technical memorandum Daresbury Laboratory

DL/SRF/TM 4

CALCULATED SYNCHROTRON RADIATION SPECTRA FOR THE S.R.S. STORAGE RING AND WIGGLER

by

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FEBRUARY, 1976

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1. INTRODUCTION

A computer program written to calculate the synchrotron radiation spectra for NINA[1] has been modified to give the corresponding spectra for the Synchrotron Radiation Source (SRS) storage ring and a 4.5T wiggler magnet. This paper presents the full details of the spectra including the polarised components. The data is presented giving spectra for the storage ring at 1.0, 1.5 and 2.0 GeV and for the wiggler at 2.0 GeV, including the vertical distributions.

2. CALCULATION OF THE SPECTRA

The computer program uses a series approximation to evaluate the Bessel functions in the expression:

$$N(\psi,\lambda) = 8\,\frac{\pi R^2 e.10^{16}}{h\lambda^2}\left(\frac{m_o c^2}{E}\right)^4\left(1+\left(\frac{E\psi}{m_o c^2}\right)^2\right)^2 \left(K^2_{2/3}(\varepsilon) + \frac{(E\psi/m_o c^2)^2}{1+(E\psi/m_o c^2)^2}\cdot K^2_{1/3}(\varepsilon)\right) \qquad (1)$$

where

$$\varepsilon = \frac{\lambda_c}{2\lambda}\left(1+\left(\frac{E\psi}{m_o c^2}\right)^2\right)^{3/2}$$

$$\lambda_c = \frac{4\pi R}{3}\left(\frac{m_o c^2}{E}\right)^3$$

$N(\psi,\lambda)$ = No.of photons/s/mrad horizontally/mrad vertically within a 0.1% bandwidth.

R = bending radius (m)

e = electronic charge (coulomb)

h = Planck's constant (Joule.s)

λ = wavelength ($\mathring{A}$)

m_o = electron rest mass ($m_o c^2$ in GeV)

E = electron energy (GeV)

ψ = angle of elevation from the orbit plane (rad)

$K_{1/3}, K_{2/3}$ = Bessel functions.

Using this expression the spectra have been evaluated over a range of ψ and λ, for operating energies of 1.0, 1.5 and 2.0 GeV and the wiggler spectra at the last energy only. The wavelength range of the computed output covers the six decades from 0.1$\mathring{A}$ to 100,000$\mathring{A}$ with data points in each decade at ten equal logarithmic increments. The Bessel functions were evaluated using series approximations as used by other authors[2-4].

Calculations of the wiggler spectra were done by substituting the correct bending radius in eqn.(1). The bending radius was evaluated using the field profile[5] and calculating the mean field along the orbit path-length visible through the beamline aperture (see below).

Total and polarised spectra were calculated at 1.0, 1.5 and 2.0 GeV and they were stored on magnetic disc on the IBM 370/165. The parallel polarised component is given by eqn.(1) without the last term i.e.

$$N_{//}(\psi,\lambda) = \frac{8\pi R^2 e.10^{16}}{h\lambda^2}\left(\frac{m_o c^2}{E}\right)^4\left(1+\left(\frac{E\psi}{m_o c^2}\right)^2\right)^2 K^2{}_{2/3}(\varepsilon)$$

Separate programs were written to extract the data for this report.

3. LIMITATIONS OF THE CALCULATIONS

The original program is described elsewhere[6] and only a brief discussion follows. The largest sources of errors in the general spectra were the series approximations used to evaluate the Bessel functions. The series

approximation for small arguments is good for $\varepsilon < 1$ as is the large argument approximation for $\varepsilon > 10$, but in the region of overlap there is some error. Investigation has shown that these errors (of the order of a few percent over a limited range) give rise to similar errors in the spectrum on the sharply rising edge at short wavelengths. These errors are only observable in a region where the intensity is several orders of magnitude down from the peak.

At the time of writing, the wiggler magnet design is still in its early stages and the field profile quoted in ref.(5) is primarily a design target. The wiggler spectra are intended as a guide only, unlike the normal spectra which correspond to a firm design.

The method of calculating the bending radius gives rise to errors $\sim$ ±5% in the wiggler spectra, and the calculation is now described.

The maximum orbit path length observable by 'looking' up a beamline is defined by the beamline horizontal collimation. It was assumed that the beamline would accept a 25 mrad beam and the path length corresponding to this was calculated using the following relationship and tracking a 2 GeV electron through the magnet.

$$R = 5.3 \times 10^{-19} \frac{E}{eB} \text{ metres} \qquad (2)$$

where B = magnetic field (T)

e = electronic charge (Coulomb)

E = Particle energy (GeV)

The electrons were tracked through the field with 1mm steps, integrating the bending angle until such time as it matched the beamline acceptance. Knowing the path through the magnet the mean magnetic field was

calculated and the appropriate bending radius calculated using eqn.(2).

The errors in this process are comparatively large because the field profile was not specified very accurately and the step size for particle tracking was rather large ($\sim$ 4% of the total path length). The bending radius was calculated to be 1.5m (±5%) corresponding to a mean field of 4.46T.

4. RESULTS

The data is presented both graphically and in tabular form.

Table 1 lists the radiation spectrum integrated over all vertical angles for 1.0, 1.5 and 2.0 GeV operation of the storage ring.

Tables 2 to 4 list the vertical angular distributions of various wavelengths of the synchrotron radiation at the above energies.

Tables 5 to 8 list the vertical distribution of the polarised components of the radiation at 10, 100, 1000 and 2000 Å for 2.0 GeV operation of the storage ring.

Tables 9 and 10 give the wiggler spectra for 2.0 GeV electrons, table 9 showing the spectrum integrated over all vertical angles and table 10 the vertical angular distribution of various wavelengths.

Figures 1 to 10 are the graphical presentation of tables 1 to 10 respectively.

1. J. POOLE, Daresbury Laboratory Technical Memorandum DL/SRF/TM1 (1975)

2. R.A. MACK, CEA Report CEAL-1027 (1966)

3. J. LANG, S.R.C. Astrophysics Research Unit Report ARU-1 (1969)

4. G.N. WATSON, A Treatise on the Theory of Bessel Functions (Cambridge University Press, 1966)

5. V.P. SULLER, S.R.S. Internal Note SRS/NS/75/67

6. J. POOLE, Daresbury Laboratory Technical Memorandum to be published

VERTICALLY INTEGRATED SYNCHROTRON RADIATION SPECTRUM

SPECTRA ARE LISTED AT LOGARITHMIC INCREMENTS OF1/10TH OF A DECADE FROM 0.1 TO 100.000 ANGSTROMS
IN UNITS OF PHOTONS/MRAD HORIZ/MA BEAM/SEC INTO A 0.1% BANDWIDTH

1.0GEV

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.2769E+01	0.3908E+03	0.1934E+05	0.4183E+06	0.5468E+07	0.3797E+08	0.1718E+09	0.5595E+09	0.1406E+10
0.2876E+10	0.5003E+10	0.7656E+10	0.1059E+11	0.1352E+11	0.1620E+11	0.1846E+11	0.2023E+11	0.2147E+11	0.2220E+11
0.2243E+11	0.2216E+11	0.2142E+11	0.2028E+11	0.1882E+11	0.1717E+11	0.1544E+11	0.1373E+11	0.1211E+11	0.1062E+11
0.9278E+10	0.8086E+10	0.7037E+10	0.6120E+10	0.5324E+10	0.4633E+10	0.4037E+10	0.3521E+10	0.3076E+10	0.2692E+10
0.2359E+10	0.2071E+10	0.1821E+10	0.1604E+10	0.1415E+10	0.1251E+10	0.1108E+10	0.9818E+09	0.8710E+09	0.7724E+09
0.6837E+09									

1.5GEV

0.0	0.0	0.0	0.0	0.0	0.4497E-01	0.1901E+02	0.1944E+04	0.7455E+05	0.1407E+07
0.1493E+08	0.9068E+08	0.3708E+09	0.1115E+10	0.2630E+10	0.5120E+10	0.8564E+10	0.1270E+11	0.1714E+11	0.2146E+11
0.2533E+11	0.2852E+11	0.3094E+11	0.3258E+11	0.3352E+11	0.3383E+11	0.3364E+11	0.3305E+11	0.3213E+11	0.3093E+11
0.2945E+11	0.2769E+11	0.2568E+11	0.2348E+11	0.2117E+11	0.1885E+11	0.1663E+11	0.1455E+11	0.1268E+11	0.1101E+11
0.9552E+10	0.8276E+10	0.7169E+10	0.6213E+10	0.5389E+10	0.4680E+10	0.4070E+10	0.3546E+10	0.3094E+10	0.2705E+10
0.2369E+10	0.2078E+10	0.1827E+10	0.1608E+10	0.1419E+10	0.1254E+10	0.1110E+10	0.9834E+09	0.8722E+09	0.7734E+09
0.6845E+09									

2.0GEV

0.0	0.0	0.6567E+01	0.8945E+03	0.4301E+05	0.9162E+06	0.1171E+08	0.8002E+08	0.3580E+09	0.1155E+10
0.2882E+10	0.5864E+10	0.1016E+11	0.1549E+11	0.2136E+11	0.2721E+11	0.3255E+11	0.3705E+11	0.4054E+11	0.4299E+11
0.4446E+11	0.4507E+11	0.4497E+11	0.4429E+11	0.4316E+11	0.4171E+11	0.4003E+11	0.3821E+11	0.3627E+11	0.3422E+11
0.3203E+11	0.2968E+11	0.2718E+11	0.2458E+11	0.2197E+11	0.1942E+11	0.1702E+11	0.1483E+11	0.1287E+11	0.1114E+11
0.9642E+10	0.8339E+10	0.7213E+10	0.6244E+10	0.5411E+10	0.4696E+10	0.4082E+10	0.3554E+10	0.3100E+10	0.2709E+10
0.2372E+10	0.2081E+10	0.1829E+10	0.1610E+10	0.1420E+10	0.1255E+10	0.1110E+10	0.9840E+09	0.8727E+09	0.7737E+09
0.6847E+09									

TABLE 1

FOR 1.0 GEV OPERATION

VERTICAL DISTRIBUTION OF 1 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 10 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.6388E+10	0.6355E+10	0.6255E+10	0.6090E+10	0.5864E+10	0.5582E+10	0.5249E+10	0.4874E+10	0.4466E+10	0.4034E+10
0.3590E+10	0.3145E+10	0.2709E+10	0.2293E+10	0.1905E+10	0.1552E+10	0.1239E+10	0.9680E+09	0.7396E+09	0.5521E+09
0.4022E+09	0.2857E+09	0.1976E+09	0.1330E+09	0.8706E+08	0.5531E+08	0.3408E+08	0.2034E+08	0.1174E+08	0.6543E+07
0.3508E+07	0.1800E+07	0.8119E+06	0.3968E+06	0.1865E+06	0.8422E+05	0.3651E+05	0.1518E+05	0.6044E+04	0.2303E+04
0.8390E+03	0.2919E+03	0.9685E+02	0.3062E+02	0.9218E+01	0.2638E+01	0.7173E+00	0.1851E+00	0.4525E-01	0.0
0.0									

VERTICAL DISTRIBUTION OF 100 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.1496E+11	0.1503E+11	0.1515E+11	0.1506E+11	0.1445E+11	0.1312E+11	0.1105E+11	0.8500E+10	0.5879E+10	0.3605E+10
0.1934E+10	0.8954E+09	0.3532E+09	0.1171E+09	0.3220E+08	0.7242E+07	0.1309E+07	0.1657E+06	0.1923E+05	0.1724E+04
0.1179E+03	0.6070E+01	0.2321E+00	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 1000 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.3780E+10	0.3797E+10	0.3847E+10	0.3924E+10	0.4022E+10	0.4129E+10	0.4233E+10	0.4320E+10	0.4377E+10	0.4390E+10
0.4349E+10	0.4246E+10	0.4078E+10	0.3845E+10	0.3555E+10	0.3217E+10	0.2845E+10	0.2455E+10	0.2066E+10	0.1692E+10
0.1346E+10	0.1040E+10	0.7795E+09	0.5654E+09	0.3966E+09	0.2686E+09	0.1755E+09	0.1104E+09	0.6679E+08	0.3882E+08
0.2165E+08	0.1156E+08	0.5908E+07	0.2884E+07	0.1342E+07	0.5948E+06	0.2502E+06	0.9955E+05	0.3350E+05	0.1221E+05
0.4207E+04	0.1369E+04	0.4202E+03	0.1215E+03	0.3304E+02	0.8443E+01	0.2024E+01	0.4546E+00	0.9554E-01	0.1876E-01
0.3438E-02									

ANGULAR DISTRUBUTION OF SYNCHROTRON RADIATION FOR THE SYNCHROTRON RADIATION SOURCE

FOR 1.5 GEV OPERATION

VERTICAL DISTRIBUTION OF 1 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.8957E+08	0.8579E+08	0.7533E+08	0.6049E+08	0.4425E+08	0.2932E+08	0.1746E+08	0.9212E+07	0.3992E+07	0.1720E+07
0.6505E+06	0.2143E+06	0.6091E+05	0.1481E+05	0.3054E+04	0.5287E+03	0.7615E+02	0.9036E+01	0.8747E+00	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 10 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.4379E+11	0.4372E+11	0.4350E+11	0.4312E+11	0.4256E+11	0.4178E+11	0.4076E+11	0.3947E+11	0.3788E+11	0.3600E+11
0.3383E+11	0.3139E+11	0.2873E+11	0.2589E+11	0.2297E+11	0.2001E+11	0.1712E+11	0.1436E+11	0.1180E+11	0.9479E+10
0.7444E+10	0.5706E+10	0.4266E+10	0.3106E+10	0.2201E+10	0.1516E+10	0.1014E+10	0.6579E+09	0.4136E+09	0.2517E+09
0.1481E+09	0.8415E+08	0.4613E+08	0.2436E+08	0.1237E+08	0.6032E+07	0.2812E+07	0.1115E+07	0.4870E+06	0.2035E+06
0.8129E+05	0.3102E+05	0.1129E+05	0.3918E+04	0.1294E+04	0.4067E+03	0.1214E+03	0.3439E+02	0.9237E+01	0.2349E+01
0.5653E+00									

VERTICAL DISTRIBUTION OF 100 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.1707E+11	0.1733E+11	0.1796E+11	0.1858E+11	0.1867E+11	0.1778E+11	0.1572E+11	0.1269E+11	0.9215E+10	0.5931E+10
0.3339E+10	0.1623E+10	0.6720E+09	0.2339E+09	0.6756E+08	0.1596E+08	0.3041E+07	0.4561E+06	0.4874E+05	0.4599E+04
0.3309E+03	0.1792E+02	0.7206E+00	0.2124E-01	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 1000 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.3806E+10	0.3826E+10	0.3884E+10	0.3975E+10	0.4091E+10	0.4220E+10	0.4349E+10	0.4463E+10	0.4547E+10	0.4586E+10
0.4569E+10	0.4486E+10	0.4332E+10	0.4108E+10	0.3818E+10	0.3473E+10	0.3088E+10	0.2679E+10	0.2266E+10	0.1865E+10
0.1492E+10	0.1159E+10	0.8726E+09	0.6362E+09	0.4485E+09	0.3053E+09	0.2004E+09	0.1267E+09	0.7708E+08	0.4503E+08
0.2524E+08	0.1355E+08	0.6957E+07	0.3413E+07	0.1597E+07	0.7115E+06	0.3011E+06	0.1205E+06	0.4058E+05	0.1487E+05
0.5150E+04	0.1685E+04	0.5198E+03	0.1511E+03	0.4130E+02	0.1061E+02	0.2556E+01	0.5770E+00	0.1219E+00	0.2406E-01
0.4431E-02									

ANGULAR DISTRUBUTION OF SYNCHROTRON RADIATION FOR THE SYNCHROTRON RADIATION SOURCE

FOR 2.0 GEV OPERATION

VERTICAL DISTRIBUTION OF 1 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.1445E+11	0.1405E+11	0.1290E+11	0.1115E+11	0.9015E+10	0.6780E+10	0.4703E+10	0.2984E+10	0.1716E+10	0.8864E+09
0.4073E+09	0.1648E+09	0.5803E+08	0.1749E+08	0.4020E+07	0.9038E+06	0.1701E+06	0.2653E+05	0.3392E+04	0.3521E+03
0.2935E+02	0.1945E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 10 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.6583E+11	0.6586E+11	0.6595E+11	0.6604E+11	0.6608E+11	0.6597E+11	0.6563E+11	0.6495E+11	0.6384E+11	0.6221E+11
0.6002E+11	0.5723E+11	0.5386E+11	0.4996E+11	0.4562E+11	0.4094E+11	0.3608E+11	0.3119E+11	0.2641E+11	0.2188E+11
0.1772E+11	0.1401E+11	0.1080E+11	0.8116E+10	0.5935E+10	0.4219E+10	0.2913E+10	0.1951E+10	0.1267E+10	0.7962E+09
0.4839E+09	0.2841E+09	0.1610E+09	0.8790E+08	0.4621E+08	0.2336E+08	0.1133E+08	0.5264E+07	0.2333E+07	0.8821E+06
0.3648E+06	0.1441E+06	0.5430E+05	0.1950E+05	0.6669E+04	0.2169E+04	0.6701E+03	0.1965E+03	0.5463E+02	0.1438E+02
0.3582E+01									

VERTICAL DISTRIBUTION OF 100 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.1749E+11	0.1783E+11	0.1871E+11	0.1967E+11	0.2013E+11	0.1953E+11	0.1759E+11	0.1446E+11	0.1069E+11	0.7002E+10
0.4012E+10	0.1984E+10	0.8361E+09	0.2962E+09	0.8705E+08	0.2094E+08	0.4061E+07	0.6221E+06	0.6718E+05	0.6454E+04
0.4728E+03	0.2607E+02	0.1067E+01	0.3201E-01	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 1000 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.3811E+10	0.3832E+10	0.3893E+10	0.3989E+10	0.4111E+10	0.4248E+10	0.4386E+10	0.4510E+10	0.4604E+10	0.4654E+10
0.4646E+10	0.4570E+10	0.4422E+10	0.4201E+10	0.3912E+10	0.3566E+10	0.3176E+10	0.2761E+10	0.2339E+10	0.1929E+10
0.1546E+10	0.1203E+10	0.9075E+09	0.6628E+09	0.4681E+09	0.3192E+09	0.2099E+09	0.1330E+09	0.8102E+08	0.4742E+08
0.2662E+08	0.1432E+08	0.7365E+07	0.3620E+07	0.1697E+07	0.7574E+06	0.3211E+06	0.1289E+06	0.4339E+05	0.1592E+05
0.5527E+04	0.1811E+04	0.5599E+03	0.1630E+03	0.4465E+02	0.1149E+02	0.2773E+01	0.6271E+00	0.1327E+00	0.2624E-01
0.4842E-02									

TABLE 4

ANGULAR DISTRIBUTION OF POLARISED COMPONENTS OF SYNCHROTRON RADIATION FOR 10 ANGSTROM RADIATION FROM THE SRS

FOR 2.0 GEV OPERATION

THE SPECTRA ARE LISTED AT INCREMENTS OF 0.02MRAD FROM 0.0 TO 1.0MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC IN A 0.1% BANDWIDTH

TOTAL INTENSITY OF RADIATION

0.6583E+11	0.6586E+11	0.6595E+11	0.6604E+11	0.6608E+11	0.6597E+11	0.6563E+11	0.6495E+11	0.6384E+11	0.6221E+11
0.6002E+11	0.5723E+11	0.5386E+11	0.4996E+11	0.4562E+11	0.4094E+11	0.3608E+11	0.3119E+11	0.2641E+11	0.2188E+11
0.1772E+11	0.1401E+11	0.1080E+11	0.8116E+10	0.5935E+10	0.4219E+10	0.2913E+10	0.1951E+10	0.1267E+10	0.7962E+09
0.4839E+09	0.2841E+09	0.1610E+09	0.8790E+08	0.4621E+08	0.2336E+08	0.1133E+08	0.5264E+07	0.2333E+07	0.8821E+06
0.3648E+06	0.1441E+06	0.5430E+05	0.1950E+05	0.6669E+04	0.2169E+04	0.6701E+03	0.1965E+03	0.5463E+02	0.1438E+02
0.3582E+01									

INTENSITY OF PARALLEL POLARISED RADIATION

0.6583E+11	0.6567E+11	0.6517E+11	0.6433E+11	0.6315E+11	0.6160E+11	0.5969E+11	0.5741E+11	0.5476E+11	0.5175E+11
0.4842E+11	0.4480E+11	0.4094E+11	0.3692E+11	0.3282E+11	0.2873E+11	0.2472E+11	0.2090E+11	0.1734E+11	0.1409E+11
0.1121E+11	0.8723E+10	0.6627E+10	0.4911E+10	0.3546E+10	0.2491E+10	0.1702E+10	0.1129E+10	0.7261E+09	0.4525E+09
0.2729E+09	0.1590E+09	0.8949E+08	0.4854E+08	0.2534E+08	0.1270E+08	0.6089E+07	0.2766E+07	0.1166E+07	0.4686E+06
0.1932E+06	0.7612E+05	0.2861E+05	0.1025E+05	0.3498E+04	0.1135E+04	0.3500E+03	0.1025E+03	0.2843E+02	0.7474E+01
0.1858E+01									

INTENSITY OF PERPENDICULARLY POLARISED RADIATION

0.0	0.1980E+09	0.7801E+09	0.1711E+10	0.2934E+10	0.4374E+10	0.5943E+10	0.7545E+10	0.9082E+10	0.1046E+11
0.1160E+11	0.1243E+11	0.1292E+11	0.1304E+11	0.1279E+11	0.1222E+11	0.1136E+11	0.1028E+11	0.9067E+10	0.7783E+10
0.6502E+10	0.5284E+10	0.4175E+10	0.3205E+10	0.2389E+10	0.1728E+10	0.1211E+10	0.8227E+09	0.5408E+09	0.3437E+09
0.2110E+09	0.1251E+09	0.7148E+08	0.3936E+08	0.2087E+08	0.1065E+08	0.5243E+07	0.2497E+07	0.1167E+07	0.4135E+06
0.1716E+06	0.6798E+05	0.2569E+05	0.9251E+04	0.3171E+04	0.1034E+04	0.3201E+03	0.9404E+02	0.2619E+02	0.6908E+01
0.1723E+01									

TABLE 5

ANGULAR DISTRIBUTION OF POLARISED COMPONENTS OF SYNCHROTRON RADIATION FOR 100 ANGSTROM RADIATION FROM THE SRS

FOR 2.0 GEV OPERATION

THE SPECTRA ARE LISTED AT INCREMENTS OF 0.1MRAD FROM 0.0 TO 5.0MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC IN A 0.1% BANDWIDTH

TOTAL INTENSITY OF RADIATION

0.1749E+11	0.1783E+11	0.1871E+11	0.1967E+11	0.2013E+11	0.1953E+11	0.1759E+11	0.1446E+11	0.1069E+11	0.7002E+10
0.4012E+10	0.1984E+10	0.8361E+09	0.2962E+09	0.8705E+08	0.2094E+08	0.4061E+07	0.6221E+06	0.6718E+05	0.6454E+04
0.4728E+03	0.2607E+02	0.1067E+01	0.3201E-01	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PARALLEL POLARISED RADIATION

0.1749E+11	0.1743E+11	0.1718E+11	0.1662E+11	0.1558E+11	0.1395E+11	0.1173E+11	0.9110E+10	0.6435E+10	0.4068E+10
0.2267E+10	0.1097E+10	0.4543E+09	0.1587E+09	0.4613E+08	0.1099E+08	0.2101E+07	0.3021E+06	0.3428E+05	0.3286E+04
0.2402E+03	0.1322E+02	0.5405E+00	0.1619E-01	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PERPENDICULARLY POLARISED RADIATION

0.0	0.4093E+09	0.1528E+10	0.3049E+10	0.4545E+10	0.5583E+10	0.5868E+10	0.5354E+10	0.4253E+10	0.2933E+10
0.1745E+10	0.8874E+09	0.3819E+09	0.1375E+09	0.4092E+08	0.9949E+07	0.1959E+07	0.3200E+06	0.3289E+05	0.3168E+04
0.2326E+03	0.1285E+02	0.5267E+00	0.1582E-01	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

ANGULAR DISTRIBUTION OF POLARISED COMPONENTS OF SYNCHROTRON RADIATION FOR 1000 ANGSTROM RADIATION FROM THE SRS

FOR 2.0 GEV OPERATION

THE SPECTRA ARE LISTED AT INCREMENTS OF 0.2MRAD FROM 0.0 TO 10.0MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC IN A 0.1% BANDWIDTH

TOTAL INTENSITY OF RADIATION

0.3811E+10	0.3893E+10	0.4111E+10	0.4386E+10	0.4604E+10	0.4646E+10	0.4422E+10	0.3912E+10	0.3176E+10	0.2339E+10
0.1546E+10	0.9075E+09	0.4681E+09	0.2099E+09	0.8102E+08	0.2662E+08	0.7365E+07	0.1697E+07	0.3211E+06	0.4339E+05
0.5527E+04	0.5599E+03	0.4465E+02	0.2773E+01	0.1327E+00	0.4842E-02	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PARALLEL POLARISED RADIATION

0.3811E+10	0.3807E+10	0.3788E+10	0.3727E+10	0.3589E+10	0.3342E+10	0.2967E+10	0.2477E+10	0.1920E+10	0.1363E+10
0.8750E+09	0.5020E+09	0.2543E+09	0.1125E+09	0.4291E+08	0.1397E+08	0.3834E+07	0.8753E+06	0.1613E+06	0.2199E+05
0.2797E+04	0.2829E+03	0.2253E+02	0.1398E+01	0.6685E-01	0.2437E-02	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PERPENDICULARLY POLARISED RADIATION

0.0	0.8542E+08	0.3228E+09	0.6587E+09	0.1015E+10	0.1304E+10	0.1456E+10	0.1435E+10	0.1256E+10	0.9762E+09
0.6710E+09	0.4054E+09	0.2137E+09	0.9749E+08	0.3812E+08	0.1265E+08	0.3531E+07	0.8216E+06	0.1598E+06	0.2139E+05
0.2730E+04	0.2770E+03	0.2211E+02	0.1375E+01	0.6586E-01	0.2405E-02	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

ANGULAR DISTRIBUTION OF POLARISED COMPONENTS OF SYNCHROTRON RADIATION FOR 2000 ANGSTROM RADIATION FROM THE SRS

FOR 2.0 GEV OPERATION

THE SPECTRA ARE LISTED AT INCREMENTS OF 0.2MRAD FROM 0.0 TO 10.0MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC IN A 0.1% BANDWIDTH

TOTAL INTENSITY OF RADIATION

0.2401E+10	0.2435E+10	0.2529E+10	0.2662E+10	0.2804E+10	0.2914E+10	0.2956E+10	0.2897E+10	0.2721E+10	0.2434E+10
0.2060E+10	0.1640E+10	0.1222E+10	0.8478E+09	0.5445E+09	0.3221E+09	0.1746E+09	0.8629E+08	0.3866E+08	0.1562E+08
0.5659E+07	0.1829E+07	0.5240E+06	0.1319E+06	0.2565E+05	0.5054E+04	0.8630E+03	0.1270E+03	0.1603E+02	0.1727E+01
0.1578E+00	0.1216E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PARALLEL POLARISED RADIATION

0.2401E+10	0.2401E+10	0.2396E+10	0.2380E+10	0.2343E+10	0.2274E+10	0.2160E+10	0.1997E+10	0.1782E+10	0.1527E+10
0.1246E+10	0.9624E+09	0.6994E+09	0.4752E+09	0.3001E+09	0.1750E+09	0.9378E+08	0.4589E+08	0.2039E+08	0.8180E+07
0.2946E+07	0.9460E+06	0.2681E+06	0.6513E+05	0.1299E+05	0.2557E+04	0.4360E+03	0.6411E+02	0.8086E+01	0.8700E+00
0.7944E-01	0.6122E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

INTENSITY OF PERPENDICULARLY POLARISED RADIATION

0.0	0.3452E+08	0.1333E+09	0.2824E+09	0.4604E+09	0.6405E+09	0.7952E+09	0.9000E+09	0.9388E+09	0.9074E+09
0.8141E+09	0.6778E+09	0.5228E+09	0.3726E+09	0.2445E+09	0.1471E+09	0.8085E+08	0.4040E+08	0.1827E+08	0.7437E+07
0.2713E+07	0.8830E+06	0.2559E+06	0.6677E+05	0.1266E+05	0.2498E+04	0.4270E+03	0.6291E+02	0.7948E+01	0.8565E+00
0.7832E-01	0.6043E-02	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

TABLE 8

FOR 2.0 GEV ELECTRONS IN THE WIGGLER

SPECTRA ARE LISTED AT LOGARITHMIC INCREMENTS OF1/10TH OF A DECADE FROM 0.1 TO 100,000 ANGSTROMS
IN UNITS OF PHOTONS/MRAD HORIZ/MA BEAM/SEC INTO A 0.1% ANDWIDTH

0.5756E+07	0.4634E+08	0.2336E+09	0.8275E+09	0.2222E+10	0.4792E+10	0.8692E+10	0.1375E+11	0.1951E+11	0.2543E+11
0.3097E+11	0.3575E+11	0.3956E+11	0.4233E+11	0.4410E+11	0.4497E+11	0.4507E+11	0.4455E+11	0.4355E+11	0.4219E+11
0.4057E+11	0.3879E+11	0.3688E+11	0.3487E+11	0.3273E+11	0.3043E+11	0.2797E+11	0.2540E+11	0.2278E+11	0.2020E+11
0.1775E+11	0.1549E+11	0.1345E+11	0.1166E+11	0.1009E+11	0.8724E+10	0.7545E+10	0.6530E+10	0.5656E+10	0.4906E+10
0.4263E+10	0.3710E+10	0.3234E+10	0.2825E+10	0.2472E+10	0.2167E+10	0.1903E+10	0.1675E+10	0.1476E+10	0.1304E+10
0.1153E+10	0.1022E+10	0.9059E+09	0.8033E+09	0.7114E+09	0.6283E+09	0.5527E+09	0.4839E+09	0.4216E+09	0.3655E+09
0.3156E+09									

TABLE 9

ANGULAR DISTRUBUTION OF SYNCHROTRON RADIATION FOR THE SYNCHROTRON RADIATION SOURCE

FOR 2.0 GEV ELECTRONS IN THE WIGGLER

VERTICAL DISTRIBUTION OF 0.1 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.4980E+08	0.4552E+08	0.3465E+08	0.2169E+08	0.1087E+08	0.4315E+07	0.1472E+07	0.3920E+06	0.7975E+05	0.1212E+05
0.1343E+04	0.1059E+03	0.5795E+01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 1.0 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.02MRADS FROM ZERO TO 1 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.7647E+11	0.7618E+11	0.7527E+11	0.7368E+11	0.7127E+11	0.6796E+11	0.6368E+11	0.5843E+11	0.5234E+11	0.4561E+11
0.3854E+11	0.3148E+11	0.2478E+11	0.1875E+11	0.1358E+11	0.9403E+10	0.6200E+10	0.3883E+10	0.2303E+10	0.1290E+10
0.6806E+09	0.3372E+09	0.1564E+09	0.6769E+08	0.2724E+08	0.1014E+08	0.3454E+07	0.9887E+06	0.2944E+06	0.8036E+05
0.2005E+05	0.4561E+04	0.9429E+03	0.1767E+03	0.2992E+02	0.4565E+01	0.6260E+00	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 10.0 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.3287E+11	0.3374E+11	0.3537E+11	0.3542E+11	0.3175E+11	0.2419E+11	0.1501E+11	0.7313E+10	0.2697E+10	0.7264E+09
0.1379E+09	0.1778E+08	0.1489E+07	0.7086E+05	0.2361E+04	0.4594E+02	0.5037E+00	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

VERTICAL DISTRIBUTION OF 100.0 ANGSTROM RADIATION

THIS SPECTRUM IS LISTED AT INCREMENTS OF 0.1 MRADS FROM ZERO TO 5 MRAD
IN UNITS OF PHOTONS/MA BEAM/MRAD HORIZ/MRAD VERT/SEC. IN A 0.1% BANDWIDTH

0.7375E+10	0.7448E+10	0.7657E+10	0.7963E+10	0.8309E+10	0.8622E+10	0.8826E+10	0.8846E+10	0.8628E+10	0.8146E+10
0.7410E+10	0.6467E+10	0.5395E+10	0.4285E+10	0.3228E+10	0.2300E+10	0.1543E+10	0.9717E+09	0.5724E+09	0.3143E+09
0.1602E+09	0.7560E+08	0.3289E+08	0.1314E+08	0.4805E+07	0.1601E+07	0.4830E+06	0.1154E+06	0.2896E+05	0.6524E+04
0.1314E+04	0.2358E+03	0.3758E+02	0.5298E+01	0.6584E+00	0.7187E-01	0.6865E-02	0.0	0.0	0.0
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
0.0									

FIGURE CAPTIONS

Fig. 1 Radiation Spectra for total vertical acceptance.

Fig. 2 Vertical angular distribution for 1.0 GeV operation.

Fig. 3 Vertical angular distribution for 1.5 GeV operation.

Fig. 4 Vertical angular distribution for 2.0 GeV operation.

Fig. 5 Vertical angular distribution of polarised components of 10Å radiation for 2.0 GeV operation.

Fig. 6 Vertical angular distribution of polarised components of 100Å radiation for 2.0 GeV operation.

Fig. 7 Vertical angular distribution of polarised components of 1000Å radiation for 2.0 GeV operation.

Fig. 8 Vertical angular distribution of polarised components of 2000Å radiation for 2.0 GeV operation.

Fig. 9 Vertically integrated radiation spectrum for 2.0 GeV electrons in the Wiggler.

Fig.10 Vertical angular distribution of radiation from 2.0 GeV electrons in the Wiggler.

The units for the intensities in the figures are:

Figs. 1 and 9 Photons/s/mA beam/mrad horizontally within a 0.1% bandwidth.

Figs. 2-8 and 10 Photons/s/mA beam/mrad horizontally/mrad vertically within a 0.1% bandwidth.

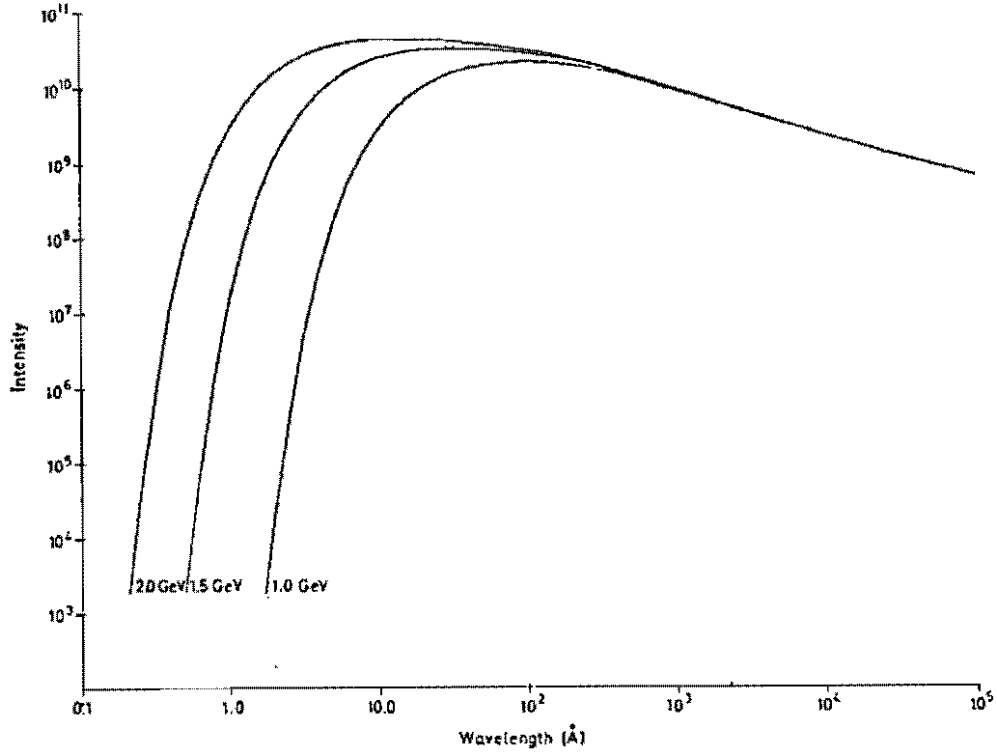

Fig.1

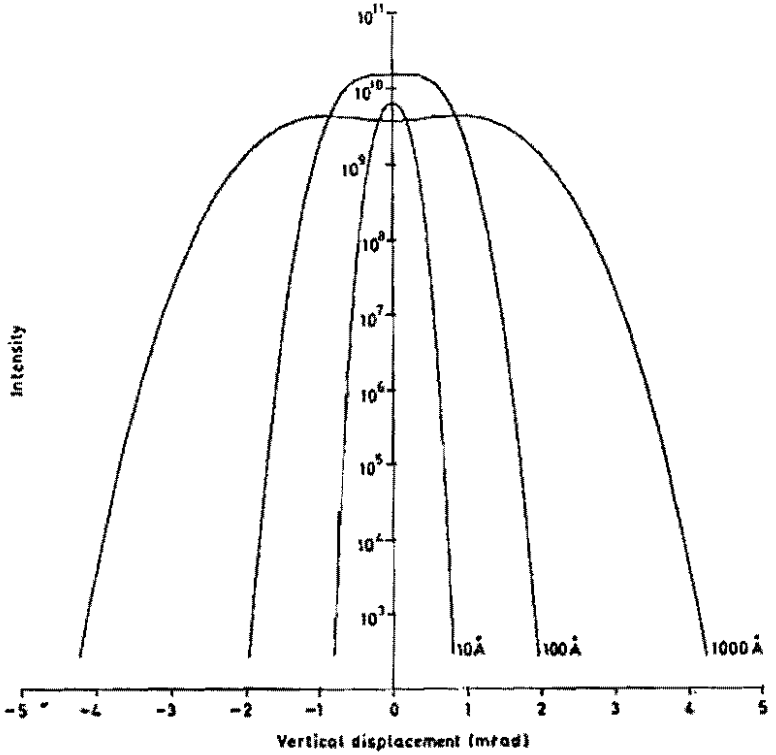
Intensity
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
10Å
100Å
1000Å
-5
-4
-3
-2
-1
0
1
2
3
4
5
Vertical displacement (mrad)

Fig. 2

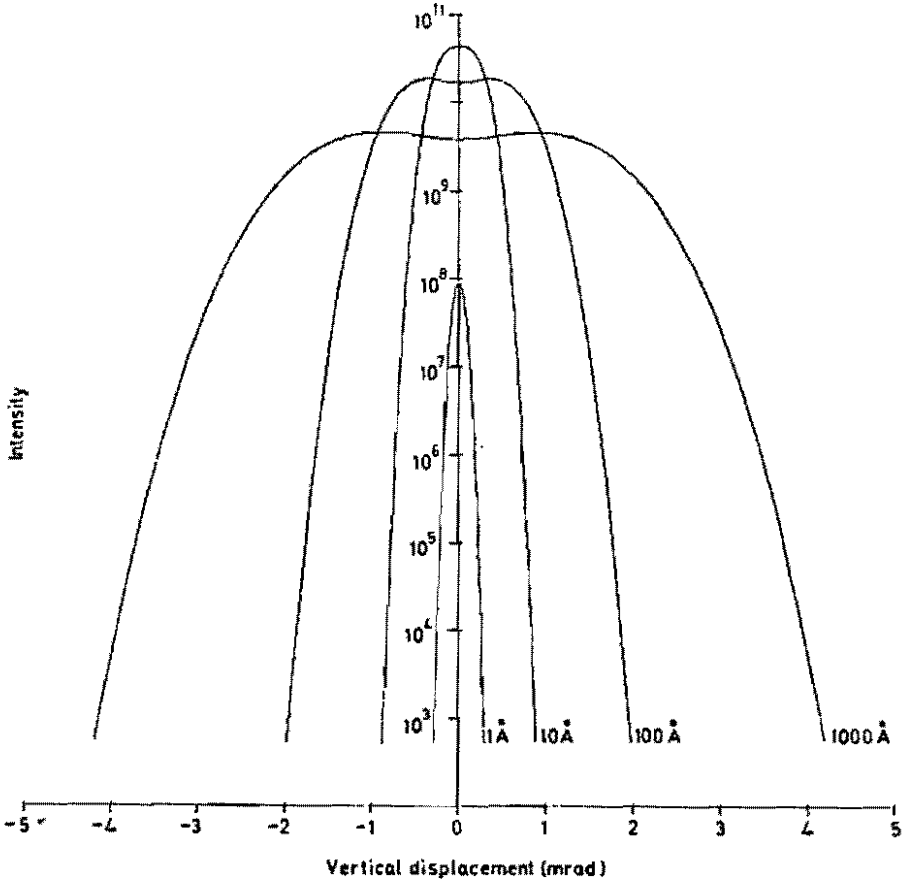
Intensity
10^{11}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
1Å
10Å
100Å
1000Å
-5
-4
-3
-2
-1
0
1
2
3
4
5
Vertical displacement (mrad)

Fig. 3

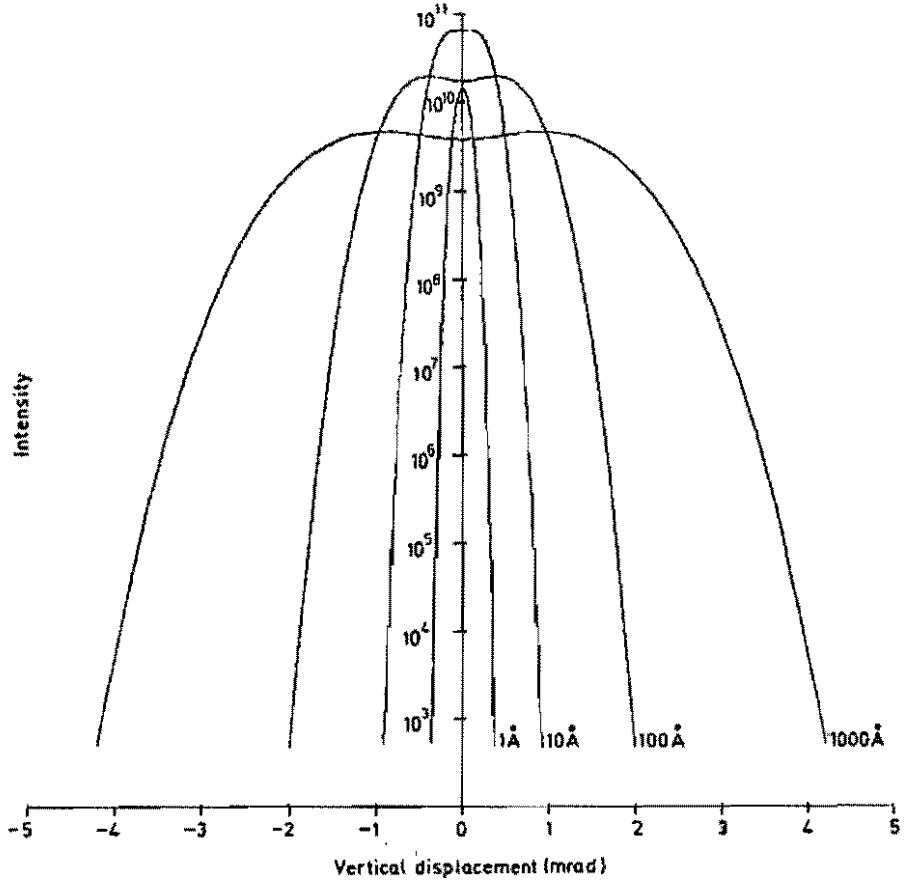
Intensity
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
1Å
10Å
100Å
1000Å
−5
−4
−3
−2
−1
0
1
2
3
4
5
Vertical displacement (mrad)

Fig. 4

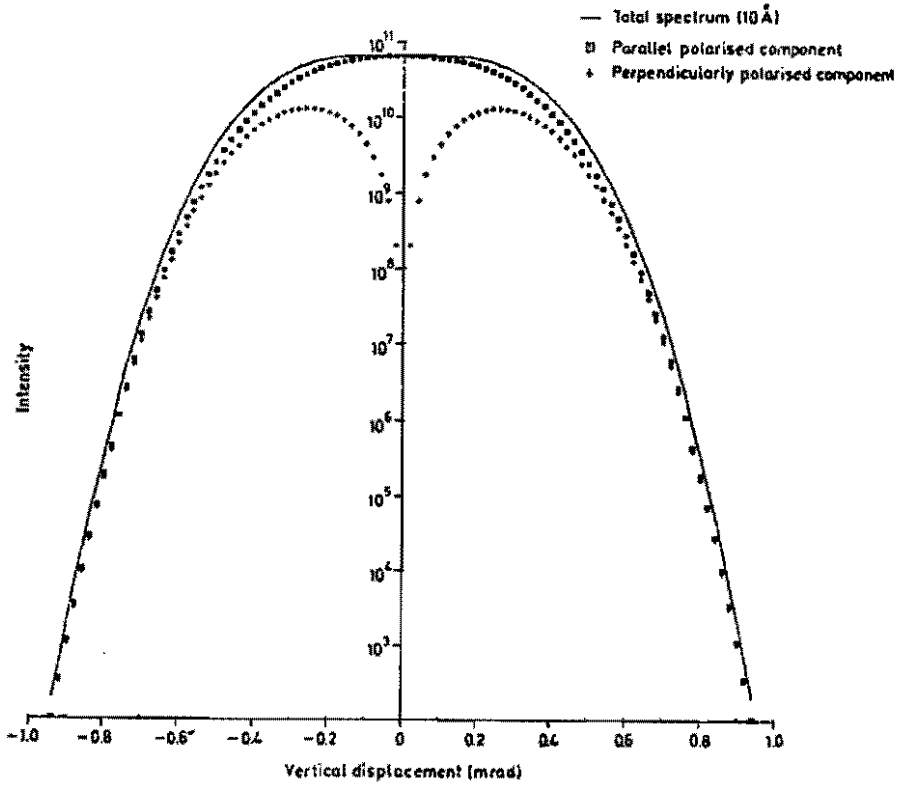
Total spectrum (10Å)
Parallel polarised component
Perpendicularly polarised component
Intensity
10^{11}
10^{10}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
10^{3}
−1.0
−0.8
−0.6
−0.4
−0.2
0
0.2
0.4
0.6
0.8
1.0
Vertical displacement (mrad)

Fig. 5

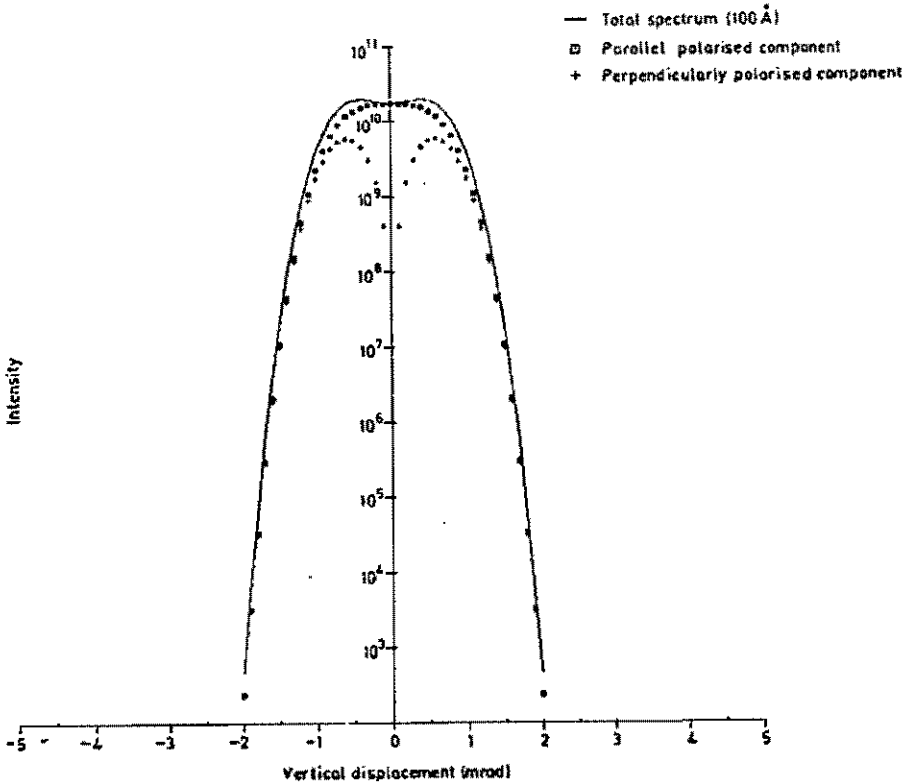
Total spectrum (100 Å)
Parallel polarised component
Perpendicularly polarised component
Intensity
Vertical displacement (mrad)

Fig.6

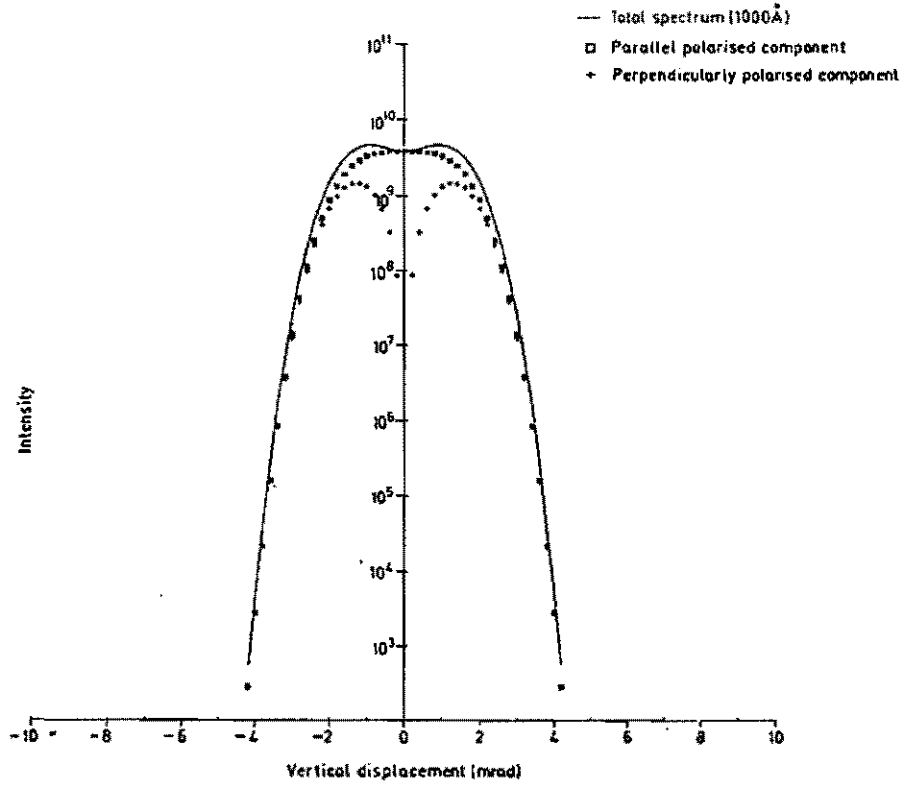
Total spectrum (1000 Å)
Parallel polarised component
Perpendicularly polarised component
Intensity
Vertical displacement (mrad)

Fig.7

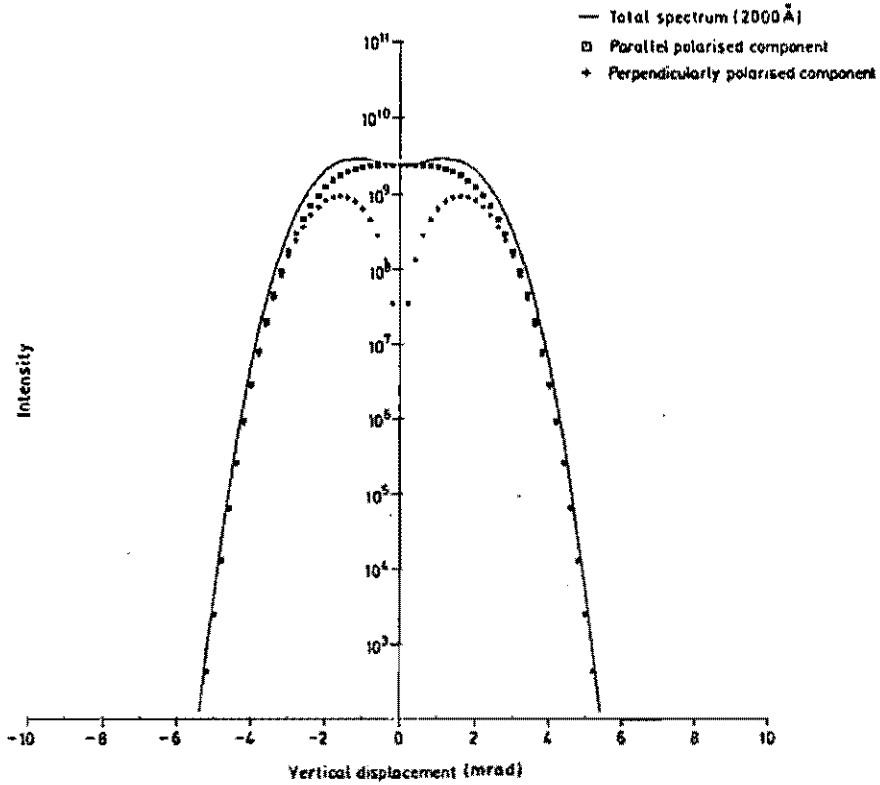
Total spectrum (2000 Å)
Parallel polarised component
Perpendicularly polarised component
Intensity
Vertical displacement (mrad)

Fig. 8

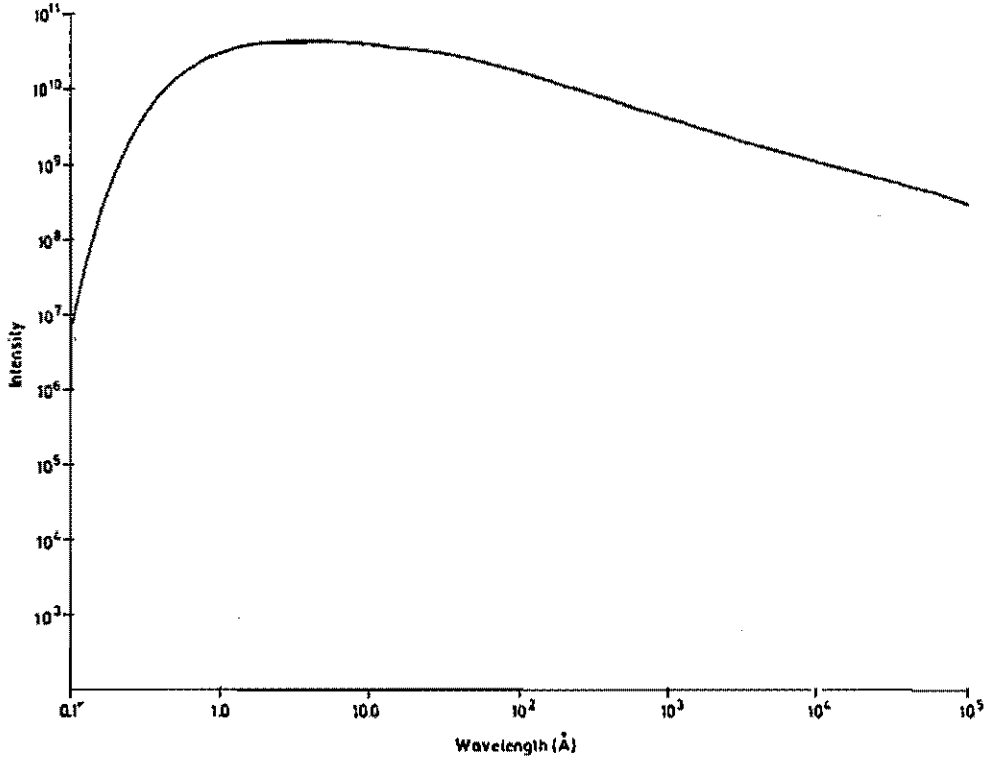
Intensity
Wavelength (Å)

Fig. 9

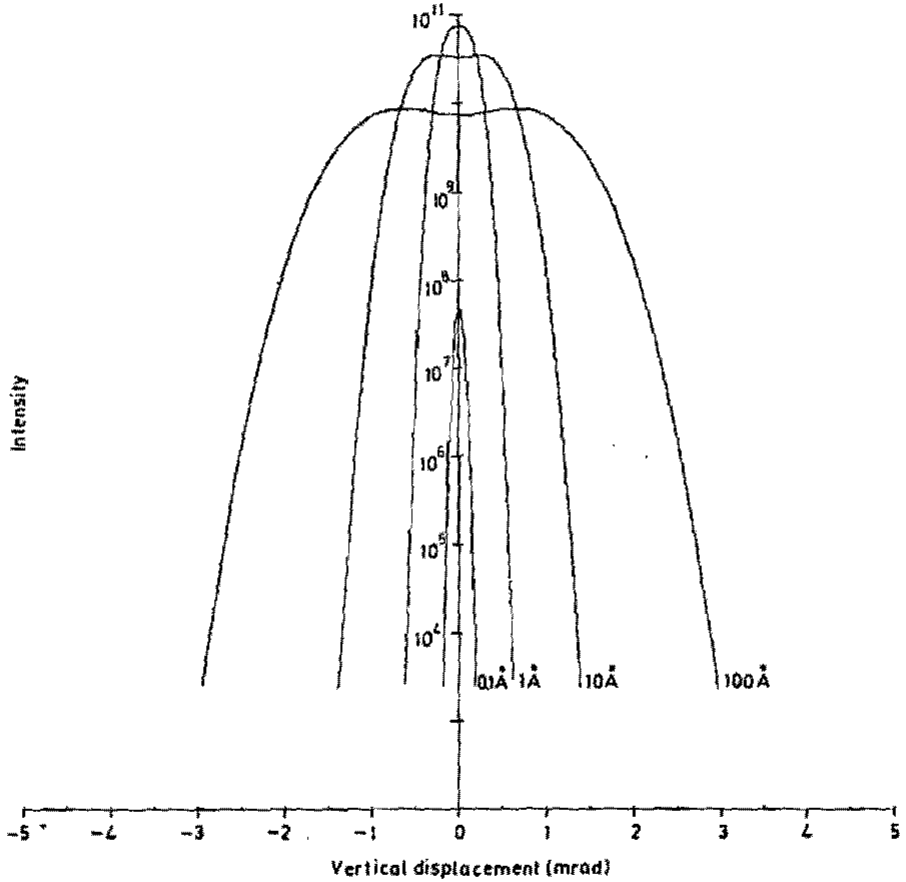
Intensity
10^{11}
10^{9}
10^{8}
10^{7}
10^{6}
10^{5}
10^{4}
0.1Å
1Å
10Å
100Å
-5
-4
-3
-2
-1
0
1
2
3
4
5
Vertical displacement (mrad)

Fig. 10