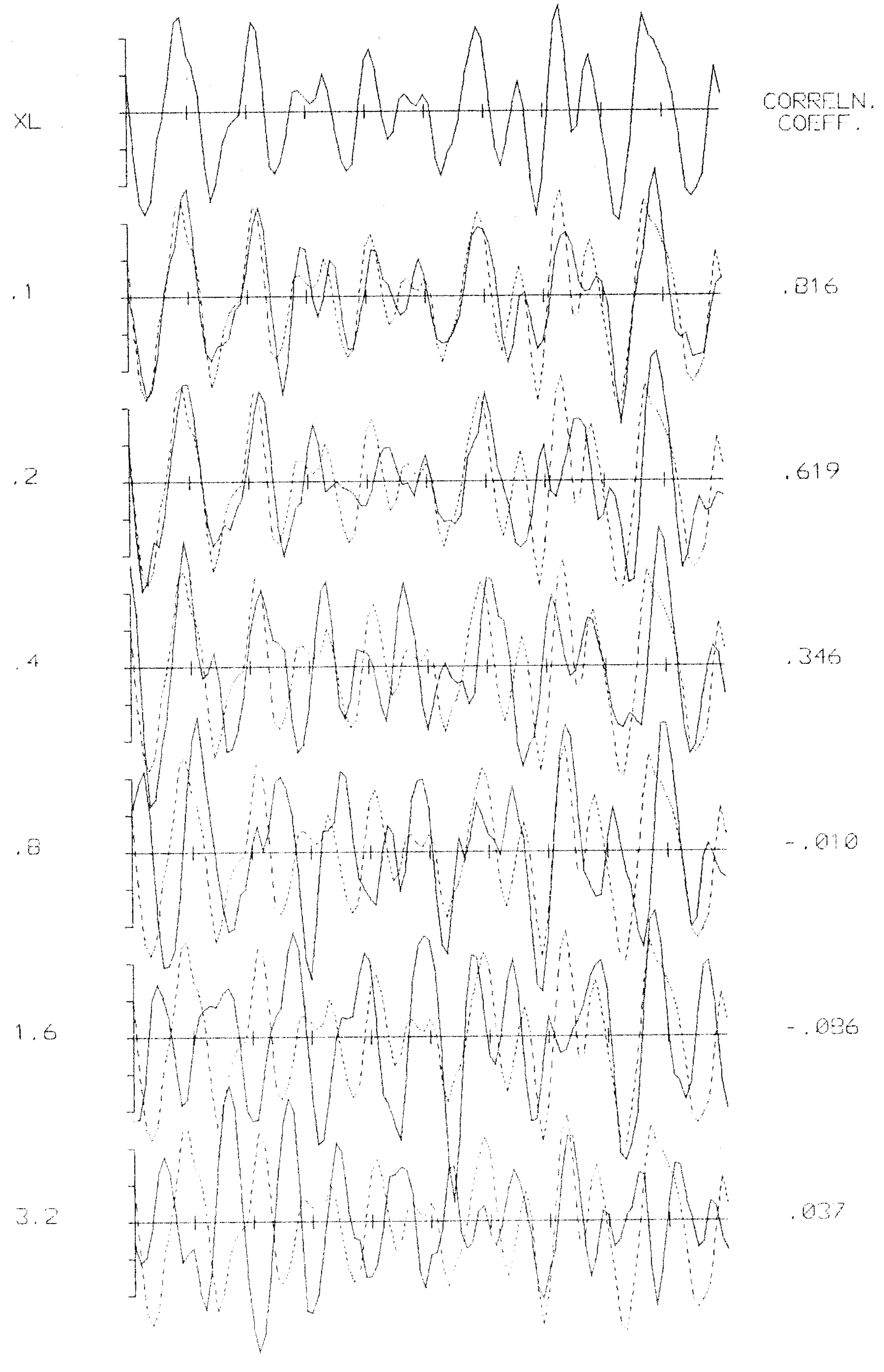

CORRELN.
COEFF.
.870
.714
.430
.184
.070
.116

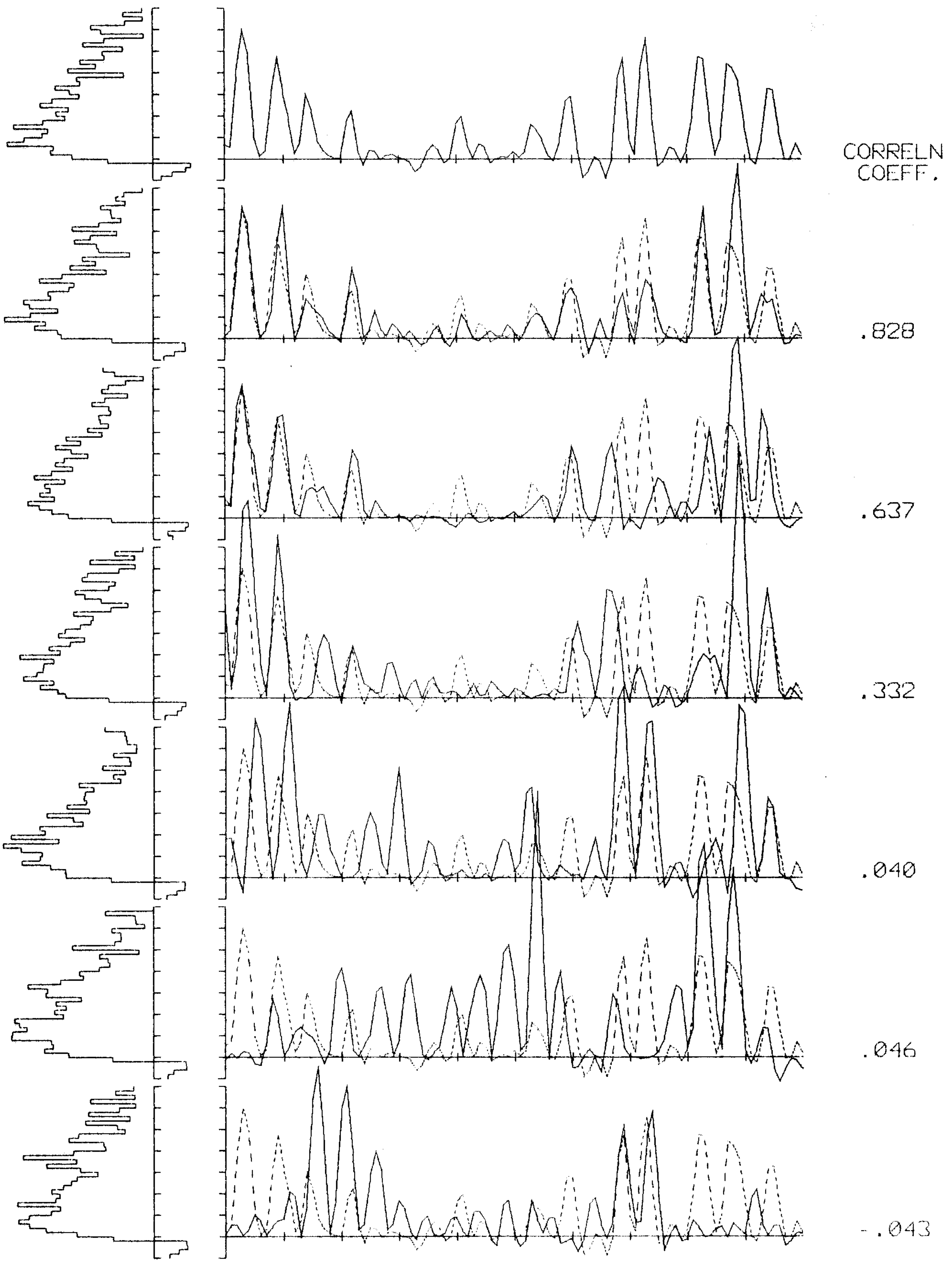
```
THØ   NL   IR
 45    6   1012
XL( 1-NL)  = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE   =   9.998
HRMS=   1.000
POW IN  =  40.73(  52.2 % OF POW)
```



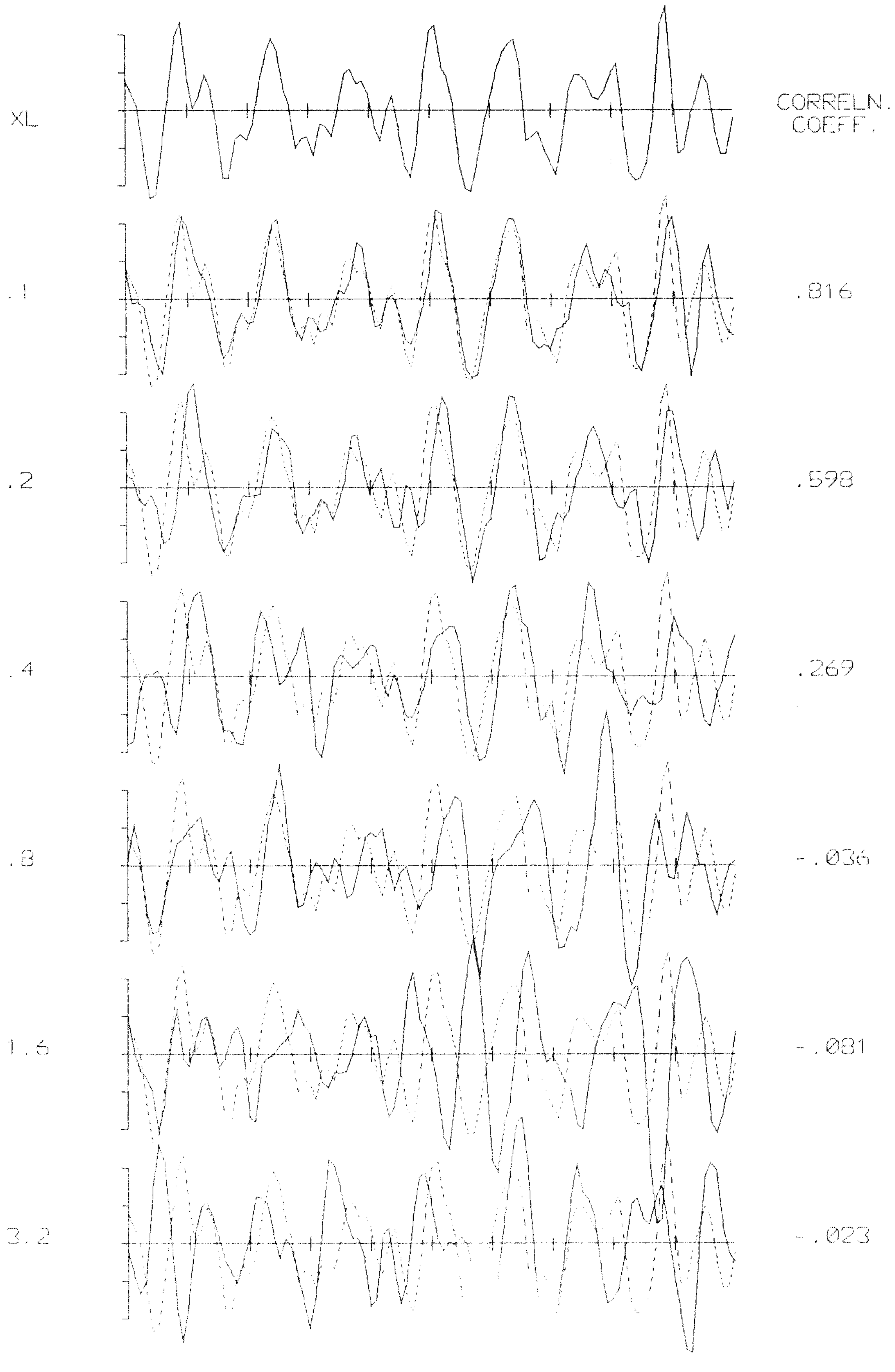

CORRELN.
COEFF.
.829
.621
.290
.020
-.001
.104

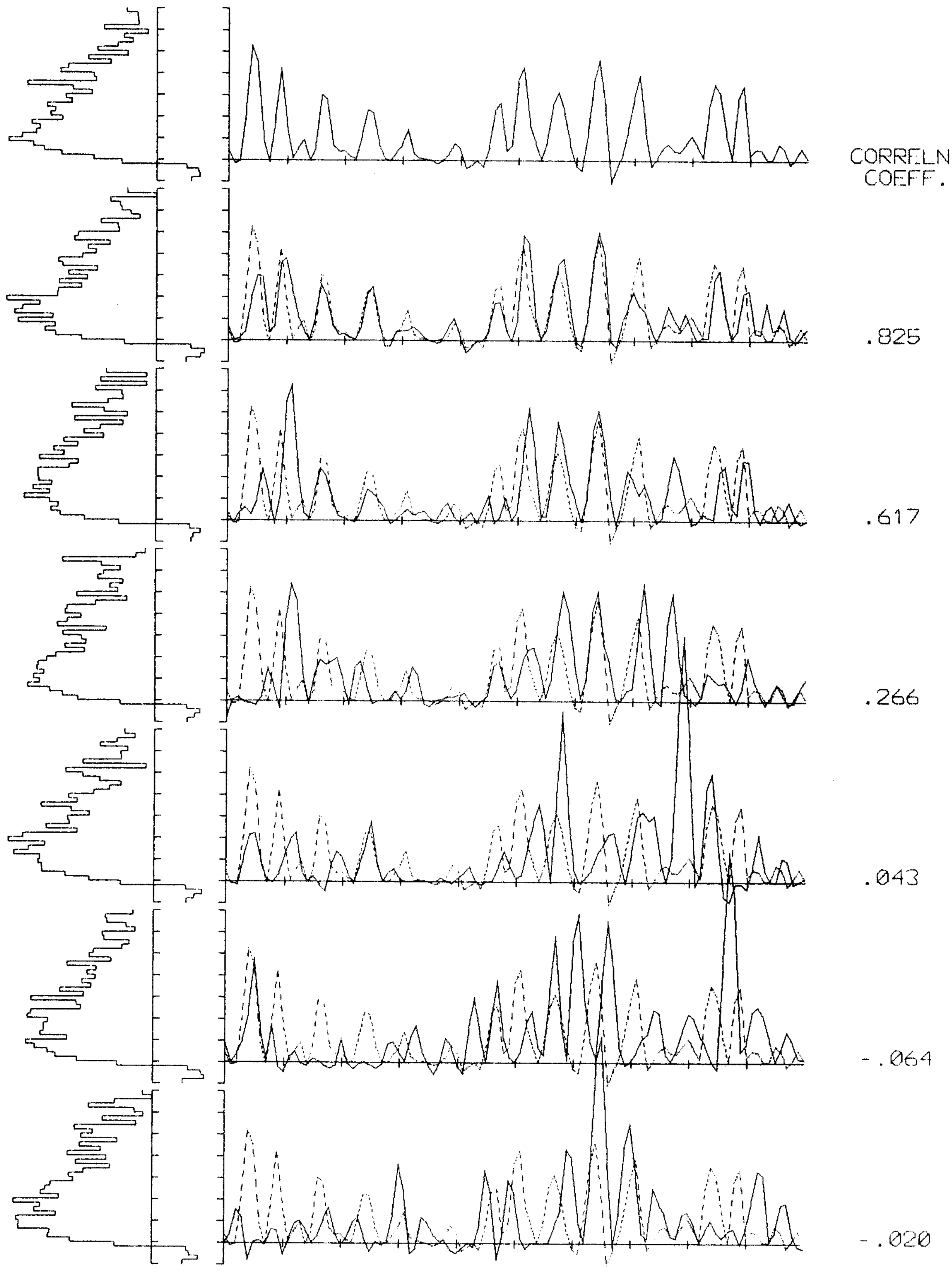
```
 THØ  NL  IR
  6Ø   6  1127
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE   =   9.998
HRMS=   1.ØØØ
POW IN = 38.04( 48.7 % OF POW)
```



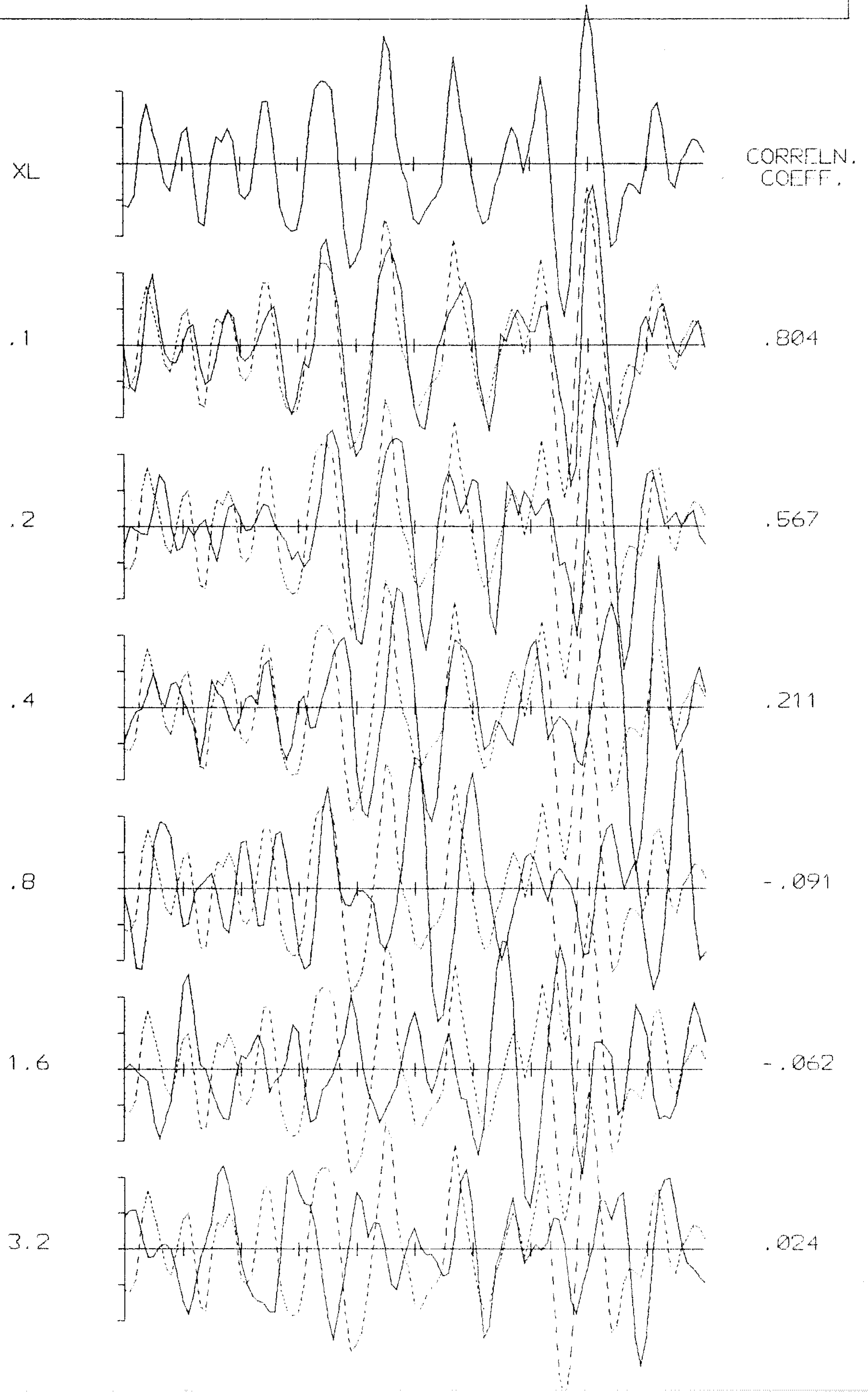

CORRELN.
COEFF.
.828
.637
.332
.040
.046
-.043

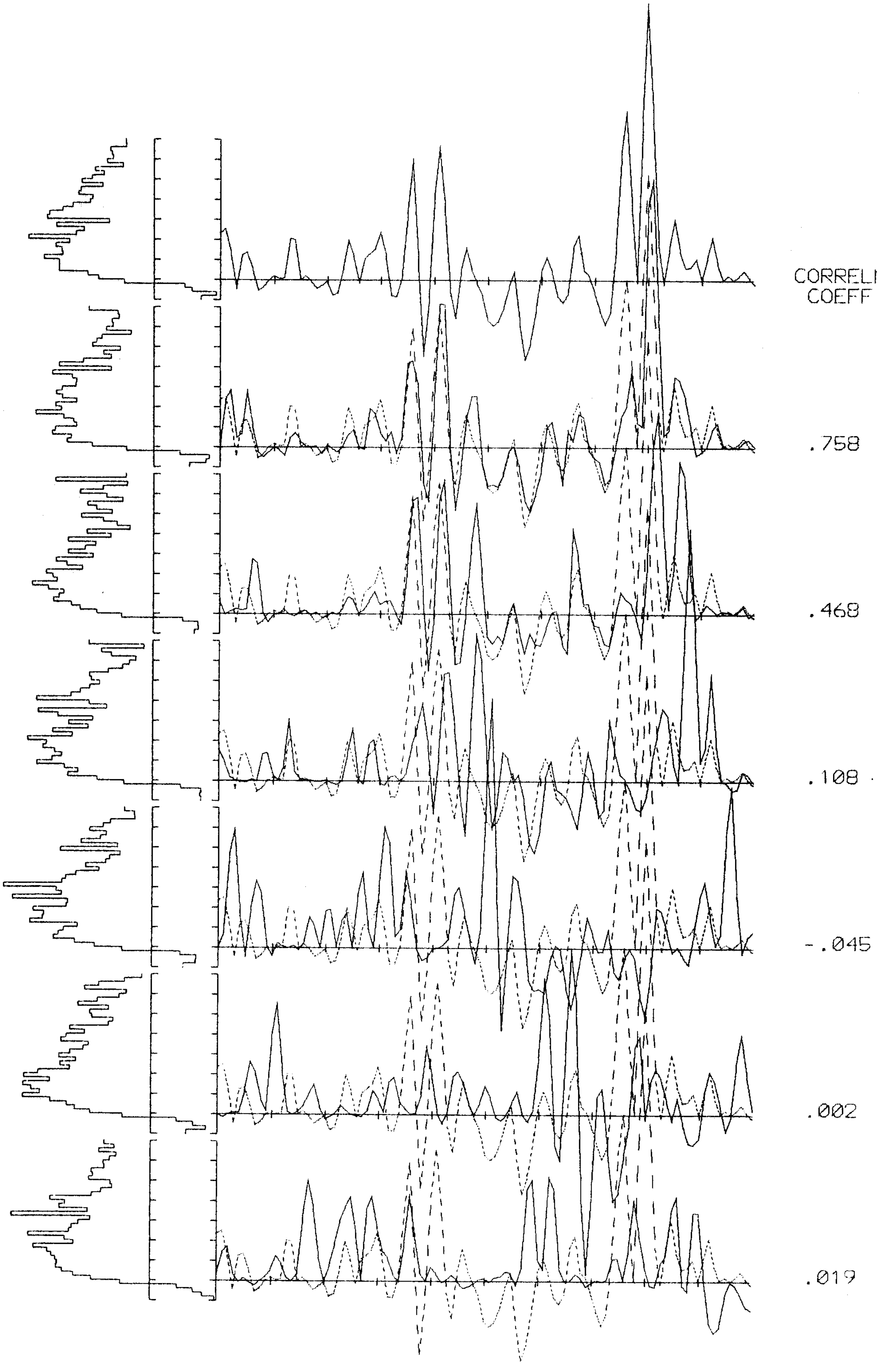
```
 TH0   NL   IR
  75    6   1111
XL(1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE  =  9.998
HRMS=  1.000
POW IN = 29.05( 37.2 % OF POW)
```



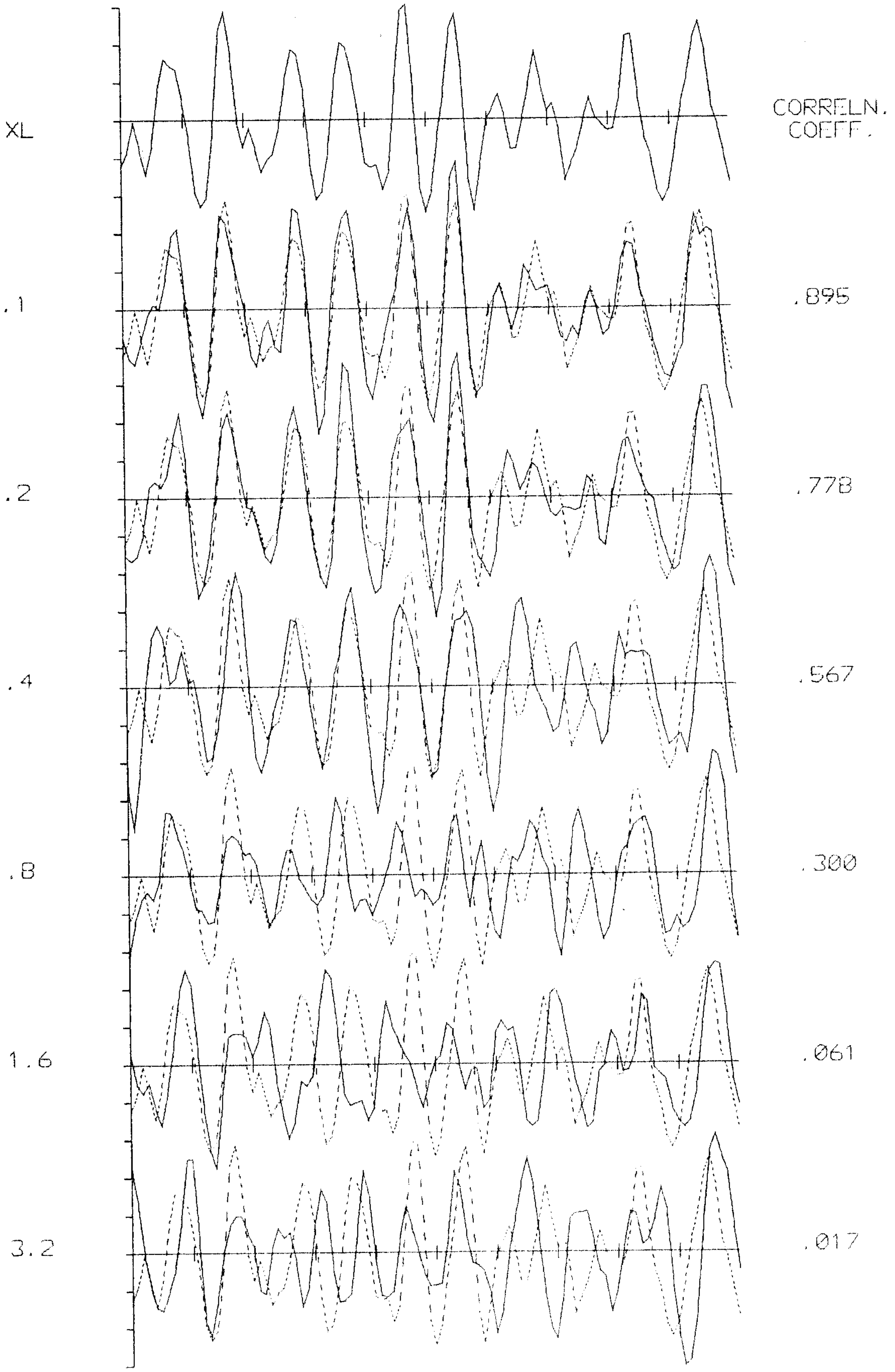

CORRELN.
COEFF.
.825
.617
.266
.043
-.064
-.020

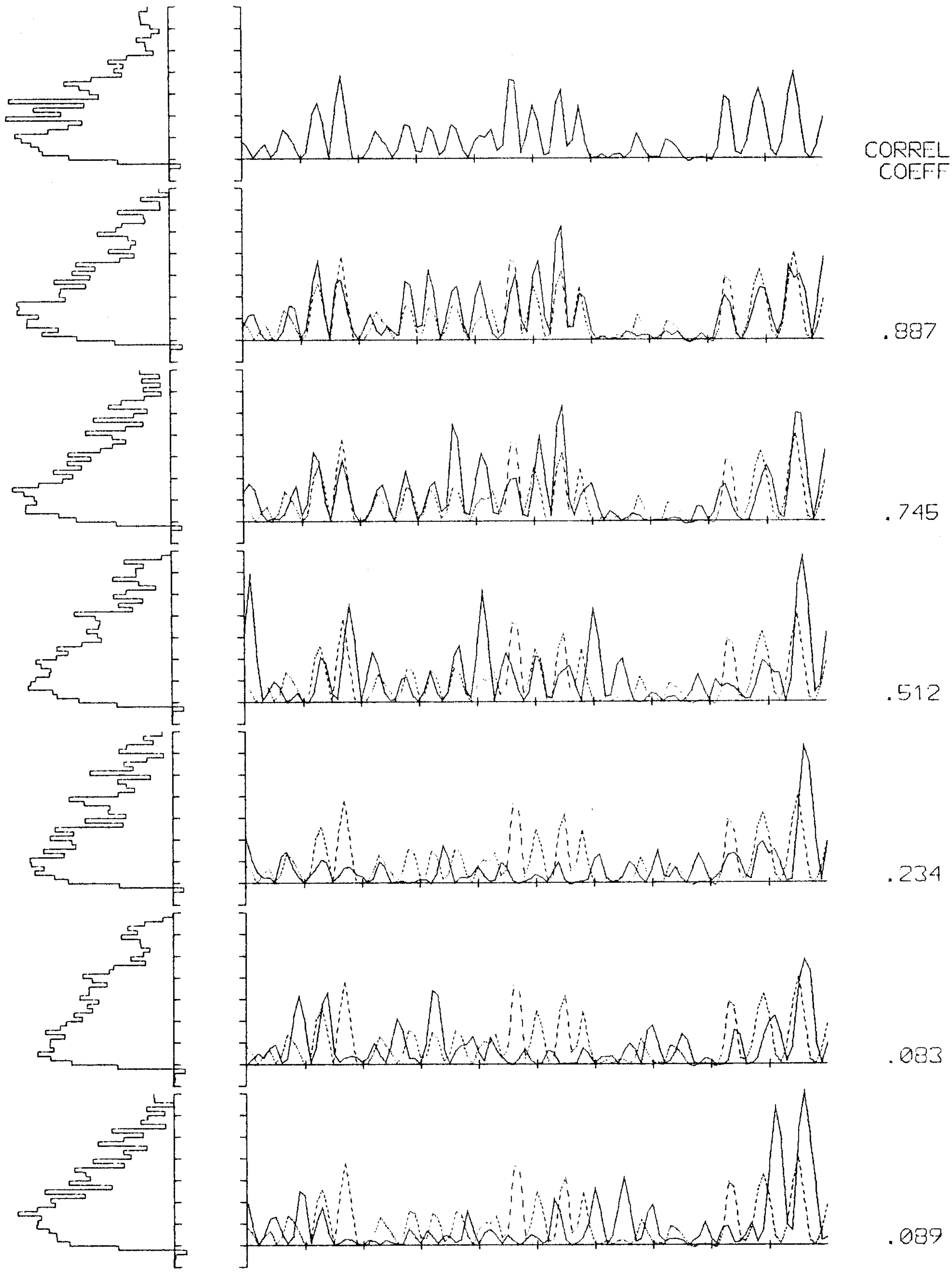
```
THØ   NL   IR
 90    6   1351
XL( 1-NL) = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
MITSUYASU SPREADING FUNCTION
TE  =  9.998
HRMS=  1.ØØØ
POW IN = 16.Ø8( 2Ø.6 % OF POW)
```



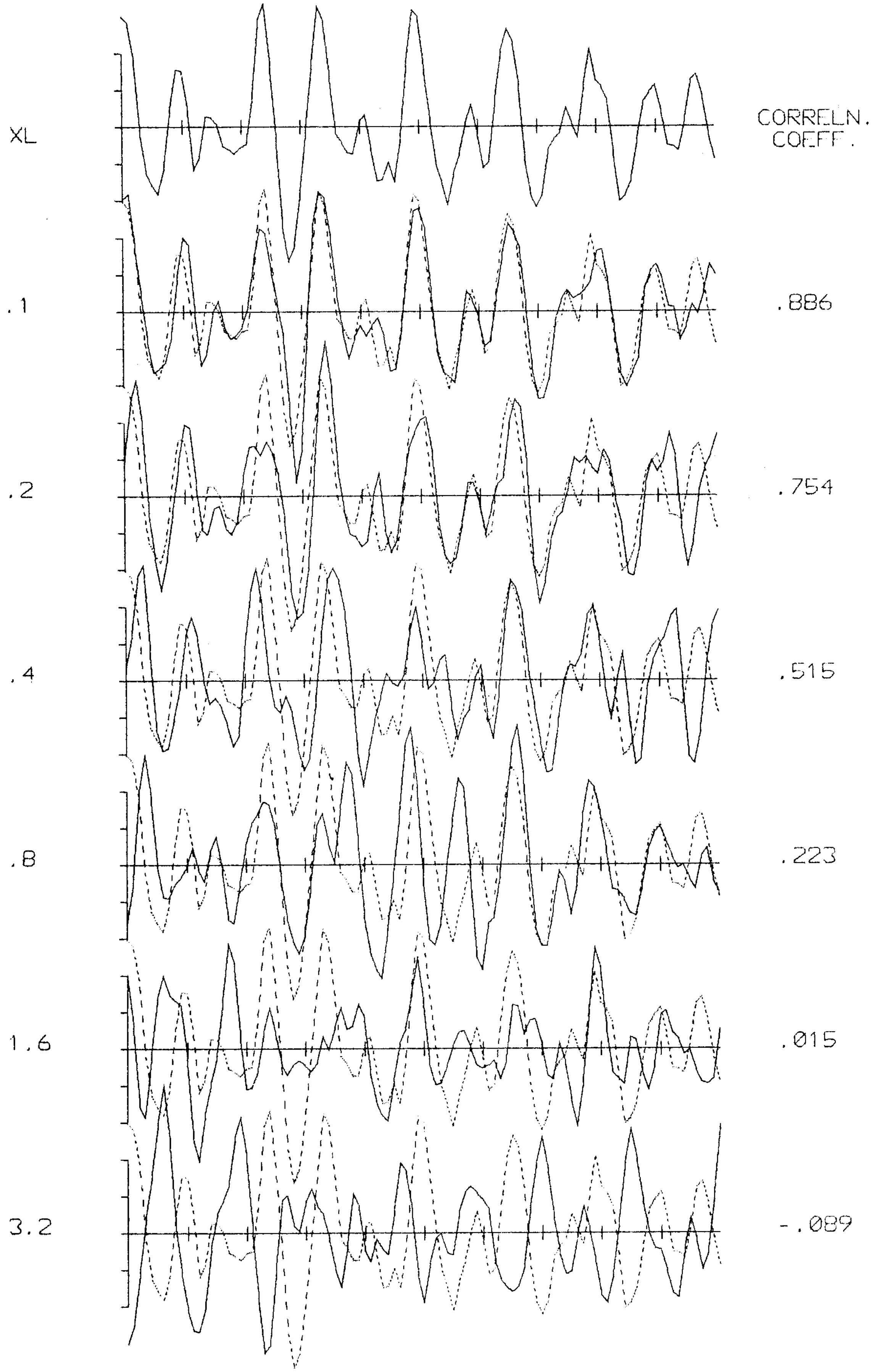

CORRELN.
COEFF.
.758
.468
.108
-.045
.002
.019

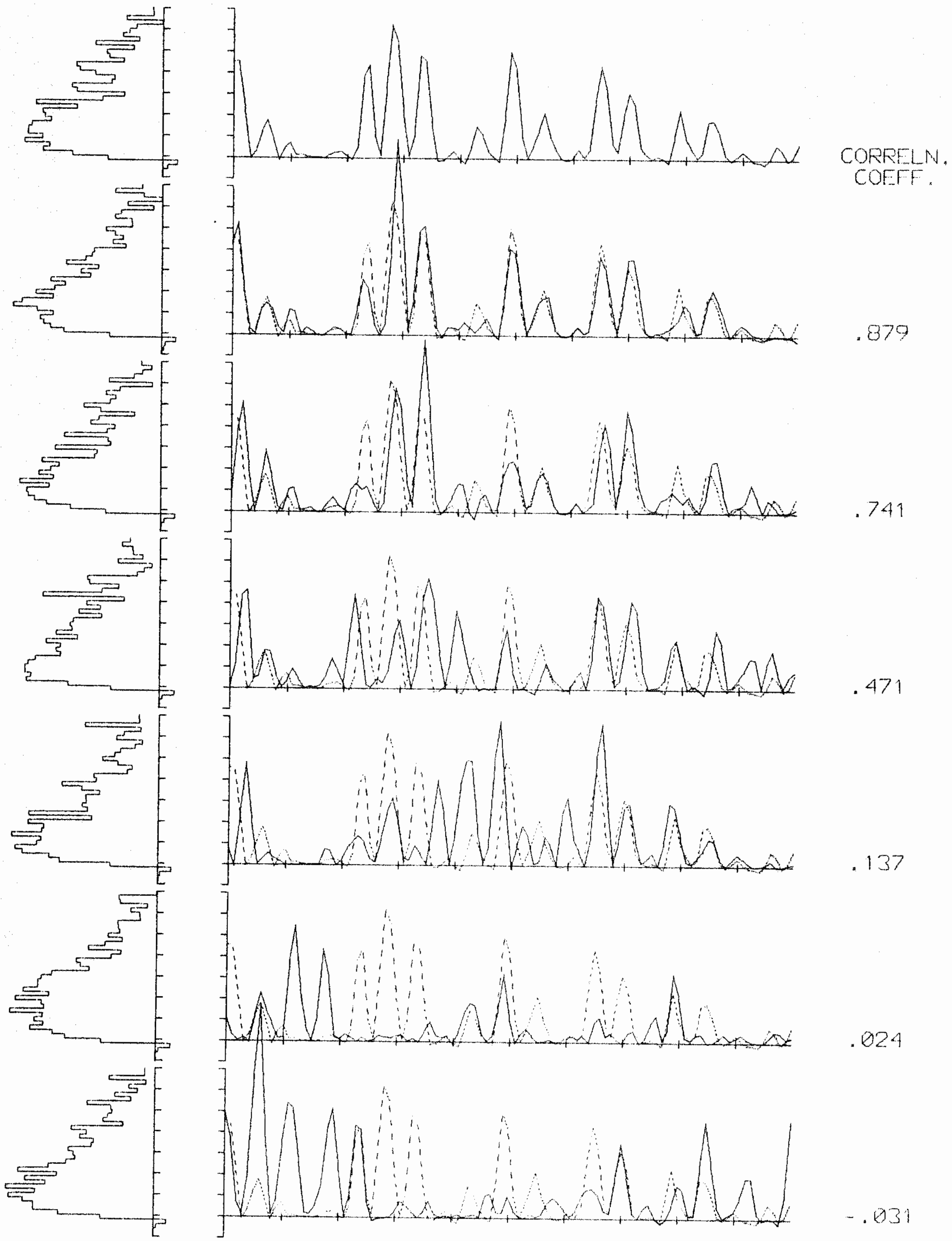
```
TH0   NL   IR
 0     6   1234
XL( 1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S ( TH) SPECTRUM, S =  2.0
TE   =  9.998
HRMS=   1.000
POW IN = 67.00( 85.8 % OF POW)
```



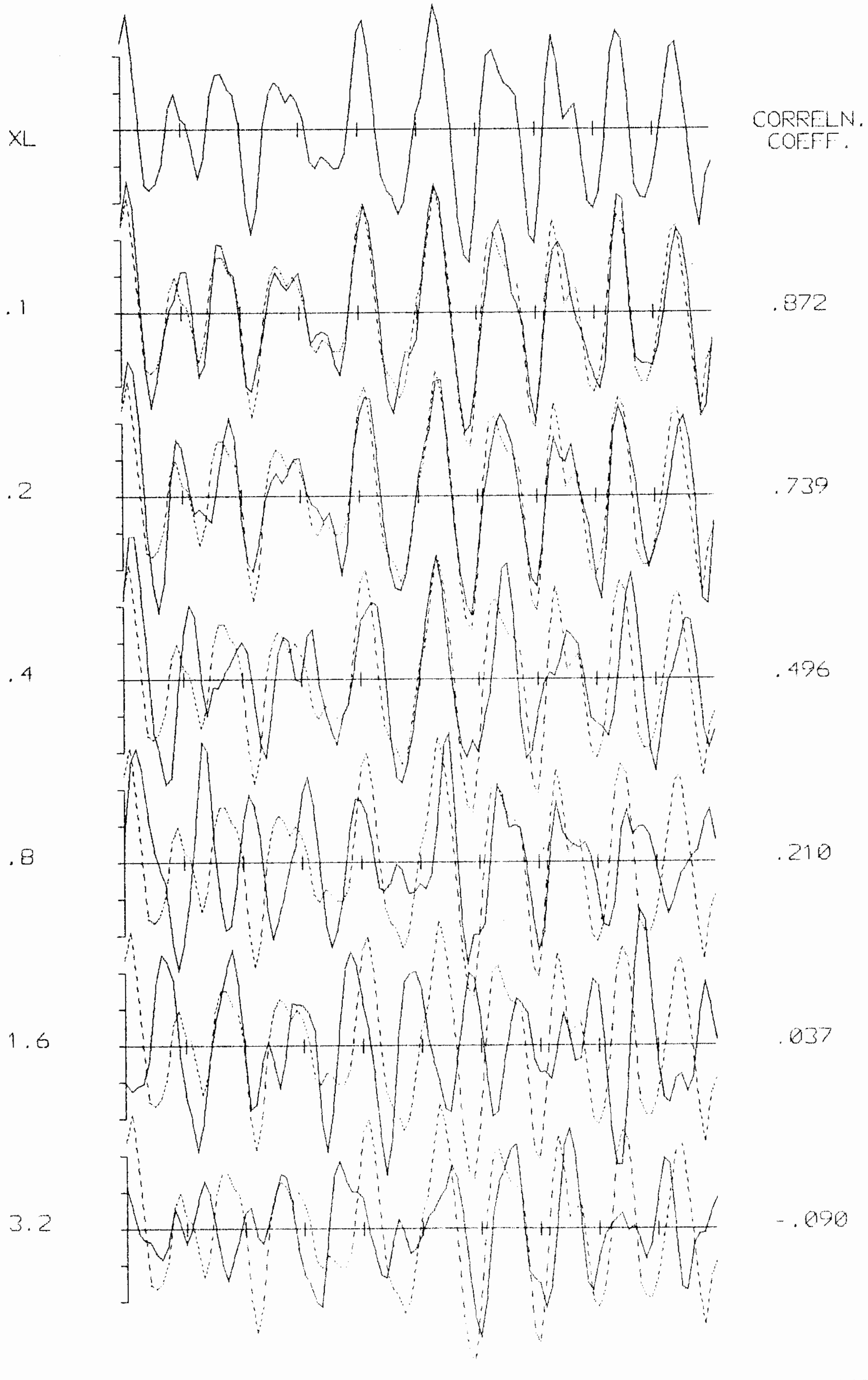

CORRELN.
COEFF.
.887
.745
.512
.234
.083
.089

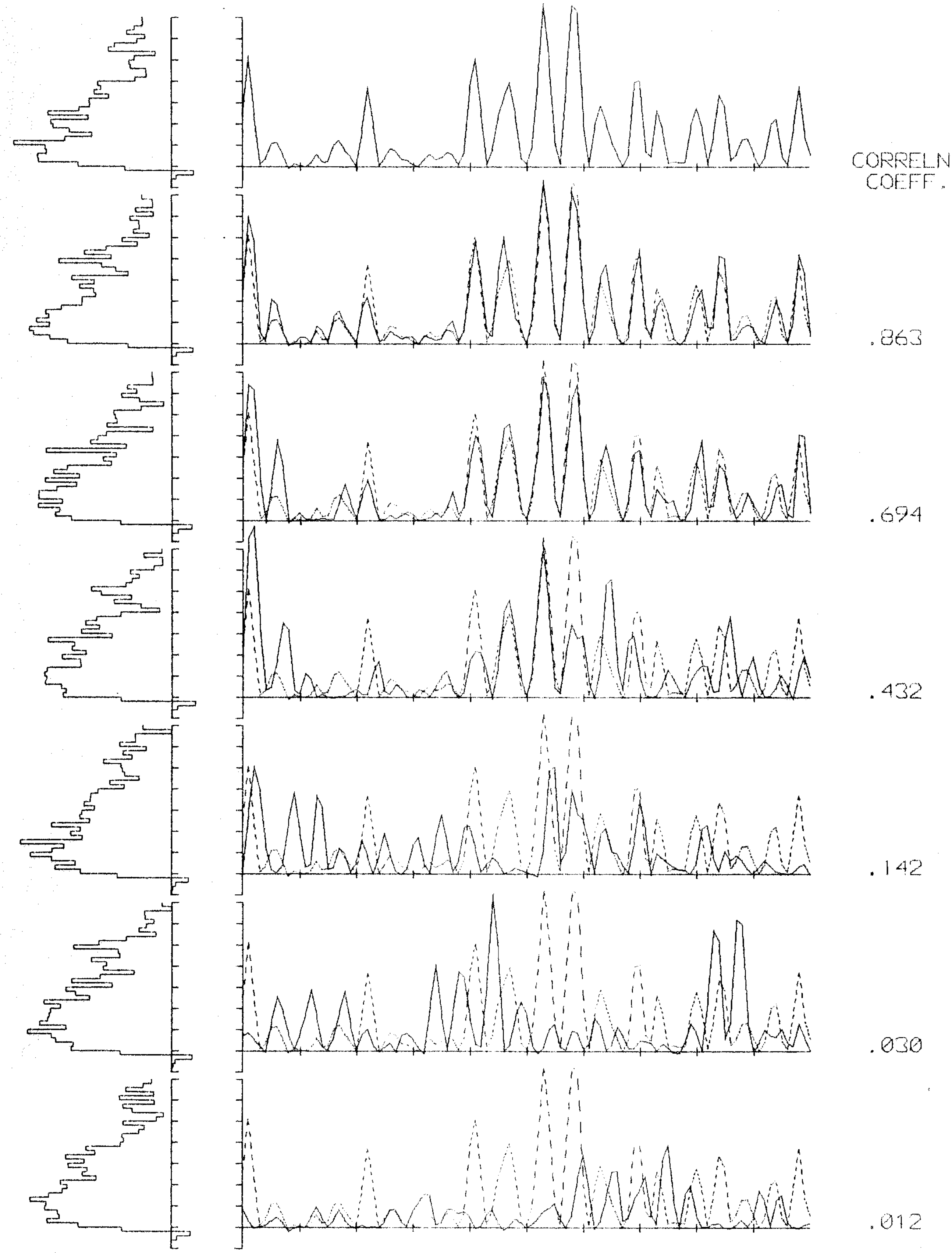
```
TH0   NL   IR
 15    6   1144
XL( 1-NL)  = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S ( TH) SPECTRUM,  S =   2.0
TE   =   9.998
HRMS=   1.000
POW IN = 62.67(  80.2 % OF POW)
```



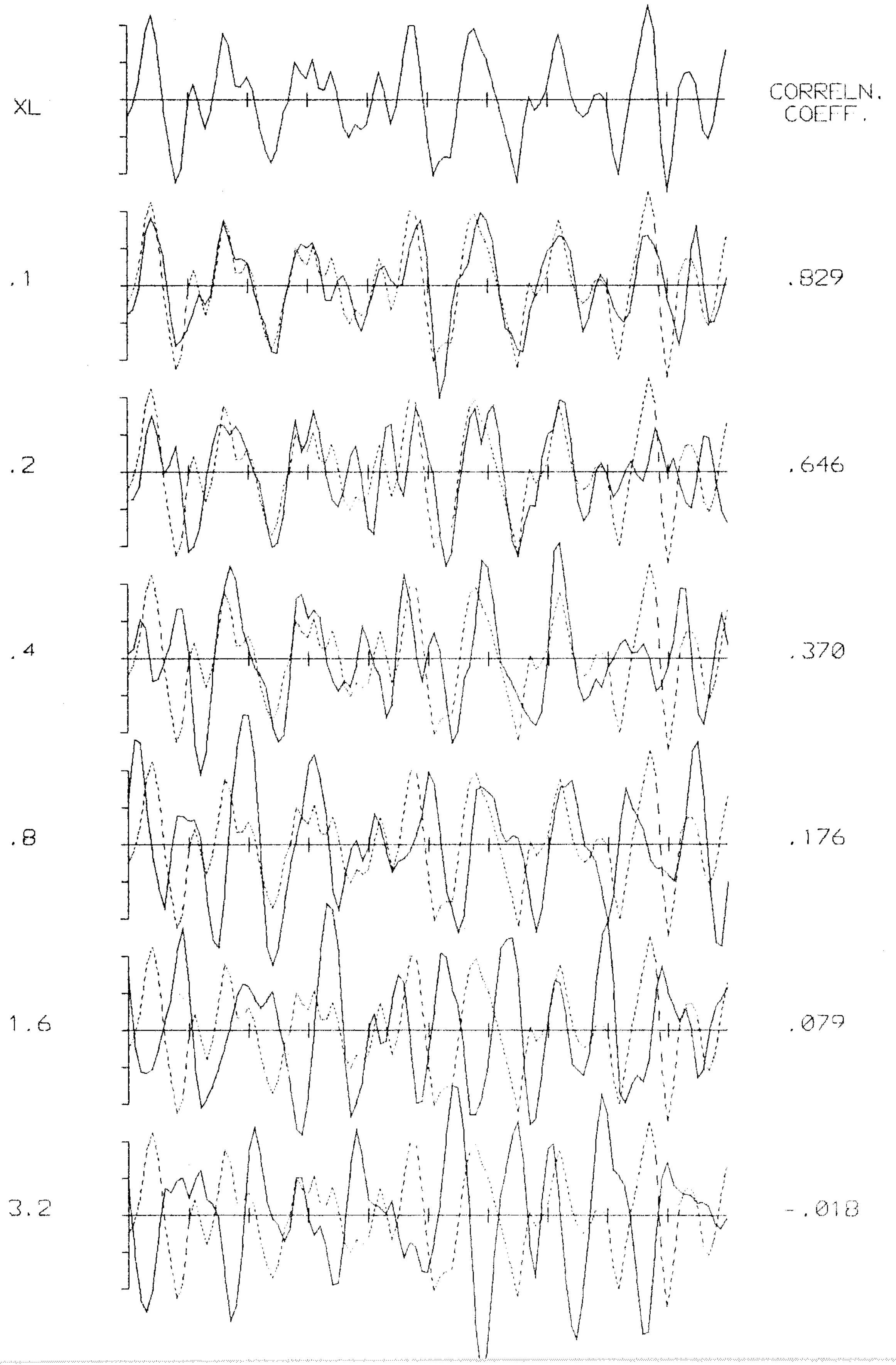

CORRELN.
COEFF.
.879
.741
.471
.137
.024
-.031

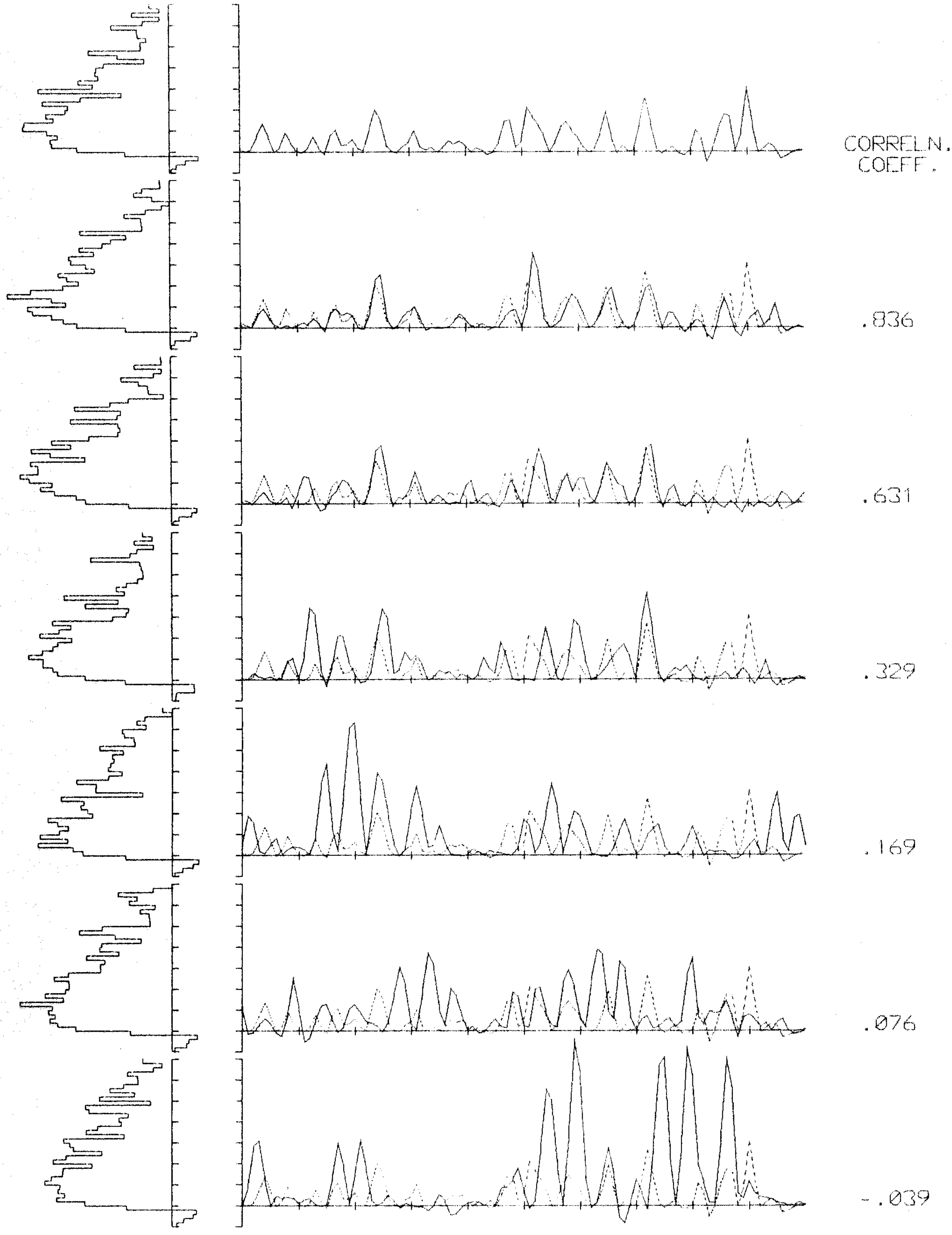
```
THØ  NL   IR
 30   6  1029
XL(1-NL) = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S (TH) SPECTRUM, S =  2.Ø
TE  =  9.998
HRMS=  1.ØØØ
POW IN = 59.45( 76.1 % OF POW)
```




CORRELN.
COEFF.
.863
.694
.432
.142
.030
.012

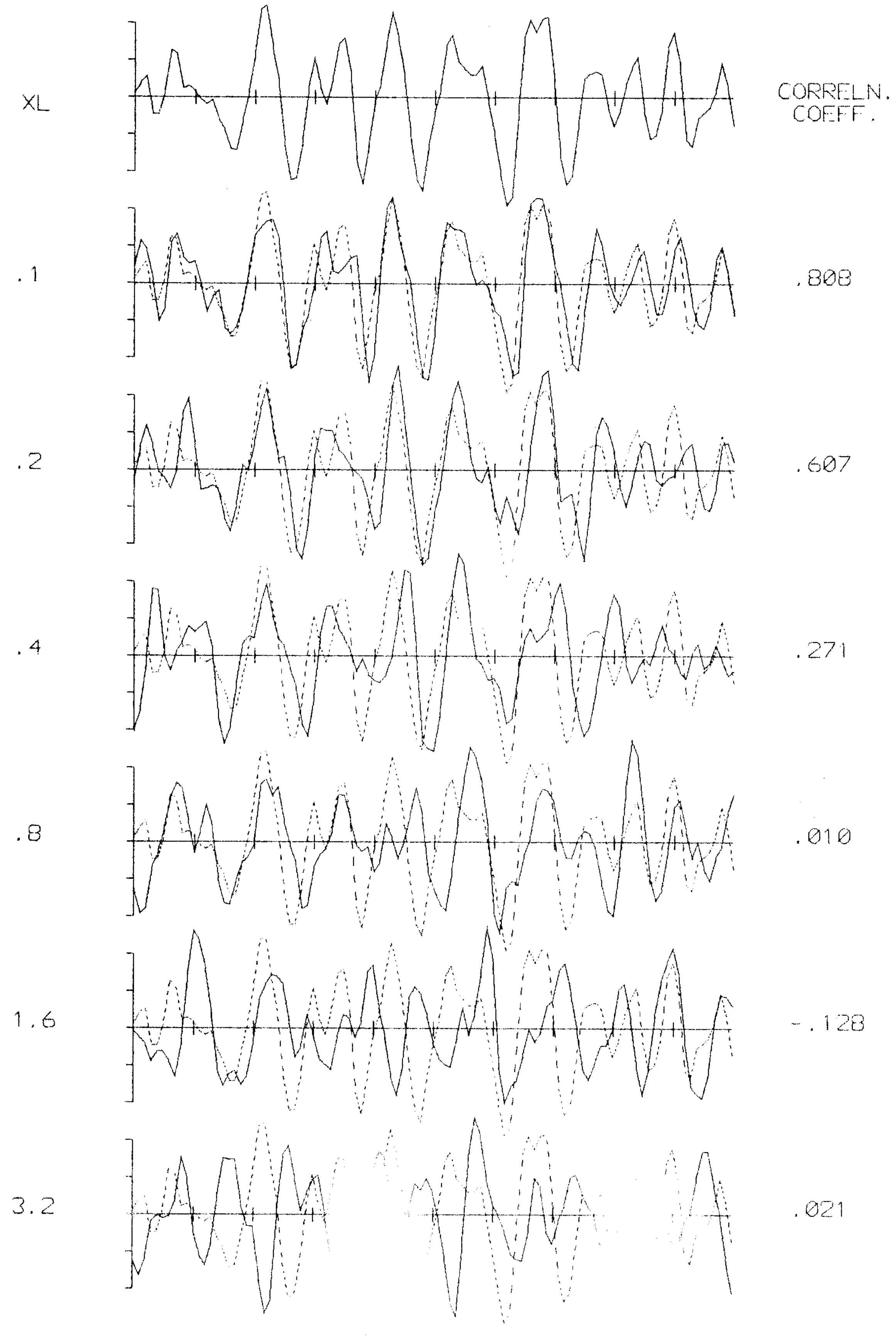
```
THØ  NL  IR
 45   6  1091
XL( 1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S (TH) SPECTRUM, S = 2.0
TE  = 9.998
HRMS= 1.000
POW IN = 51.68( 66.2 % OF POW)
```

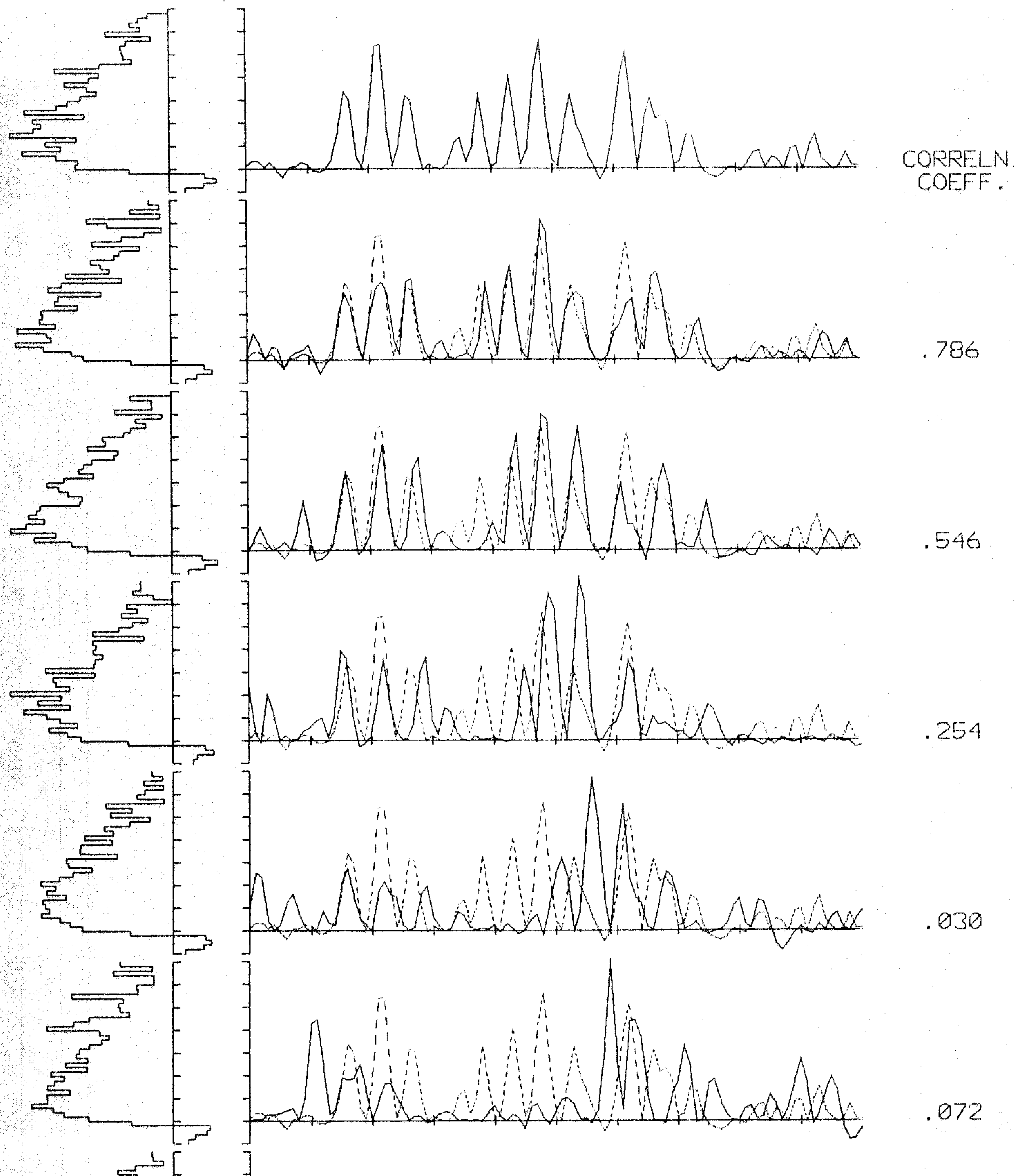




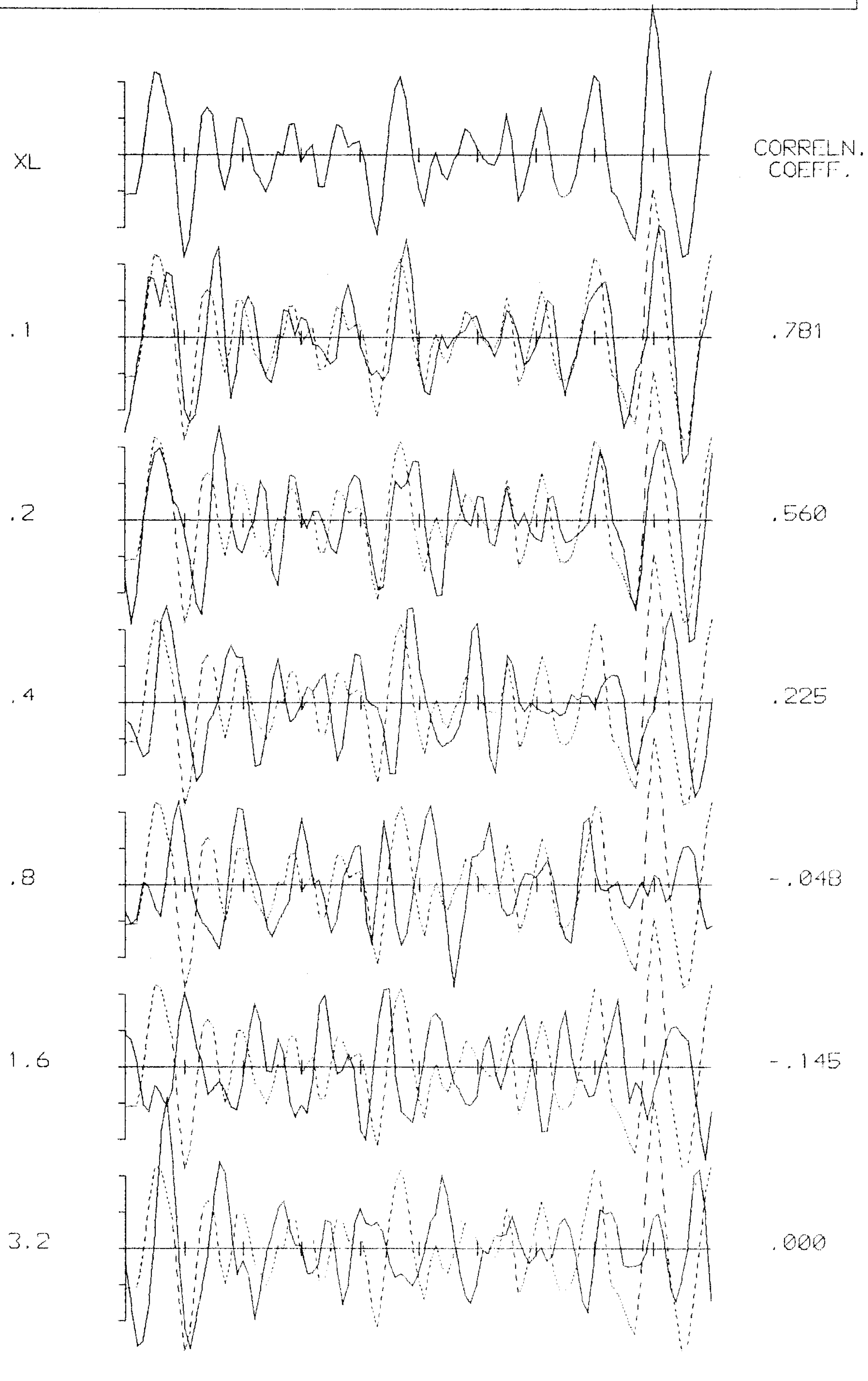
CORRELN.
COEFF.
.836
.631
.329
.169
.076
-.039

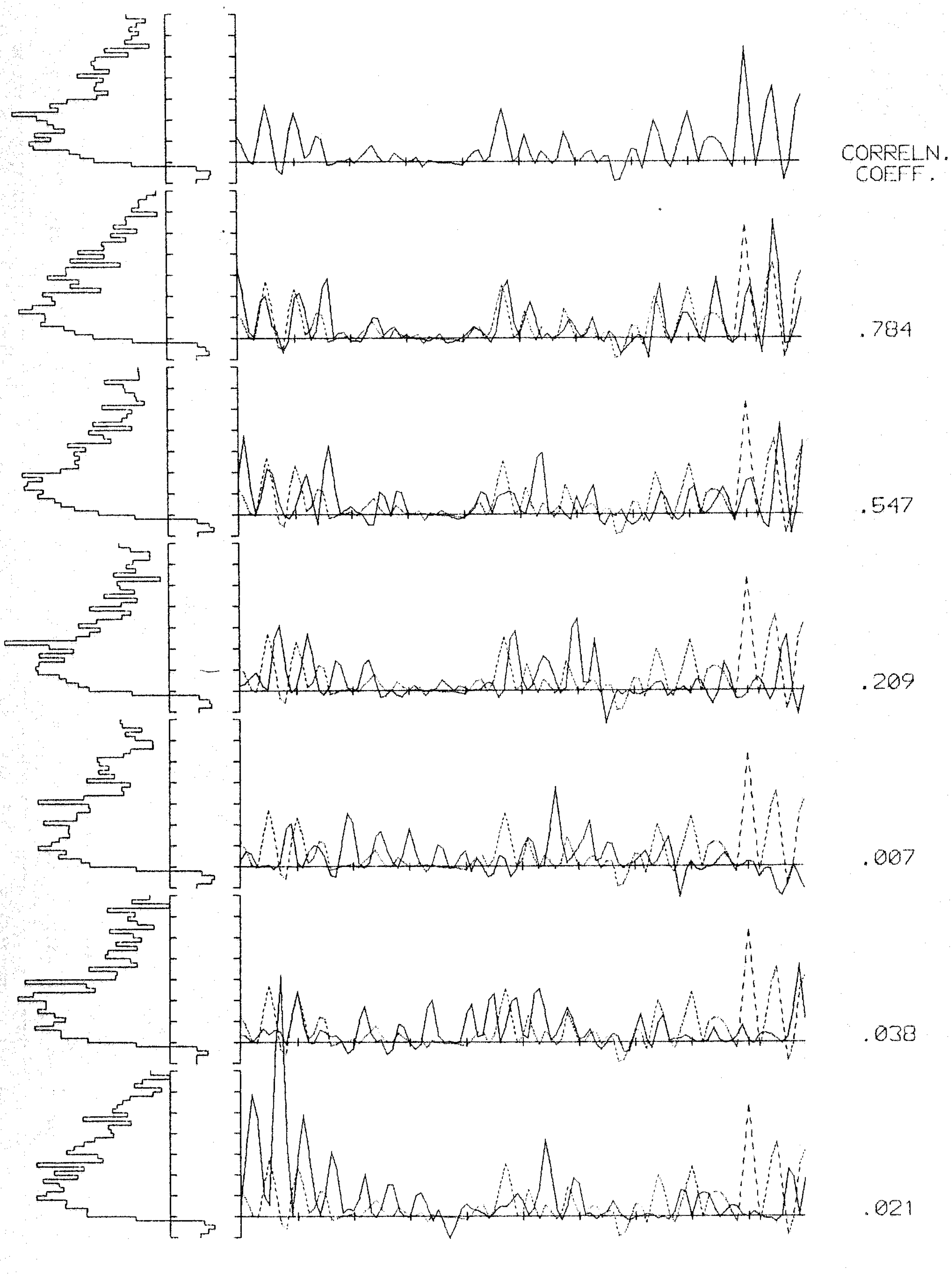
```
 THØ   NL   IR
  60    6   1562
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S ( TH)  SPECTRUM,  S =   2.Ø
TE   =   9.998
HRMS=   1.ØØØ
POW IN  = 33.87(  43.4 % OF POW)
```



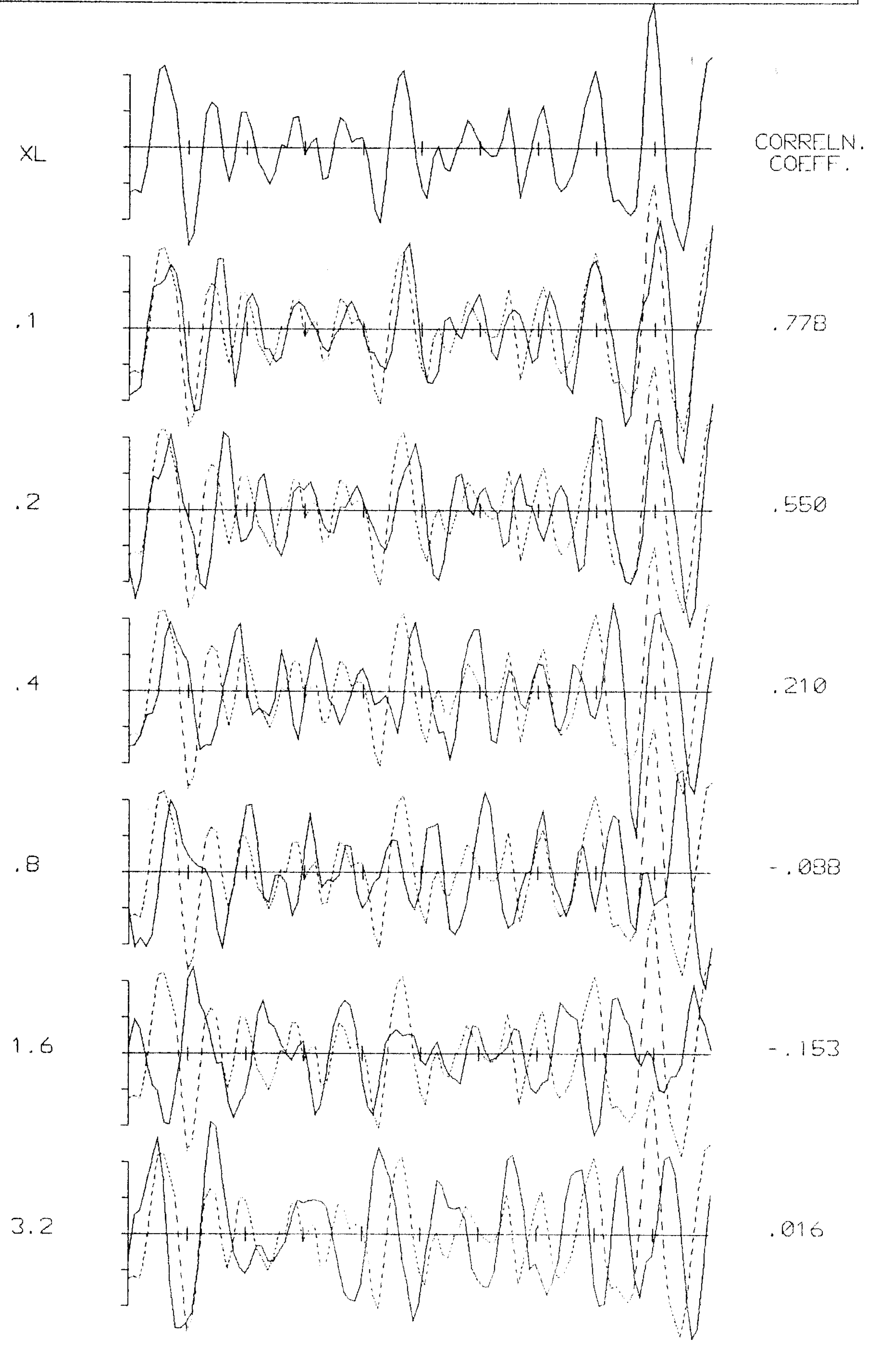

CORRELN.
COEFF.
.786
.546
.254
.030
.072
.035

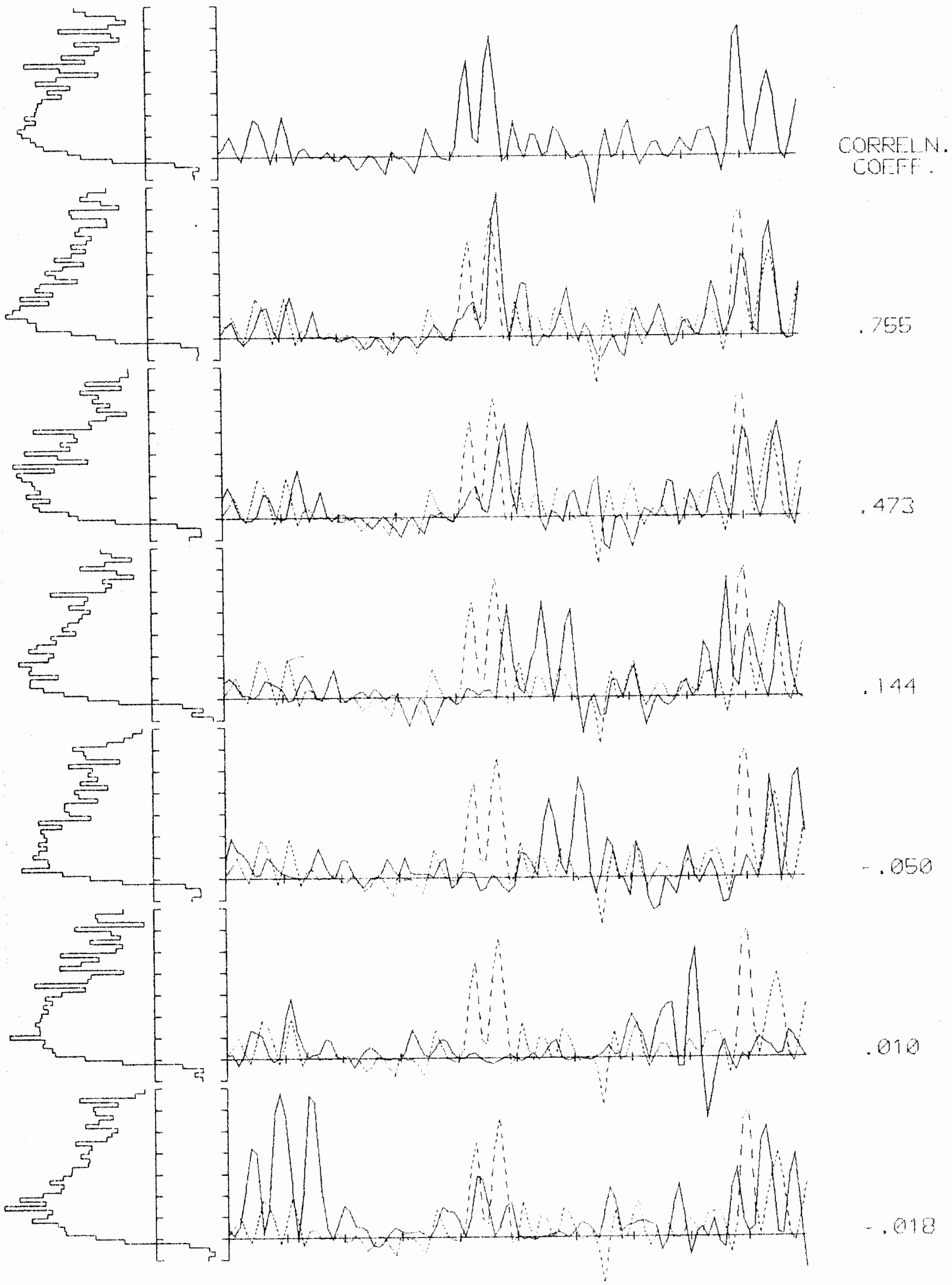
```
TH0   NL   IR
 75    6   1503
XL( 1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S ( TH) SPECTRUM, S =  2.0
TE  =  9.998
HRMS=  1.000
POW IN = 28.83( 36.9 % OF POW)
```



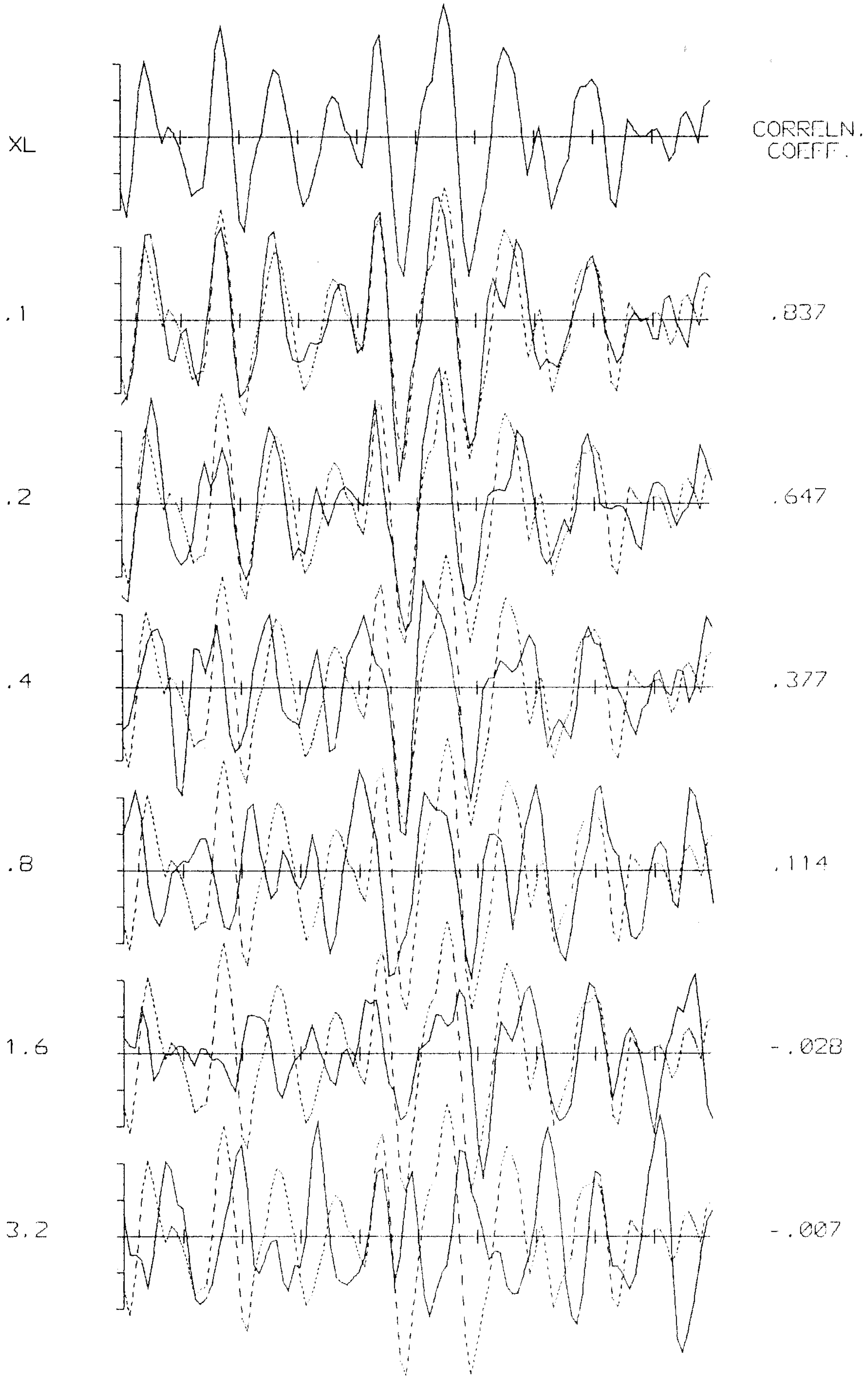

CORRELN.
COEFF.
.784
.547
.209
.007
.038
.021

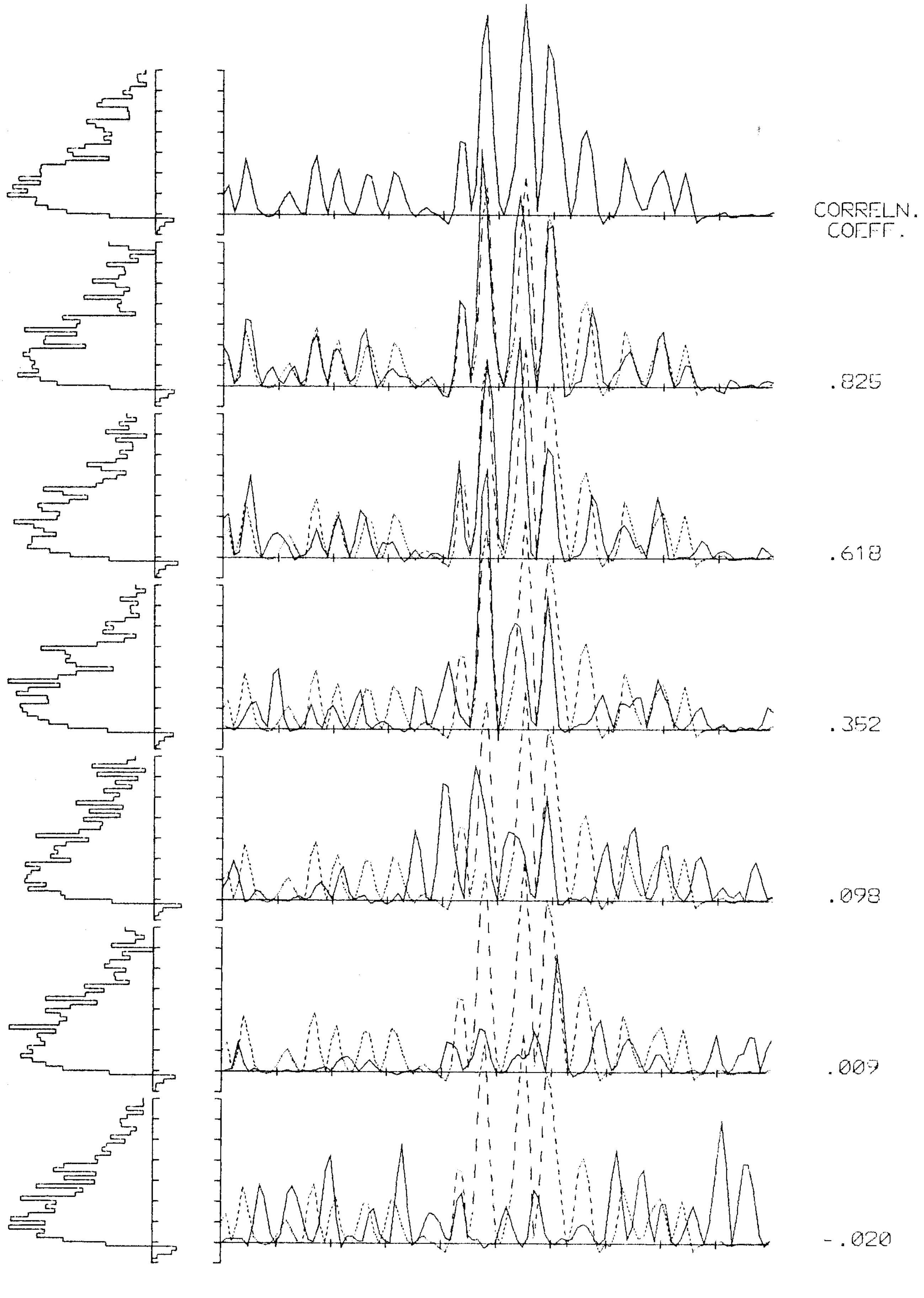
```
TH0   NL   IR
 90    6   1437
XL(1-NL)  = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S (TH) SPECTRUM, S =  2.0
TE   =   9.998
HRMS=   1.000
POW IN = 19.21(  24.6 % OF POW)
```



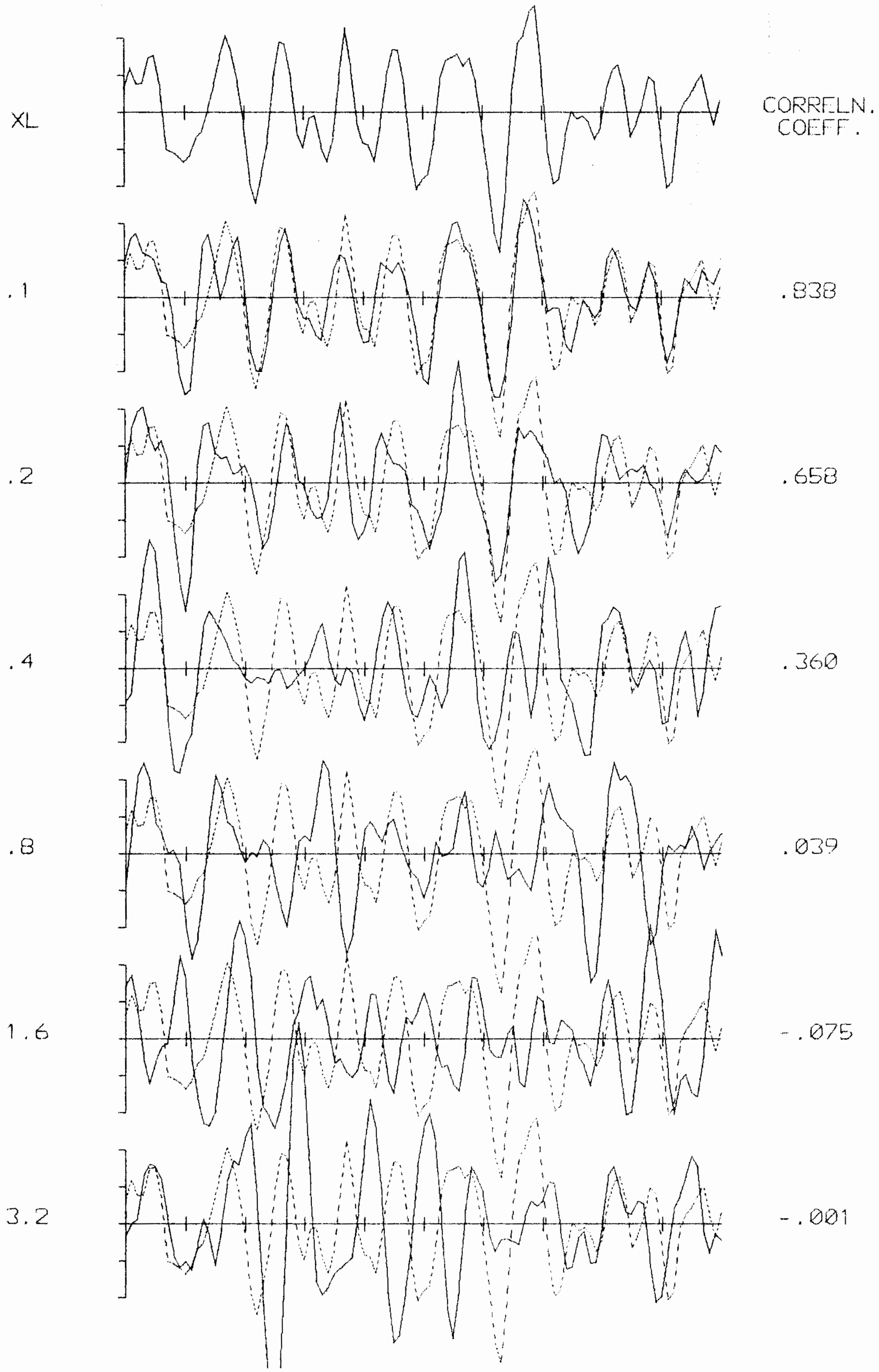

CORRELN.
COEFF.
.755
.473
.144
-.050
.010
-.018

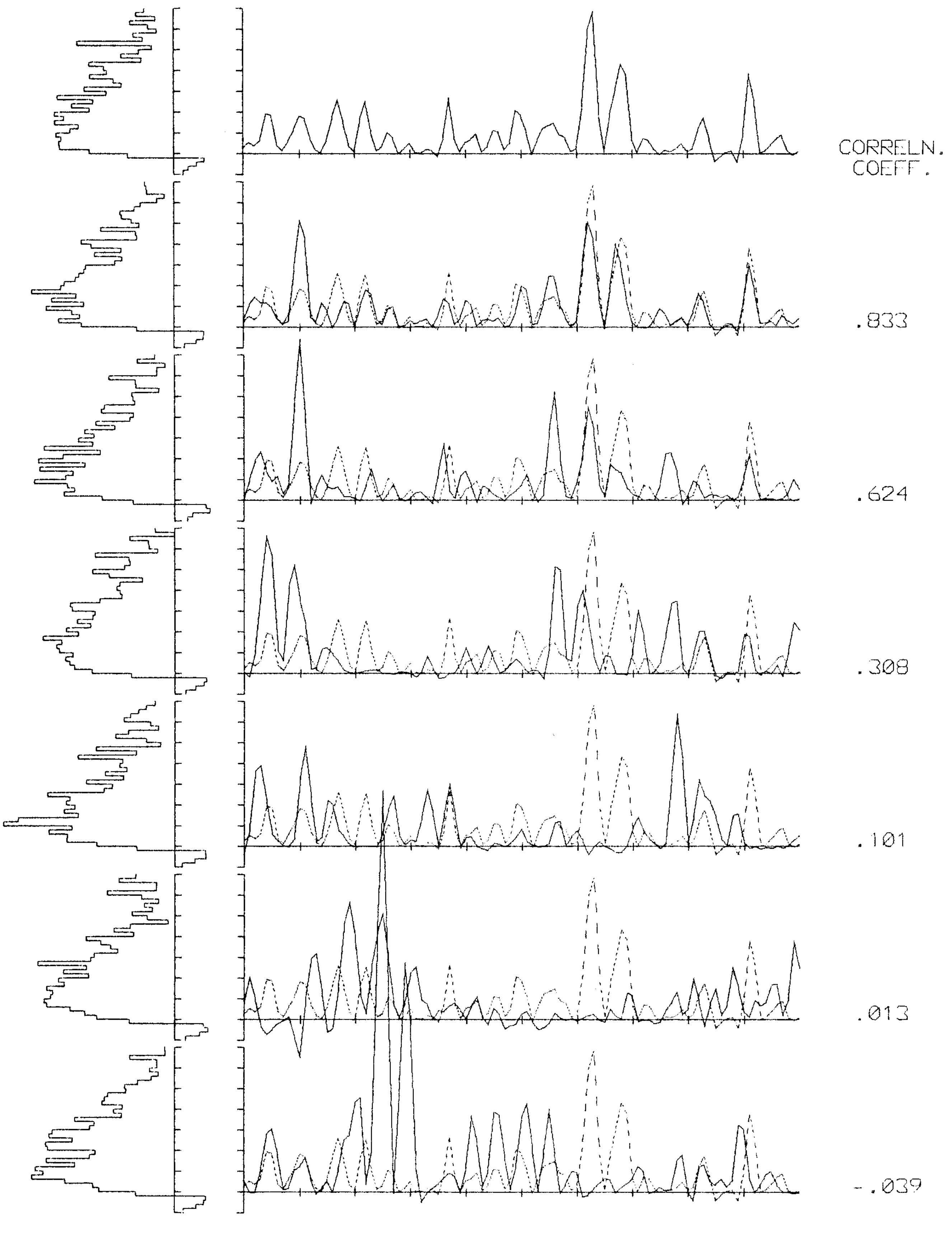
```
THØ   NL   IR
 Ø    6   1324
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S ( TH)  SPECTRUM,  S =   Ø.Ø
TE   =   9.998
HRMS=   1.ØØØ
POW IN = 51.36( 65.8 % OF POW)
```



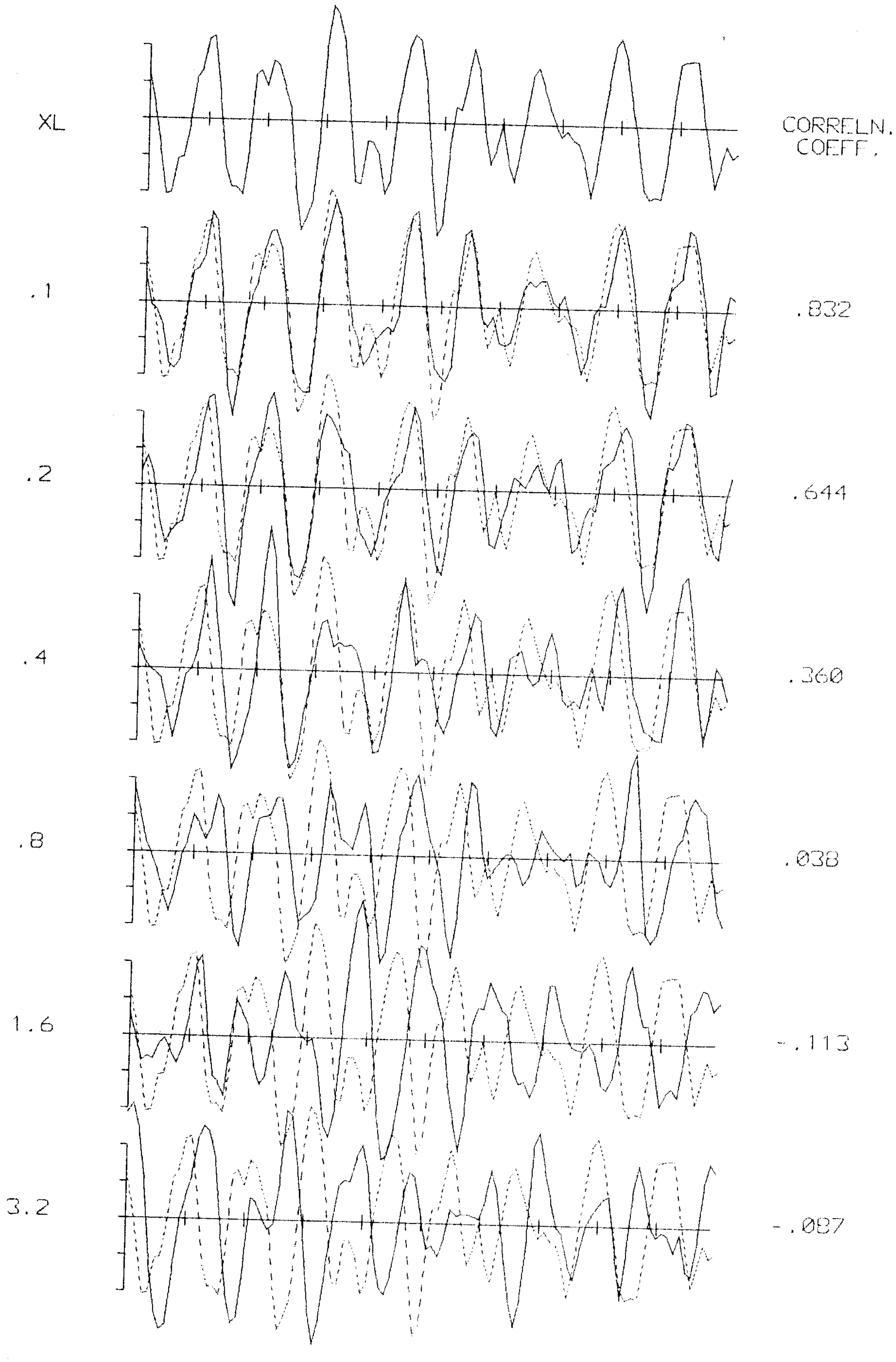

CORRELN.
COEFF.
.825
.618
.352
.098
.009
-.020

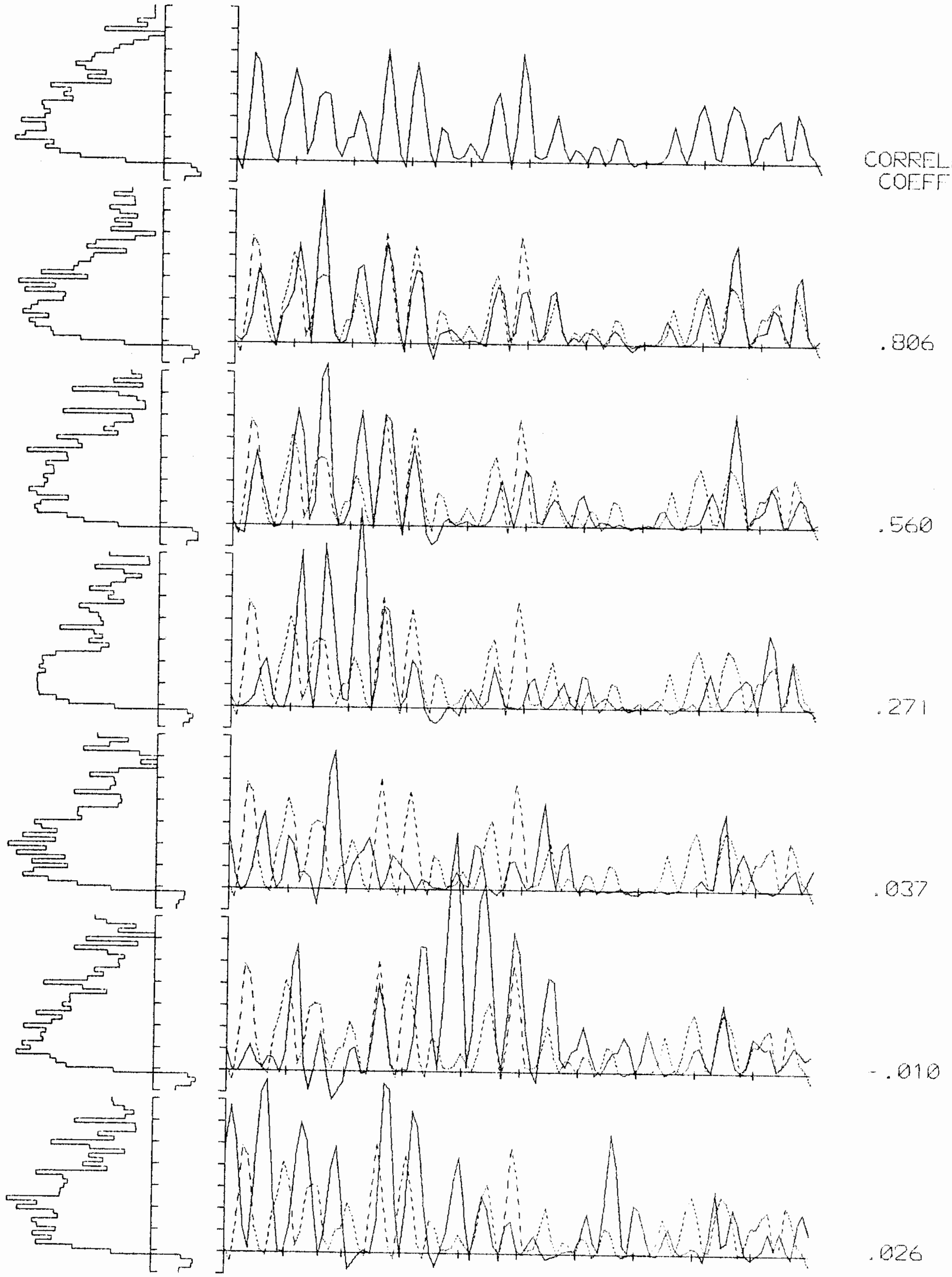
```
  TH0   NL   IR
   30    6   1309
 XL( 1-NL)  = ?
  0.0 0.1 0.2 0.4 0.8 1.6 3.2
 COS S ( TH)  SPECTRUM,  S =   0.0
 TE   =  9.998
 HRMS=   1.000
 POW IN = 42.88( 54.9 % OF POW)
```



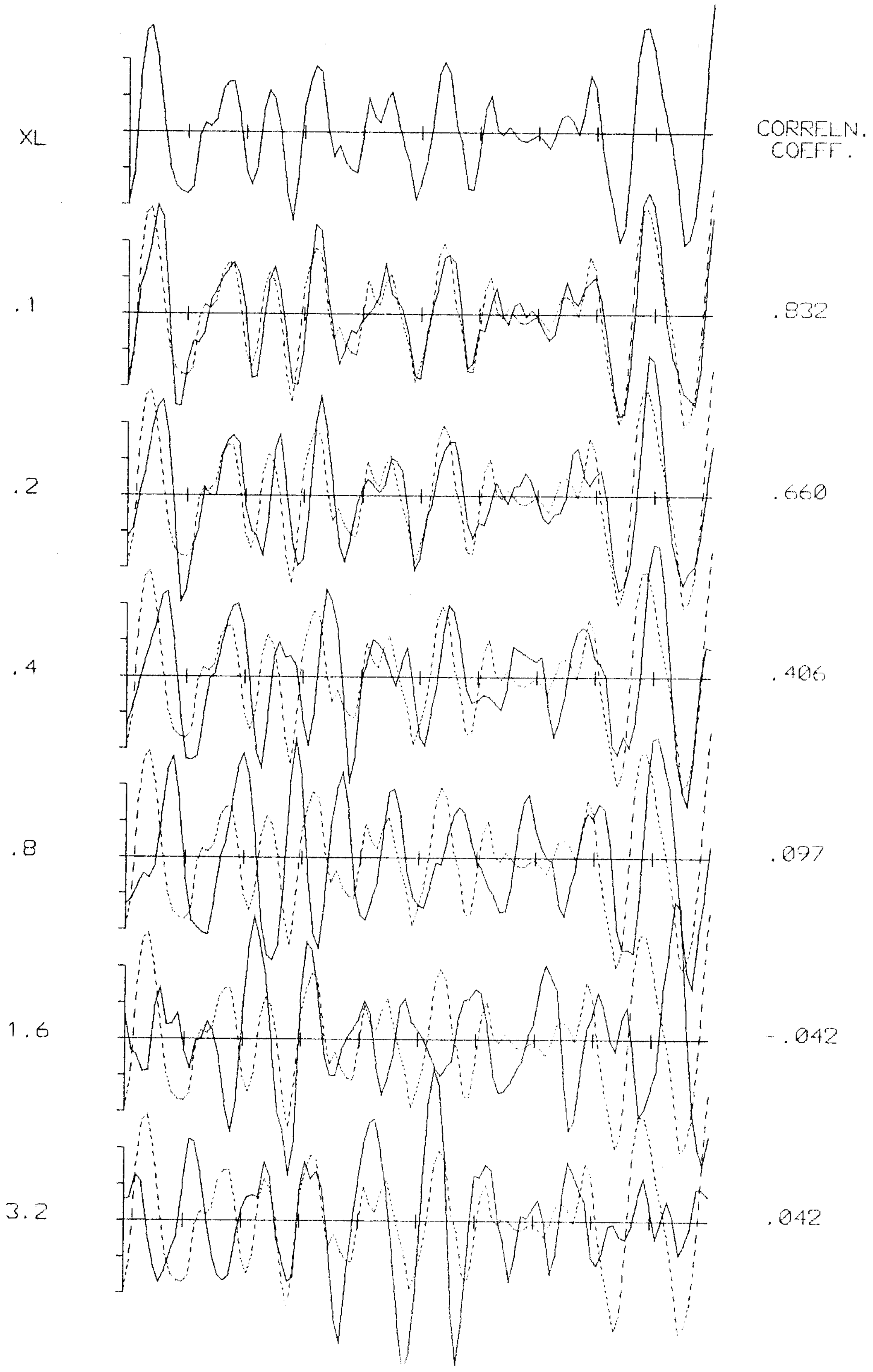

CORRELN.
COEFF.
.833
.624
.308
.101
.013
-.039

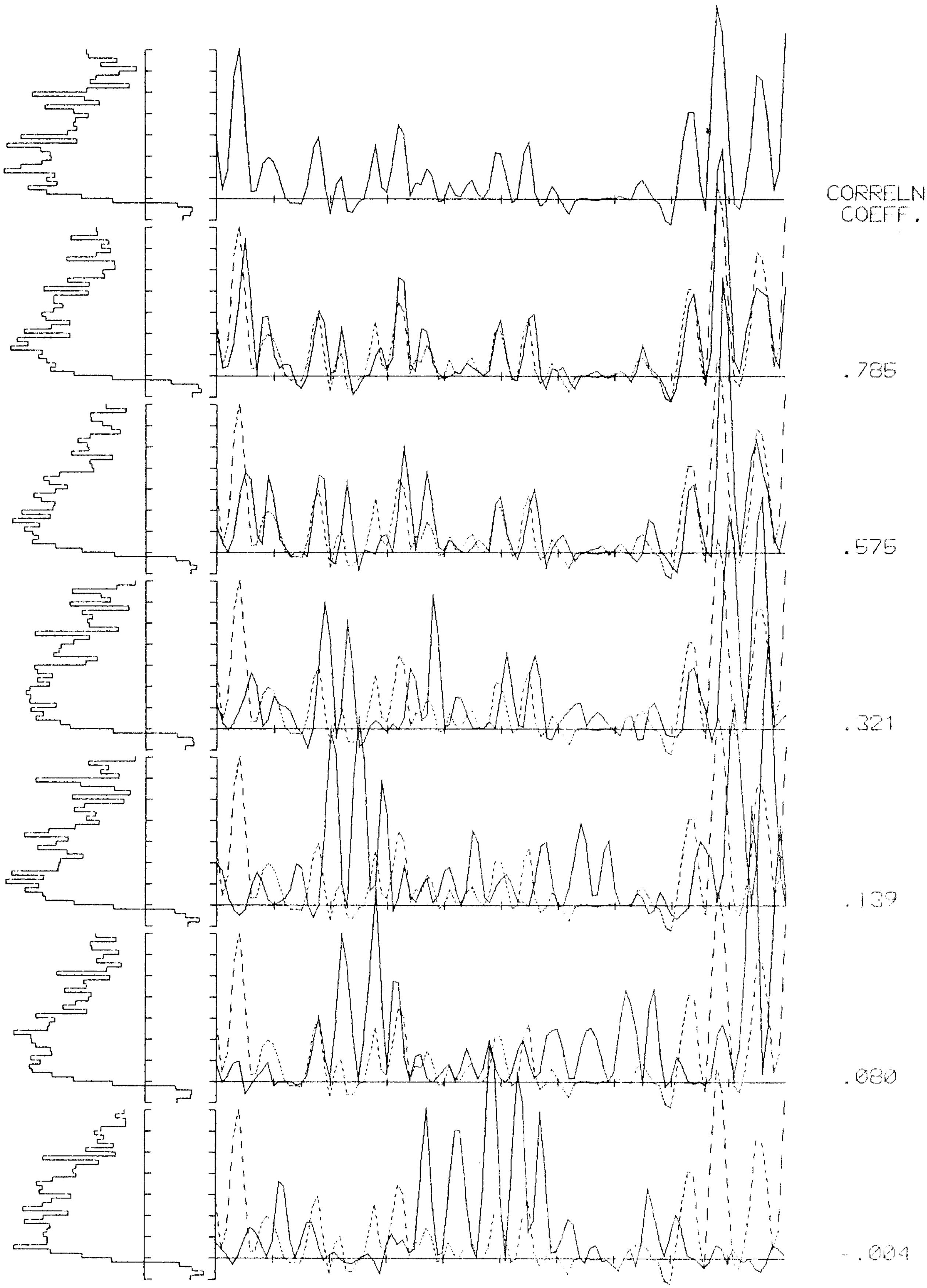
```
THØ   NL   IR
 6Ø    6   1514
XL( 1-NL) = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S ( TH) SPECTRUM, S =  Ø.Ø
TE   =  9.998
HRMS=  1.ØØØ
POW IN = 34.35( 44.Ø % OF POW)
```



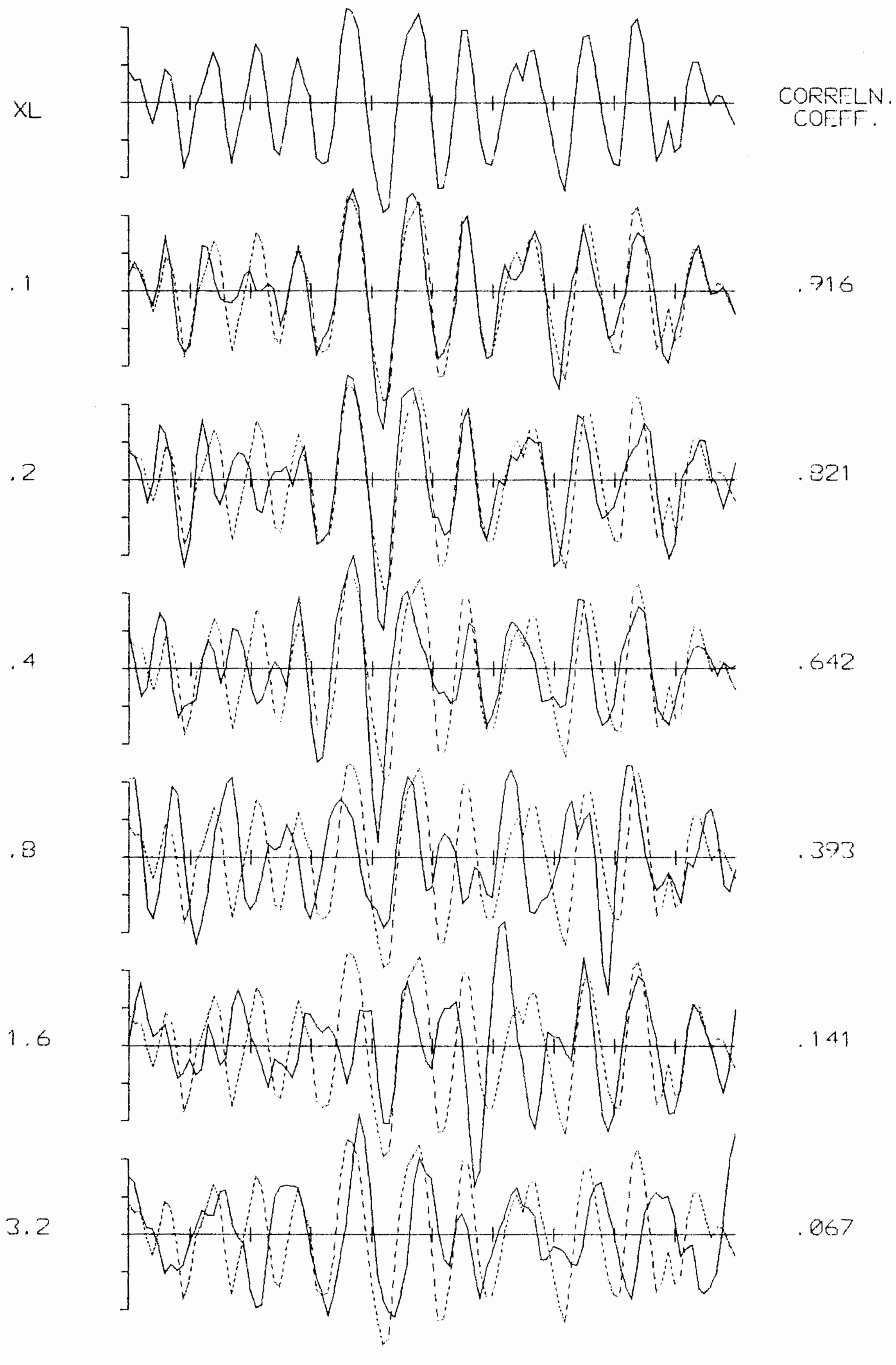

CORRELN.
COEFF.
.806
.560
.271
.037
-.010
.026

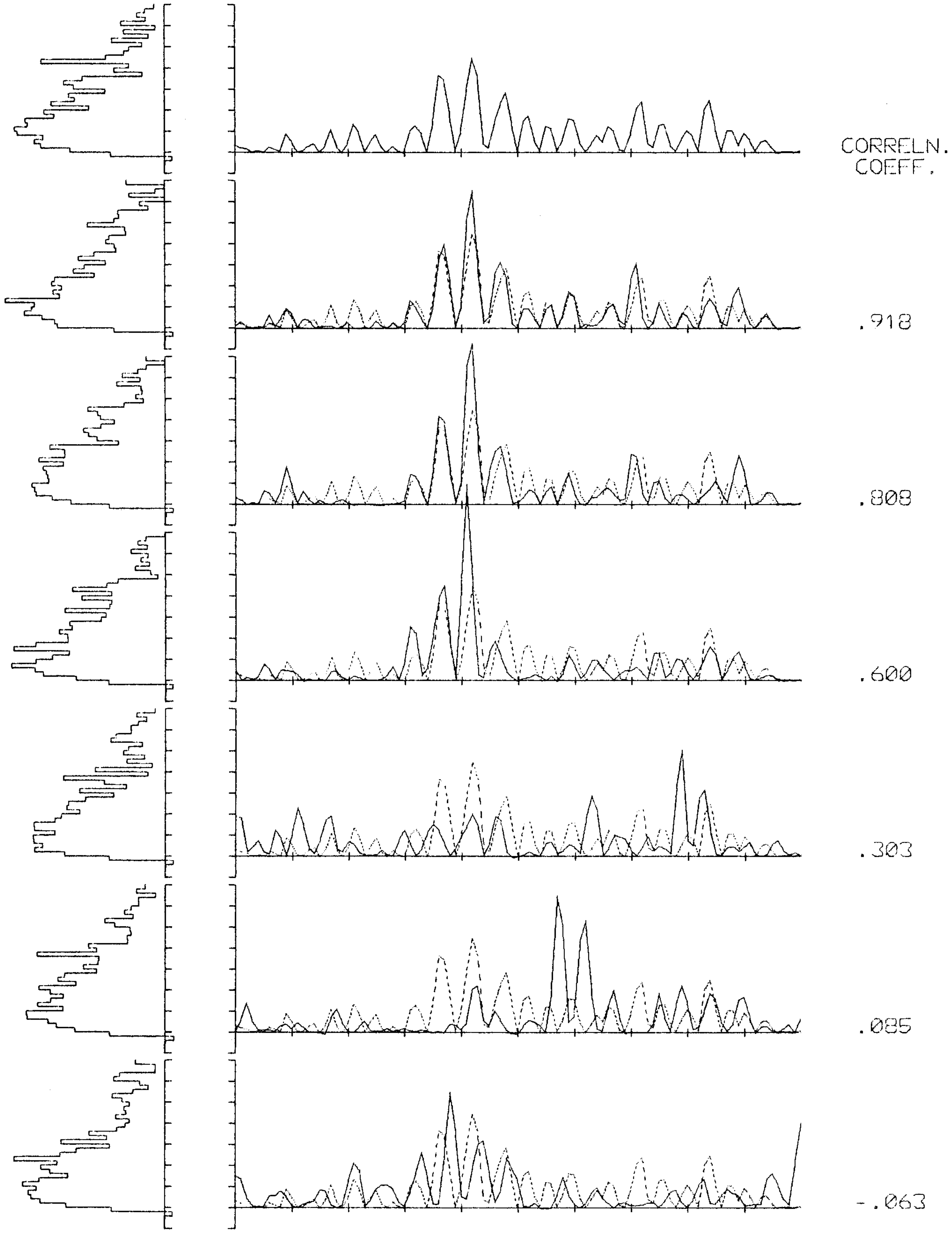
```
TH0   NL   IR
 90    6   1392
XL(1-NL) = ?
 0.0 0.1 0.2 0.4 0.8 1.6 3.2
COS S (TH) SPECTRUM, S =  0.0
TE  =  9.998
HRMS=  1.000
POW IN = 24.73( 31.7 % OF POW)
```



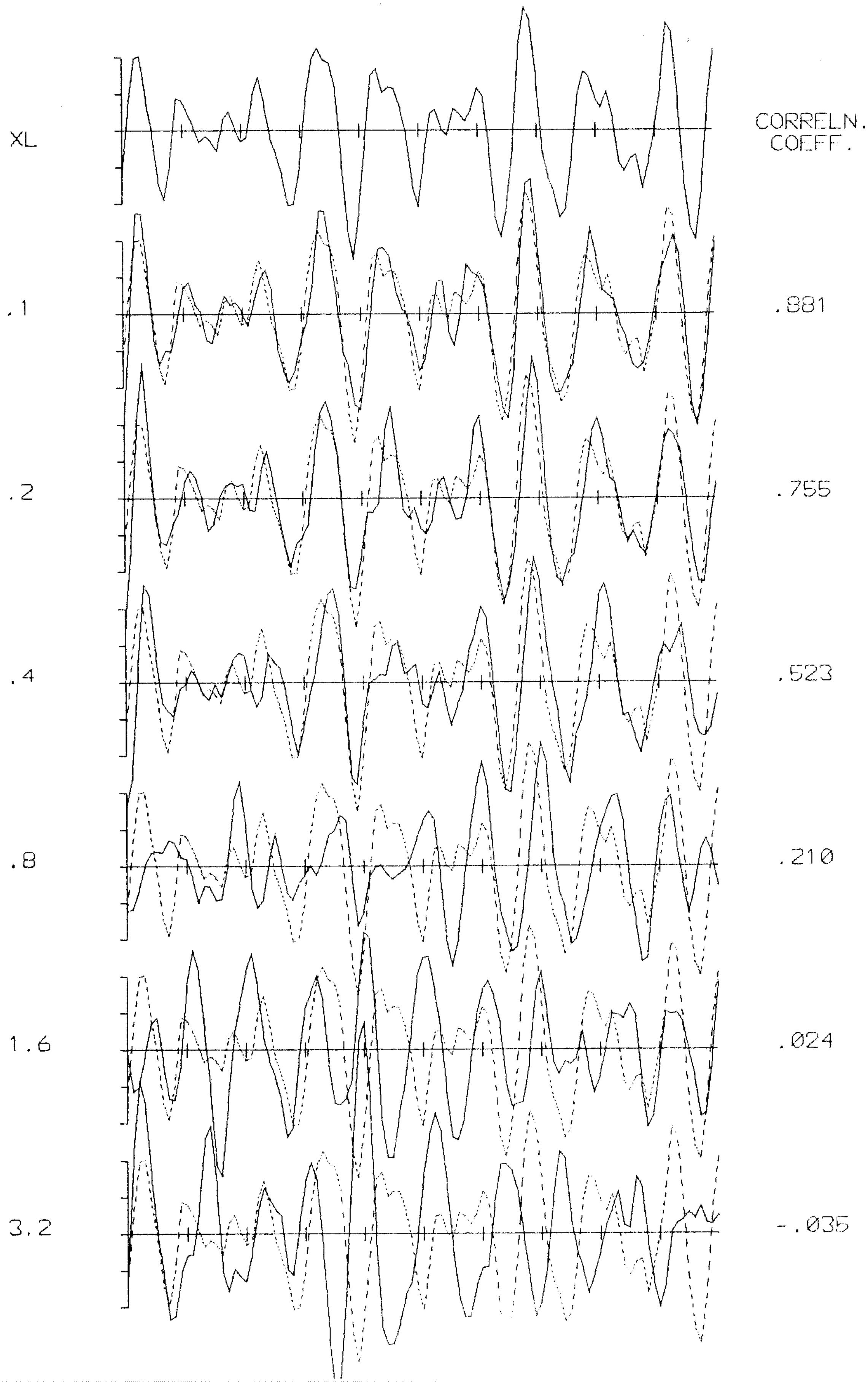

CORRELN.
COEFF.
.785
.575
.321
.139
.080
-.004

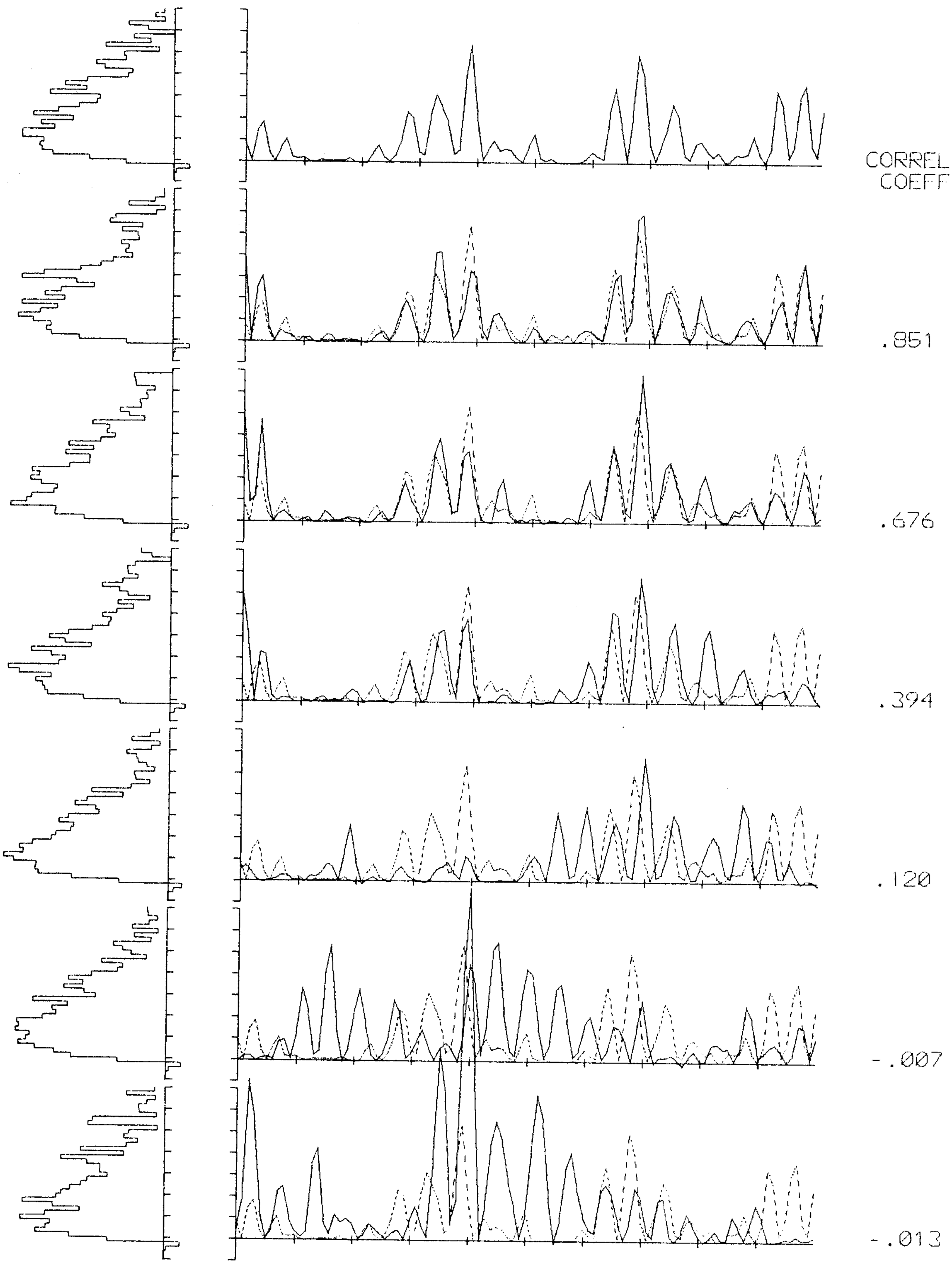
```
 THØ   NL   IR
   Ø    6   1342
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S ( TH)  SPECTRUM,  S =   4.Ø
TE   =   9.998
HRMS=   1.ØØØ
POW IN = 7Ø.37(  9Ø.1  % OF POW)
```



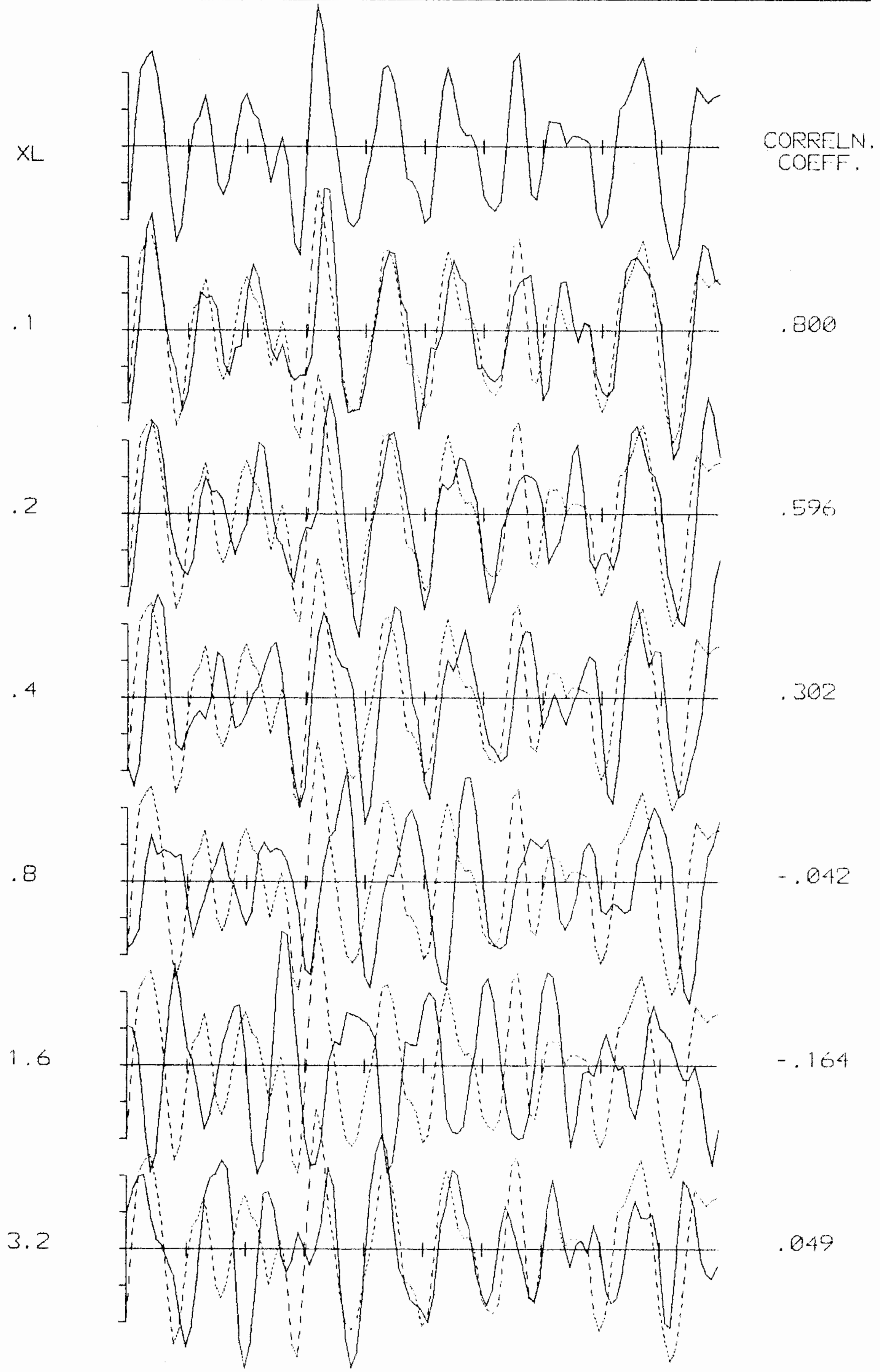

CORRELN.
COEFF.
.918
.808
.600
.303
.085
-.063

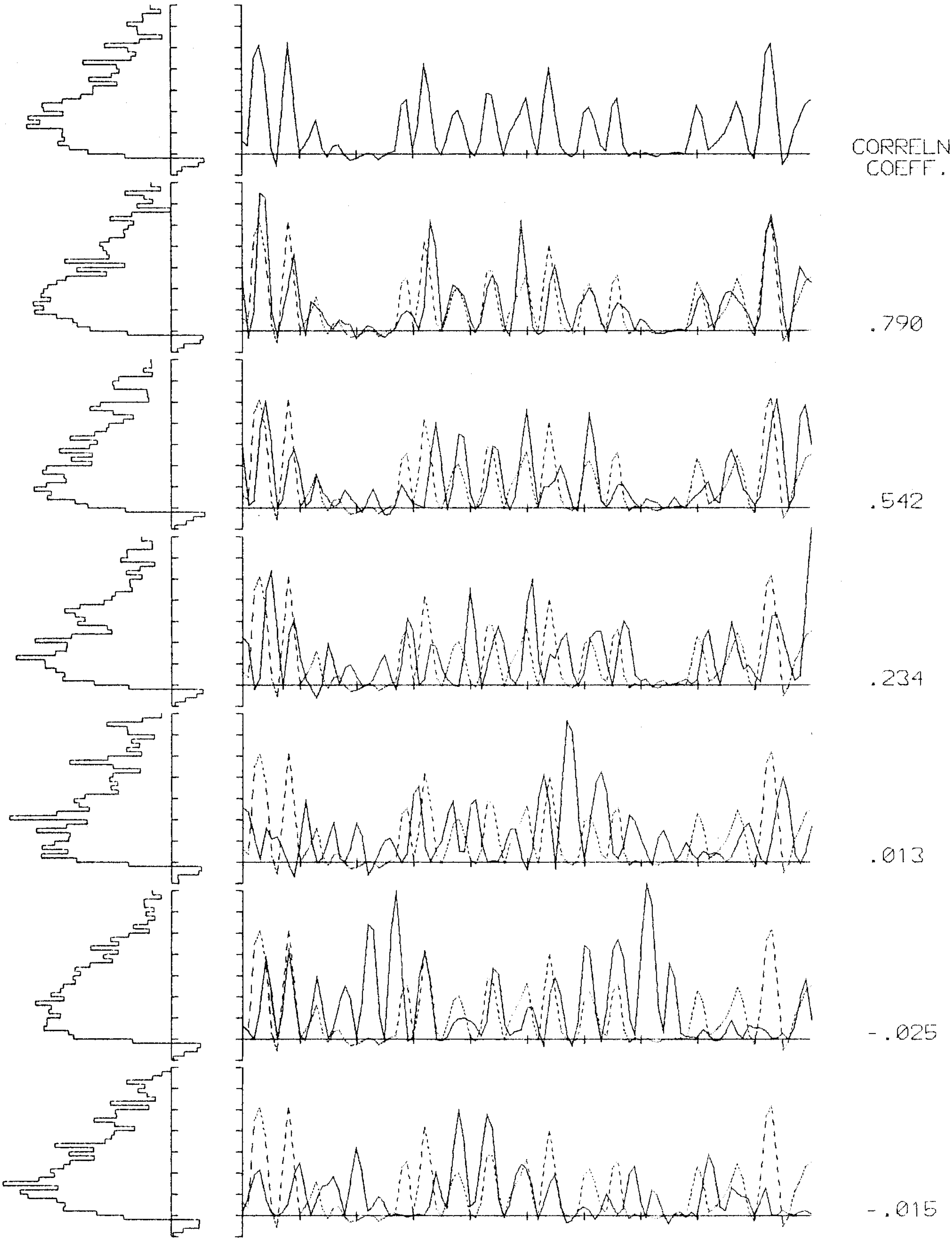
```
   TH0   NL   IR
    30    6   1178
  XL( 1-NL)  = ?
   0.0 0.1 0.2 0.4 0.8 1.6 3.2
  COS S ( TH)  SPECTRUM.  S =   4.0
  TE   =   9.998
  HRMS=   1.000
  POW IN  = 61.97(  79.3 % OF POW)
```



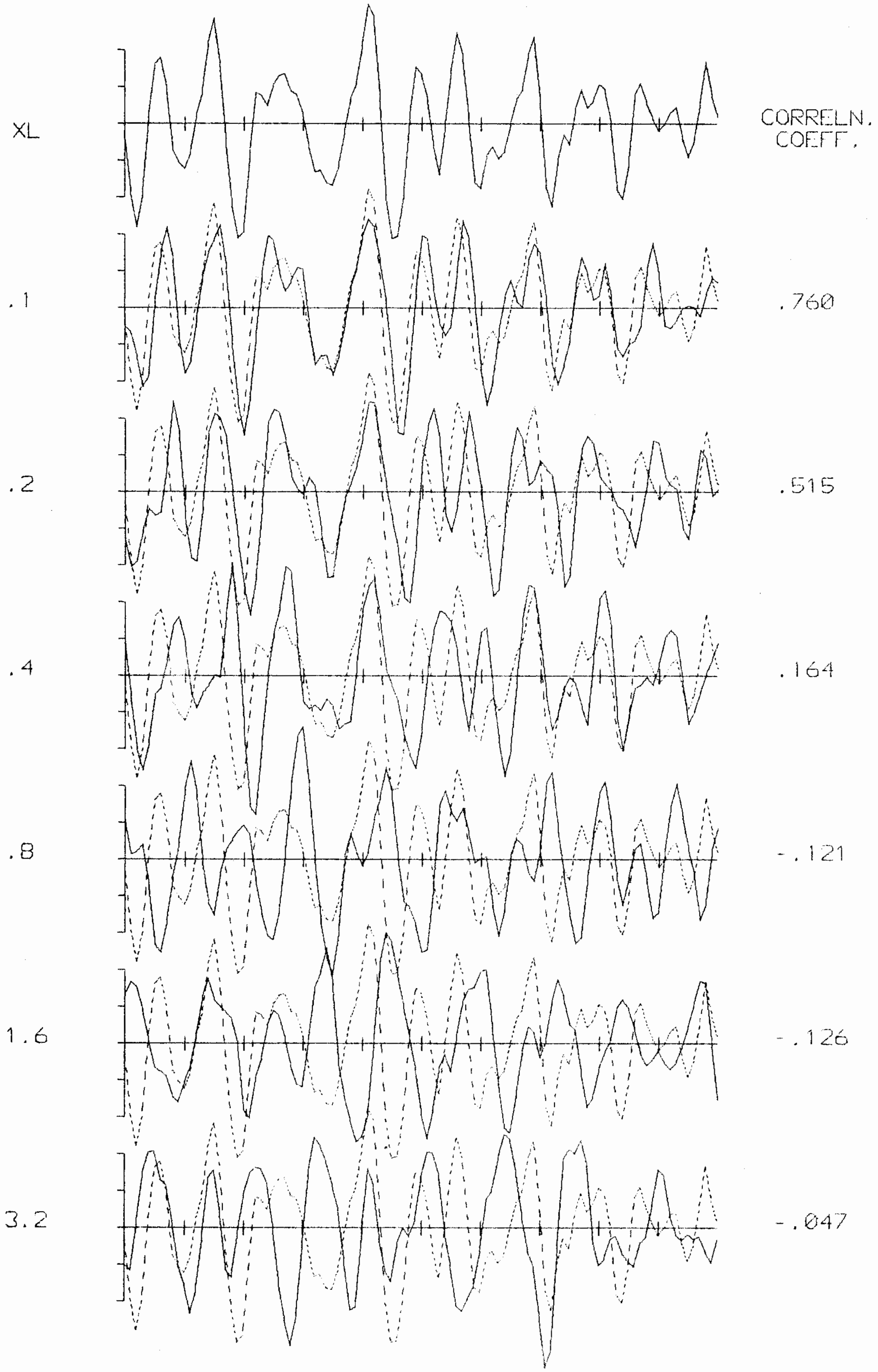

CORRELN.
COEFF.
.851
.676
.394
.120
-.007
-.013

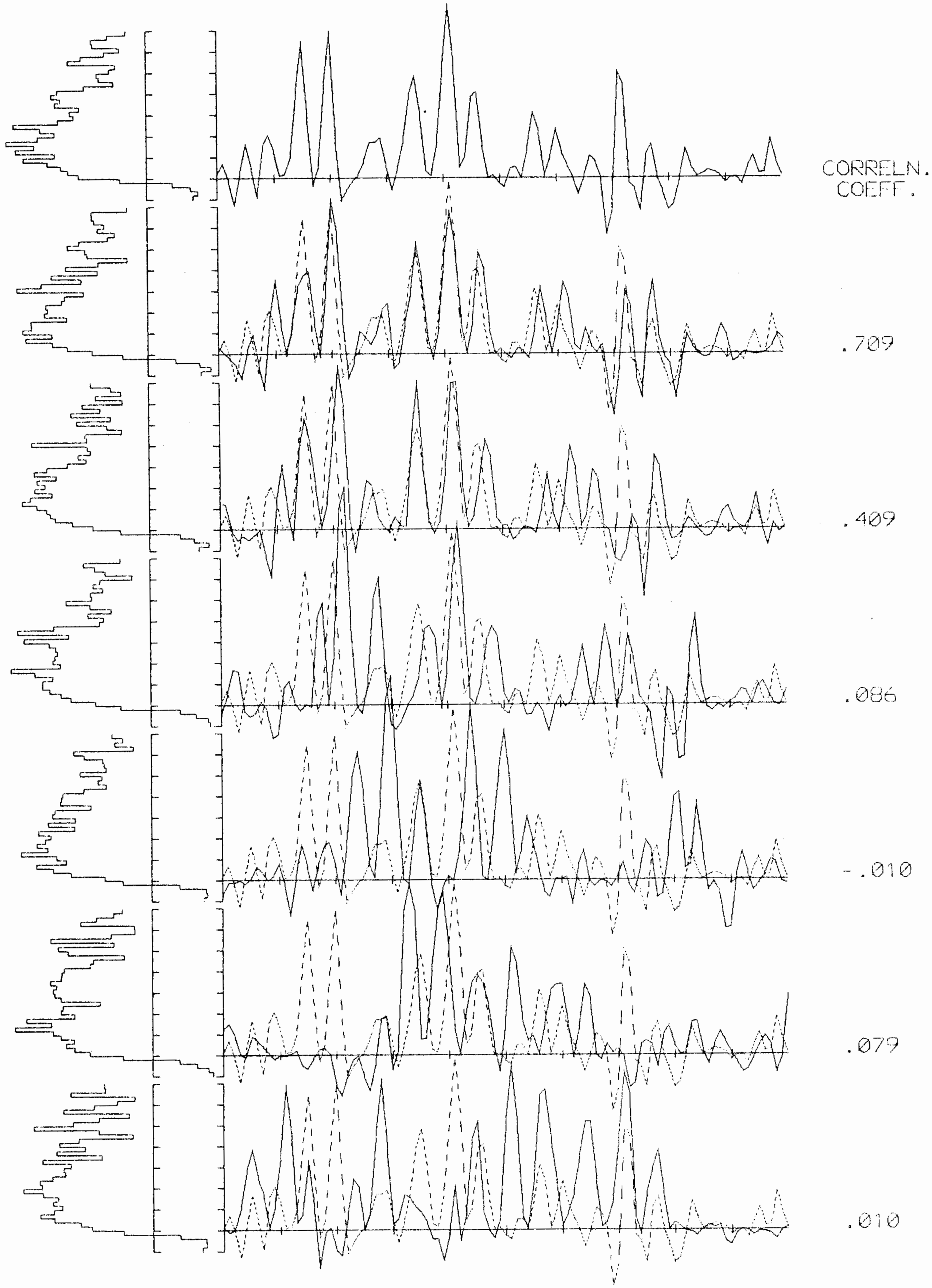
```
THØ   NL   IR
 6Ø    6   1256
XL( 1-NL)  = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S ( TH)  SPECTRUM,  S =   4.Ø
TE   =   9.998
HRMS=   1.ØØØ
POW IN = 39.61(  5Ø.7 % OF POW)
```




CORRELN.
COEFF.
.790
.542
.234
.013
-.025
-.015

```
THØ   NL   IR
 90    6   1437
XL(1-NL) = ?
 Ø.Ø Ø.1 Ø.2 Ø.4 Ø.8 1.6 3.2
COS S (TH) SPECTRUM, S =   4.Ø
TE  =  9.998
HRMS=  1.ØØØ
POW IN = 12.33( 15.8 % OF POW)
```




CORRELN.
COEFF.
.709
.409
.086
-.010
.079
.010