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Some Thoughts on the LAMPF II Lattice

Henry A. Thiessen

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SOME THOUGHTS ON THE LAMPF II LATTICE

by

Henry A. Thiessen

ABSTRACT

The lattice proposal of Rees and Cooper is discussed. It is shown that dispersion-free straight sections result if the appropriate symmetry is observed within each group of bends. The increase of dispersion in the straight sections is investigated for a lattice with nominal dispersion-free straight sections in which the phase shift per cell is tuned slightly to avoid resonances. A method of tuning the transition energy without changing v in such a lattice is also investigated. An alternative to the Rees and Cooper lattice is proposed. This lattice is of the FOFODODO type, has six long straight sections, and will permit 32 GeV to be obtained in the same circumference as the Rees and Cooper lattice. The proposed design offers reasonable hope that our specification of 1-ns time definition in the extracted beam will be met. We note with caution that the suggested lattice has some controversial features. Included are a transition energy of 5 GeV and 16-kG field in the bending magnets. This proposal is intended as a stimulus for further discussion, not as a final design.

In November 1981, Rees and Cooper¹ made a study of the design for a 16-GeV rapid cycling synchrotron. In addition to the 100 μ A and 16 GeV considered in earlier designs, the authors attempted to meet the specification of a pulse width of less than 1 ns at a final frequency of 50 MHz. The important feature of their lattice is that it is a separated-function design with approximately 90° phase shift per cell. The straight sections were obtained by eliminating

the bending magnets from some of the cells ("missing magnet lattice"). These straight sections were bunched together to give four long straight sections of six cells each. An essential feature of the design was a high value of ν (23.25), which was chosen to give a transition energy slightly above that of the machine final energy. The most important advantage of the high ν is that by avoiding crossing transition, a significant source of longitudinal phase-space dilution and resulting losses is eliminated. Secondary advantages of this proposal are that the beam size in the bending magnets is small and a small final rf voltage is required in order to obtain good bunching, both tending to reduce costs. The disadvantages of this proposal include the very large radius, the low β in the straight sections, the short space allocated to straight sections, and the lack of explicit space reserved for correction elements. The high ν also leads to the possibility of large second-order or higher aberrations and exaggerated sensitivity to alignment and field errors.

There have been three recent suggestions that resulted in a change of specifications. First, the machine should be capable of running with modest slow extraction without a stretcher ring.² This allows a reduction in the cash flow required during construction and may shorten the time required to obtain first beam. Second, there was the suggestion that the internal rf frequency be increased and that the micropulse frequency be reduced with an rf beam splitter after extraction and before targeting. This reduces the difficulty of providing bunched beam. Finally, there was the suggestion³ that the slow extraction process has a natural time selection, which reduces the extracted beam pulse width by a significant factor. Such an effect has been observed at the Brookhaven AGS (Alternating-Gradient Synchrotron) and further reduces the need for tight bunching in the accelerator.

In a recent paper Karl Brown⁴ has shown that in a periodic lattice where n cells result in a phase shift of 360° , then R16, R26, and all second-order geometric aberrations are zero as long as n is not equal to 1 or 3. Furthermore, if two families of sextuples are included in each cell, then all chromatic aberrations can be corrected without creating large geometric aberrations at the same time. In the language of accelerator designers, this means that both dv_x/dp and dv_y/dp can be made identically zero without reducing the effective aperture of the lattice due to higher order effects.

The properties of a simple lattice with this symmetry were investigated. The lattice chosen consisted of four cells with bending magnets and two cells with missing magnets. It was intended as one sixth of a 32-GeV machine including straight sections. The parameters of one half cell for $B\rho$ of 1100 kG m are tabulated as follows:

<u>Element</u>	<u>Length</u>	<u>Strength</u>
Drift	0.5 m	
Bend	5.0 m	14.4 kG
Drift	0.5 m	
Bend	5.0 m	14.4 kG
Drift	1.5 m	(For correction element)
Quad	1.0 m	(Strength tabulated below)

This lattice was tuned for $v_x = v_y$ from 1.30 to 1.70 (7.8 to 10.2 for full lattice). The resulting lattice parameters measured at the end of the long straight section are as follows:

<u>v</u>	<u>η_x (m)</u>	<u>η'_x</u>	<u>γ_t</u>	<u>D Quad (kG/cm)</u>	<u>F Quad (kG/cm)</u>
1.30	0.15	0.23	4.89	-0.96	0.98
1.40	0.06	0.10	5.86	-1.07	1.08
1.50	0.00	0.00	6.80	-1.16	1.18
1.60	-0.06	-0.10	7.83	-1.25	1.27
1.70	-0.13	-0.22	9.17	-1.34	1.35

The tabulated values of η_x should be compared with the maximum value of 8 m, which is observed in the bends. The conclusion resulting from this example is that the dispersion is essentially zero for a wide range of tunes in the vicinity of 90° per cell. It appears that the symmetry of the lattice used should be adjusted to make the dispersion of the straight sections zero rather than adding special matching cells. By this technique 33% additional straight-section space could be obtained in a lattice similar to that of Rees and Cooper with the same circumference.

Many people have discussed the suggestion of S. Ohnuma⁵ for a method to change γ_t without changing v_x for the Fermilab lattice. Basically the suggestion consists of placing a set of tunable quadrupoles in the lattice at locations separated by 180° phase shift. The strength of all quadrupoles is identical but alternates in sign. In order to make more transparent the effect of such a perturbation on a typical lattice, let us place these quadrupoles at exactly 180° intervals. We shall restrict this discussion to a matched lattice (phase ellipses identical at input and output of each cell) with an even number of cells for each 360° phase shift. Between 180° phase-shifted locations, the (2×2) transport matrix will be the negative identity matrix, with dispersion nonzero. Between 360° phase-shifted locations, the (3×3) transport matrix will be the identity matrix. Between any two points in the lattice, the dispersion is given by the following formula:⁶

$$D(\theta) \propto \int_0^\theta S(\alpha) d\alpha ,$$

where $S(\alpha)$ is the amplitude of the sine-like ray, and α is the differential bending angle in the bends. If the lattice consists of two or more identical cells, then D is identically zero between 360° phase-shifted locations because of the symmetry of $S(\alpha)$. The path length difference is given by⁶

$$L(\theta) \propto \int_0^\theta D(\alpha) d\alpha .$$

This path length difference is positive definite for identical cells with nonzero total bending angle and total phase shift of 360° . Now consider the effect of a nonsymmetric perturbation of the lattice as proposed by Ohnuma. For thin lenses of opposite sign at 180° intervals, we have the following matrix:

$$\begin{pmatrix} 1 & 0 \\ -1/f & 1 \end{pmatrix} \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 1 & 0 \\ 1/f & 1 \end{pmatrix} = \begin{pmatrix} -1 & 0 \\ 0 & -1 \end{pmatrix} .$$

It is thus clear that the overall phase shift will not be affected by this perturbation.

Now consider the effect of this perturbation on the path length. Clearly the sine-like ray is affected. It is thus possible to change L , hence γ_t . However, it is also clear from this discussion that it is impossible to change L without also changing D . Thus for a lattice with pre-existing dispersion-free straight sections, the effect of such a perturbation is to create dispersion. Without additional dispersion-correcting sections, this effect cannot be avoided.

A numerical example has been studied. The lattice used was identical to the previous example with $\nu_x = \nu_y = 1.50$. First, the strength of the quadrupoles in the straight sections (not those in the bend cells) was reduced to give $\nu_x = \nu_y = 1.46$. Then additional 0.5-m quadrupoles were located at the center of each 1.5-m drift in the bend half cells with focussing quadrupoles. The results of tuning the additional quadrupoles (alternating sign) are as follows:

Quad (kG/cm)	γ_t	n_x max (m)	ν_x	ν_y
0.00	6.803	0.00	1.460	1.460
0.147	7.000	1.04	1.460	1.459
0.398	8.000	3.30	1.458	1.461
0.582	9.000	4.93	1.455	1.460

In this table, n_x max was the maximum value observed at any point in the straight section. It is clear from this example that γ_t can be changed by 2 without changing ν with modest quadrupole strength, but that unacceptably large dispersion in the straight sections results from the perturbation.

As a final example we consider a lattice that makes use of all of the information obtained above. Since it is intended that the accelerator be capable of slow extraction, the number of straight sections was increased to six. Three of these are intended as acceleration cavities. One straight section will be dedicated to fast extraction, one to slow extraction, and one to collimation. Injection is assumed to be done in a bending section since a dipole is required whether we choose H^0 or H^- injection. It should be noted that it is possible to build a collimating system capable of absorbing 10% of the beam power, which is designed from the start to facilitate remote handling. The extent to which this reduces the activation of the remainder of the machine remains to be studied.

Since both the extraction systems and the collimation system require two waists with high β , separated by approximately 90° phase shift, this feature was designed into the lattice. Thus a FOFODODO structure was chosen to give access to the waists that would otherwise occur inside the quadrupoles. The bending magnet field was chosen to be 16 kG and the quadrupole-bore radius field was 9 kG at 32 GeV. This controversial choice allows for conservative operation at 16 GeV and permits increasing the energy to 32 GeV in a later upgrade if desired. The overall periodicity of the lattice is $(4b2s)^*6$, where b is a bending cell and s is a missing-magnet straight section. In each bend cell, 1.2-m drifts are provided for correction elements at waists where x is large and y is small, and vice versa, in order to obtain maximal orthogonality of x and y corrections.

Each superperiod of the lattice was tuned for 360° phase shift in the bend sections and 162° phase shift in the straight section for a total $\nu_x = \nu_y = 8.70$. All F quadrupoles and all D quadrupoles have the same strength. The different tuning of the straight sections was accomplished by shortening the drift between the F and D quadrupoles in the straight sections only. The small residual (0.8%) difference between the F and D quadrupoles is probably irrelevant and could be used to make the horizontal and vertical betatron tunes different. The reader is cautioned that the circumference has not yet been adjusted to be a harmonic of the linac frequency at injection time, which is of course required. It should be noted that $3 \times 2 \times 4 = 24$ short straight sections are available for rf cavities, which is 2 times more than in the Rees and Cooper proposal, assuming that one half of all straight sections are dedicated to rf. Since approximately 144 Fermilab booster cavities would be required if the magnets are powered by a sine wave (10 MeV per turn energy gain), it is clear that this space is marginal even in the present proposal.

A complete LATTICE output for this proposal is presented in Appendix A and, for comparison purposes, a version of the Rees and Cooper lattice made with the same assumptions is presented as Appendix B. The salient features of the former design include a mean radius of 143 m, a transition γ of 6.7 (5.35 GeV), and a maximum β of 31.5 m (3 times that of Rees and Cooper). The phase shift between maximum β points in the straight sections is 81° , which is adequate for extraction and collimation. For an assumed input phase space of π mrad, which is conservative for tune shift of less than 0.25 for 10^{13} particles and bunching factor of three in this lattice, the beam size is never greater than 2.8 cm. Ten-cm diameter quadrupoles and 4- x 6-cm bends are the minimum

recommended. The large β and dispersion in the bends (31.5 m and 8 m, respectively) are a result of the low ν value chosen and are a major disadvantage of this design compared with that of Rees and Cooper. The magnet size is similar to that assumed by Teng⁷ and also by Huson,⁸ hence the cost estimates in these proposals are still valid.

Let us now consider the bunching of the beam in the synchrotron. Suppose that we have synchronous injection at an rf voltage of 1 MeV per turn. Let us also assume slow extraction at 16 MeV per turn. If all rf manipulations are adiabatic, then an initial 120° bucket width (intentionally widened by a debuncher in the injection line) will be reduced to 16° by the acceleration to 16 GeV in the proposed lattice. For an injection frequency of 67 MHz and extraction frequency of 80 MHz, this corresponds to a pulse width of 0.57 ns. (The Rees and Cooper proposal has a bucket width of 0.19 ns calculated under the same assumptions.) Thus it is possible to meet our timing specification if the dilution of longitudinal phase space is less than a factor of two. It will take a detailed study of the phase-space dilution in the acceleration and transition crossing processes, as well as a detailed study of slow extraction, to be sure of this conclusion. At the present time it is reasonable to assume that a method will be found to meet our specifications without resorting to the extreme variation of transition energy proposed by Rees and Cooper.

In conclusion, we note that we have shown that it is reasonable to design a lattice based on the second-order achromat of Karl Brown. We have shown that the standard method of changing transition energy is unacceptable for our lattice if large variations are desired. We have demonstrated that it is conceptually possible to put a 32-GeV machine in the same diameter proposed for the 16-GeV design of Rees and Cooper. Finally, we have indicated the possibility that with a normal value of the transition energy (i.e., 5-8 GeV) we can meet the bunching specification of less than 1-ns pulse width in slow extraction.

REFERENCES

1. G. Rees and R. Cooper, "Preliminary Notes for a Kaon Factory Design" (to be published).
2. R. Cooper, Editor, "LAMPF II Accelerator Workshop Proceedings" (to be published).
3. M. Barton, in "LAMPF II Accelerator Workshop Proceedings" (to be published).
4. K. Brown, IEEE Trans. on Nucl. Sci. NS-26, 3490 (1979).
5. S. Ohnuma, "Changing the Transition Energy in the Main Ring," Fermilab internal report, Antiproton Note 105 (December 1980).
6. K. Brown, "A First- and Second-Order Matrix Theory for the Design of Beam Transport Systems and Charged Particle Spectrometers," Stanford University report SLAC-75 (1969).
7. L. Teng, in "Proceedings of the Workshop on Nuclear and Particle Physics at Energies up to 31 GeV: Present and Future Prospects," Los Alamos National Laboratory report LA-8775-C (January 1981), p. 477.
8. R. Huson, in "LAMPF II Accelerator Workshop Proceedings" (to be published).

APPENDIX A

LATTICE PROPOSAL BASED ON FOFODODO AT 32 GeV

NEW RUN OF LATTICE: ENTER COMMANDS OR "HELP"

BEAM RIGIDITY = 1100.0000 T-M OR KG-M
X,Y EMITTANCE = 1.0000, 1.0000 PI CM-MRAD
DP/P = 0.000 PERCENT

M BEND 0 4.50 16 0
E EDGE 0 1.875 16 0.02
D QUAD 0 0.5 -186.5323
F QUAD 0 0.5 188.6571
S DRIF 0 0.5
L DRIF 0 1.2
IV DRIF 3.1 4.75
IL DRIF 0 6.20
DV QUAD 1.2 0.5 -180.
FV QUAD 2.2 0.5 180.
END

ELEMENT LIST CURRENTLY CONTAINS 10 DEFINITIONS

FV L E M E S FV S E M E S DV L E M E S DV S E M E S
FV L E M E S FV S E M E S DV L E M E S DV S E M E S
FV L E M E S FV S E M E S DV L E M E S DV S E M E S
FV L E M E S FV S E M E S DV L E M E S DV S E M E S
FV IL FV IV DV IL DV IV
FV IL FV IV DV IL DV IV
END

MACHINE CONSISTS OF 1 PERIOD(S)

*

MATCHED FUNCTIONS FOR 1 PERIOD(S).
TOTAL LENGTH = 149.400 METERS. TOTAL BEND = 60.004 DEGREES
BETAX = 30.9013 METERS ALPHAX = -2.4586 NU X = 0.406
BETAY = 12.5742 METERS ALPHAY = 1.3454 NU Y = 0.432
ETA X = -0.0195 METERS ETA X = 0.0096 TR GAMMA= 6.483

NUX 0.450
NUY 0.450
ETAX 0.0
END

FIT PARAMETERS FOR A MACHINE OF 1. PERIOD(S)

VARIABLE TARGET VALUE

NU X 0.4500
 NU Y 0.4500
 ETA X 0.0000

ITERATION SUCCESSFUL. CONVERGED IN30 STEPS

VARIABLE	INITIAL VALUE	FINAL VALUE	TARGET VALUE
NU X	0.4056	0.4500	0.4500
NU Y	0.4319	0.4500	0.4500
ETA X	-0.0195	0.0000	0.0000

INITIAL AND FINAL VALUES OF ELEMENT PARAMETERS

ELEMENT	VARY CODE	INITIAL VALUE	FINAL VALUE
IV	3.1	4.7500	4.8325
DV	1.2	-180.0000	-181.9849
FV	2.2	180.0000	183.3831

*

MATCHED FUNCTIONS FOR 1 PERIOD(S).

TOTAL LENGTH = 149.730 METERS. TOTAL BEND = 60.004 DEGREES

BETAX = 30.2793 METERS ALPHAX = -2.4439 NU X = 0.450 × 6

BETAY = 12.4838 METERS ALPHAY = 1.3470 NU Y = 0.450 × 6

ETA X = 0.0000 METERS ETA X = 0.0000 TR GAMMA= 6.731

*

ELEMT	LTH (M)	SUM L (M)	BETAX (M)	ALPHAX	ETAX (M)	ETA X (RAD)	PSIX (DEG)	X (CM)	BETAY (M)	ALPHAY	PSIY (DEG)	Y (CM)
	0.	0.	30.28	-2.44	0.00	0.00	0.	1.7	12.48	1.35	0.	1.1
FV	0.50	0.50	31.47	0.10	0.00	0.00	0.9	1.8	11.68	0.28	2.4	1.1
L	1.20	1.70	31.28	0.06	0.00	0.00	3.1	1.8	11.16	0.16	8.4	1.1
E	0.00	1.70	31.28	0.05	0.00	0.00	3.1	1.8	11.16	0.17	8.4	1.1
M	4.50	6.20	31.38	-0.07	0.15	0.07	11.4	1.8	11.49	-0.25	31.8	1.1
E	0.00	6.20	31.38	-0.08	0.15	0.07	11.4	1.8	11.49	-0.24	31.8	1.1
S	0.50	6.70	31.47	-0.10	0.18	0.07	12.3	1.8	11.76	-0.29	34.3	1.1
FV	0.50	7.20	30.28	2.44	0.21	0.05	13.2	1.7	12.57	-1.36	36.7	1.1
S	0.50	7.70	27.89	2.33	0.23	0.05	14.2	1.7	13.99	-1.48	38.8	1.2
E	0.00	7.70	27.89	2.32	0.23	0.05	14.2	1.7	13.99	-1.47	38.8	1.2
M	4.50	12.20	11.60	1.30	0.60	0.11	28.7	1.1	31.82	-2.49	51.2	1.8
E	0.00	12.20	11.60	1.29	0.60	0.11	28.7	1.1	31.82	-2.47	51.2	1.8
S	0.50	12.70	10.37	1.18	0.66	0.11	31.3	1.0	34.35	-2.59	52.0	1.9
DV	0.50	13.20	9.65	0.28	0.73	0.17	34.2	1.0	35.52	0.28	52.8	1.9
L	1.20	14.40	9.15	0.14	0.94	0.17	41.5	1.0	34.89	0.24	54.8	1.9
E	0.00	14.40	9.15	0.14	0.94	0.17	41.5	1.0	34.89	0.26	54.8	1.9
M	4.50	18.90	10.12	-0.35	1.86	0.24	69.4	1.0	33.18	0.12	62.4	1.8
E	0.00	18.90	10.12	-0.36	1.86	0.24	69.4	1.0	33.18	0.14	62.4	1.8
S	0.50	19.40	10.50	-0.41	1.98	0.24	72.1	1.0	33.05	0.12	63.3	1.8
DV	0.50	19.90	11.40	-1.40	2.14	0.41	74.8	1.1	31.59	2.76	64.1	1.8

S	0.50	20.40	12.86	-1.53	2.34	0.41	77.1	1.1	28.90	2.62	65.1	1.7
E	0.00	20.40	12.86	-1.54	2.34	0.41	77.1	1.1	28.90	2.63	65.1	1.7
M	4.50	24.90	31.86	-2.68	4.32	0.47	90.0	1.8	10.76	1.40	79.9	1.0
E	0.00	24.90	31.86	-2.70	4.32	0.47	90.0	1.8	10.76	1.40	79.9	1.0
S	0.50	25.40	34.62	-2.83	4.55	0.47	90.8	1.9	9.43	1.27	82.7	1.0
FV	0.50	25.90	36.01	0.09	4.69	0.09	91.7	1.9	8.59	0.42	85.9	0.9
L	1.20	27.10	35.85	0.05	4.80	0.09	93.6	1.9	7.78	0.26	94.4	0.9
F	0.00	27.10	35.85	0.04	4.80	0.09	93.6	1.9	7.78	0.26	94.4	0.9
M	4.50	31.60	35.93	-0.06	5.33	0.15	100.8	1.9	8.20	-0.36	128.6	0.9
E	0.00	31.60	35.93	-0.07	5.33	0.15	100.8	1.9	8.20	-0.35	128.6	0.9
S	0.50	32.10	36.01	-0.09	5.41	0.15	101.6	1.9	8.59	-0.42	132.1	0.9
FV	0.50	32.60	34.63	2.83	5.37	-0.30	102.4	1.9	9.42	-1.26	135.3	1.0
S	0.50	33.10	31.86	2.70	5.22	-0.30	103.2	1.8	10.75	-1.40	138.1	1.0
E	0.00	33.10	31.86	2.68	5.22	-0.30	103.2	1.8	10.75	-1.40	138.1	1.0
M	4.50	37.60	12.86	1.54	4.02	-0.24	116.1	1.1	28.87	-2.63	152.9	1.7
E	0.00	37.60	12.86	1.53	4.02	-0.23	116.1	1.1	28.87	-2.62	152.9	1.7
S	0.50	38.10	11.40	1.40	3.90	-0.23	118.4	1.1	31.56	-2.75	153.9	1.8
DV	0.50	38.60	10.50	0.41	3.87	0.09	121.1	1.0	33.01	-0.12	154.7	1.8
L	1.20	39.80	9.67	0.28	3.97	0.09	127.9	1.0	33.35	-0.16	156.8	1.8
E	0.00	39.80	9.67	0.28	3.97	0.09	127.9	1.0	33.35	-0.14	156.8	1.8
M	4.50	44.30	9.40	-0.22	4.50	0.15	156.0	1.0	35.25	-0.28	164.4	1.9
E	0.00	44.30	9.40	-0.22	4.50	0.15	156.0	1.0	35.25	-0.26	164.4	1.9
S	0.50	44.80	9.65	-0.28	4.58	0.15	159.0	1.0	35.52	-0.28	165.2	1.9
DV	0.50	45.30	10.37	-1.18	4.75	0.54	161.9	1.0	34.35	2.59	166.0	1.9
S	0.50	45.80	11.61	-1.29	5.02	0.54	164.5	1.1	31.81	2.48	166.8	1.8
E	0.00	45.80	11.61	-1.30	5.02	0.54	164.5	1.1	31.81	2.49	166.8	1.8
M	4.50	50.30	27.89	-2.32	7.58	0.60	179.0	1.7	13.99	1.47	179.2	1.2
E	0.00	50.30	27.89	-2.33	7.58	0.60	179.0	1.7	13.99	1.48	179.2	1.2
S	0.50	50.80	30.28	-2.44	7.88	0.60	180.0	1.7	12.56	1.36	181.3	1.1
FV	0.50	51.30	31.47	0.10	8.01	-0.06	180.9	1.8	11.75	0.29	183.7	1.1
L	1.20	52.50	31.28	0.06	7.94	-0.06	183.1	1.8	11.20	0.18	189.7	1.1
E	0.00	52.50	31.28	0.05	7.94	-0.06	183.1	1.8	11.20	0.18	189.7	1.1
M	4.50	57.00	31.38	-0.07	7.80	0.00	191.4	1.8	11.44	-0.23	213.1	1.1
E	0.00	57.00	31.38	-0.08	7.80	0.00	191.4	1.8	11.44	-0.23	213.1	1.1
S	0.50	57.50	31.47	-0.10	7.80	0.00	192.3	1.8	11.69	-0.27	215.6	1.1
FV	0.50	58.00	30.28	2.44	7.64	-0.64	193.2	1.7	12.49	-1.35	218.0	1.1
S	0.50	58.50	27.89	2.33	7.32	-0.64	194.2	1.7	13.89	-1.46	220.2	1.2
E	0.00	58.50	27.89	2.32	7.32	-0.64	194.2	1.7	13.89	-1.45	220.2	1.2
M	4.50	63.00	11.60	1.30	4.58	-0.58	208.7	1.1	31.51	-2.46	232.6	1.8
E	0.00	63.00	11.60	1.29	4.58	-0.58	208.7	1.1	31.51	-2.45	232.6	1.8
S	0.50	63.50	10.37	1.18	4.29	-0.58	211.3	1.0	34.01	-2.56	233.5	1.8
DV	0.50	64.00	9.65	0.28	4.08	-0.23	214.2	1.0	35.16	0.28	234.3	1.9
L	1.20	65.20	9.15	0.14	3.80	-0.23	221.5	1.0	34.53	0.24	236.3	1.9
E	0.00	65.20	9.15	0.14	3.80	-0.23	221.5	1.0	34.53	0.26	236.3	1.9
M	4.50	69.70	10.12	-0.35	2.90	-0.17	249.4	1.0	32.83	0.12	244.0	1.8
E	0.00	69.70	10.12	-0.36	2.90	-0.17	249.4	1.0	32.83	0.14	244.0	1.8
S	0.50	70.20	10.50	-0.41	2.82	-0.17	252.1	1.0	32.70	0.12	244.8	1.8
DV	0.50	70.70	11.40	-1.40	2.79	0.06	254.8	1.1	31.25	2.73	245.7	1.8
S	0.50	71.20	12.86	-1.53	2.83	0.06	257.2	1.1	28.59	2.59	246.7	1.7
E	0.00	71.20	12.86	-1.54	2.83	0.07	257.2	1.1	28.59	2.60	246.7	1.7
M	4.50	75.70	31.86	-2.68	3.26	0.13	270.0	1.8	10.66	1.38	261.6	1.0
E	0.00	75.70	31.86	-2.70	3.26	0.13	270.0	1.8	10.66	1.38	261.6	1.0
S	0.50	76.20	34.62	-2.83	3.33	0.13	270.8	1.9	9.35	1.25	264.5	1.0

FV	0.50	76.70	36.01	0.09	3.32	-0.15	271.7	1.9	8.53	0.41	267.7	0.9
L	1.20	77.90	35.85	0.05	3.14	-0.15	273.6	1.9	7.74	0.25	276.2	0.9
E	0.00	77.90	35.85	0.04	3.14	-0.15	273.6	1.9	7.74	0.25	276.2	0.9
M	4.50	82.40	35.93	-0.06	2.62	-0.08	280.8	1.9	8.26	-0.37	310.4	0.9
E	0.00	82.40	35.93	-0.07	2.62	-0.08	280.8	1.9	8.26	-0.36	310.4	0.9
S	0.50	82.90	36.01	-0.09	2.58	-0.08	281.6	1.9	8.66	-0.43	313.8	0.9
FV	0.50	83.40	34.63	2.83	2.48	-0.29	282.4	1.9	9.50	-1.28	317.0	1.0
S	0.50	83.90	31.86	2.70	2.34	-0.29	283.2	1.8	10.86	-1.42	319.8	1.0
E	0.00	83.90	31.86	2.68	2.34	-0.29	283.2	1.8	10.86	-1.41	319.8	1.0
M	4.50	88.40	12.86	1.54	1.16	-0.23	296.1	1.1	29.19	-2.66	334.5	1.7
E	0.00	88.40	12.86	1.53	1.16	-0.23	296.1	1.1	29.19	-2.64	334.5	1.7
S	0.50	88.90	11.40	1.40	1.04	-0.23	298.4	1.1	31.90	-2.78	335.4	1.8
DV	0.50	89.40	10.50	0.41	0.95	-0.15	301.1	1.0	33.37	-0.12	336.3	1.8
L	1.20	90.60	9.67	0.28	0.77	-0.15	307.9	1.0	33.71	-0.16	338.3	1.8
E	0.00	90.60	9.67	0.28	0.77	-0.15	307.9	1.0	33.71	-0.14	338.3	1.8
M	4.50	95.10	9.40	-0.22	0.26	-0.08	336.0	1.0	35.60	-0.28	345.8	1.9
E	0.00	95.10	9.40	-0.22	0.26	-0.08	336.0	1.0	35.60	-0.26	345.8	1.9
S	0.50	95.60	9.65	-0.28	0.22	-0.08	339.1	1.0	35.87	-0.28	346.6	1.9
DV	0.50	96.10	10.37	-1.18	0.18	-0.07	341.9	1.0	34.68	2.62	347.4	1.9
S	0.50	96.60	11.61	-1.29	0.15	-0.07	344.5	1.1	32.12	2.50	348.3	1.8
E	0.00	96.60	11.61	-1.30	0.15	-0.07	344.5	1.1	32.12	2.52	348.3	1.8
M	4.50	101.10	27.89	-2.32	0.00	0.00	359.0	1.7	14.08	1.49	360.5	1.2
E	0.00	101.10	27.89	-2.33	0.00	0.00	359.0	1.7	14.08	1.50	360.5	1.2
S	0.50	101.60	30.28	-2.44	0.00	0.00	360.0	1.7	12.64	1.38	362.6	1.1
FV	0.50	102.10	31.47	0.10	0.00	0.00	360.9	1.8	11.81	0.30	365.0	1.1
IL	6.20	108.30	31.47	-0.10	0.00	0.00	372.3	1.8	11.67	-0.27	396.9	1.1
FV	0.50	108.80	30.28	2.44	0.00	0.00	373.2	1.7	12.47	-1.34	399.3	1.1
IV	4.83	113.63	12.04	1.33	0.00	0.00	387.9	1.1	30.73	-2.43	413.6	1.8
DV	0.50	114.13	11.23	0.30	0.00	0.00	390.4	1.1	31.90	0.13	414.5	1.8
IL	6.20	120.33	11.23	-0.30	0.00	0.00	423.9	1.1	31.54	-0.07	425.7	1.8
DV	0.50	120.83	12.04	-1.33	0.00	0.00	426.3	1.1	30.32	2.46	426.7	1.7
IV	4.83	125.66	30.28	-2.44	0.00	0.00	441.0	1.7	11.99	1.34	441.3	1.1
FV	0.50	126.16	31.47	0.10	0.00	0.00	441.9	1.8	11.18	0.30	443.8	1.1
IL	6.20	132.36	31.47	-0.10	0.00	0.00	453.3	1.8	11.19	-0.30	477.5	1.1
FV	0.50	132.86	30.28	2.44	0.00	0.00	454.2	1.7	12.00	-1.34	480.0	1.1
IV	4.83	137.70	12.04	1.33	0.00	0.00	468.9	1.1	30.36	-2.46	494.6	1.7
DV	0.50	138.20	11.23	0.30	0.00	0.00	471.4	1.1	31.57	0.07	495.6	1.8
IL	6.20	144.40	11.23	-0.30	0.00	0.00	504.9	1.1	31.94	-0.13	506.8	1.8
DV	0.50	144.90	12.04	-1.33	0.00	0.00	507.3	1.1	30.77	2.44	507.7	1.8
IV	4.83	149.73	30.28	-2.44	0.00	0.00	522.0	1.7	12.48	1.35	522.0	1.1

ELEMT	LTH	SUM L	BETAX	ALPHAX	ETAX	ETA X	PSIX	X	BETAY	ALPHAY	PSIY	Y
	(M)	(M)	(M)		(M)	(RAD)	(DEG)	(CM)	(M)		(DEG)	(CM)

TRANSITION GAMMA = 6.7307, NUX = 1.4500 × 6, NUY = 1.4500 × 6

MATRIX FOR LATTICE TO THE 1. POWER FOR 1 PERIOD IS

-1.7063	9.3569	0.0000	0.0000	0.0000	0.0000
-0.0712	-0.1959	0.0000	0.0000	0.0000	0.0000

0.0000	0.0000	-0.5348	3.8577	0.0000	0.0000
0.0000	0.0000	-0.0697	-1.3673	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	1.0000	-3.3051
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

APPENDIX B

LATTICE BASED ON PROPOSAL OF REES AND COOPER - MODIFIED BY HAT JUNE 1982

32 GeV

(16b,8s)**4

Tuned for NUX=NUY=23.25

NEW RUN OF LATTICE: ENTER COMMANDS OR "HELP"

BEAM RIGIDITY =1100.0000 T-M OR KG-M

X,Y EMITTANCE = 1.0000, 1.0000 PI CM-MRAD

DP/P = 0.000 PERCENT

M BEND 0 5.50 19.64 0

E EDGE 0 2.8125 19.64 0.02

D QUAD 0 0.75 -186.5323

F QUAD 0 0.75 188.6571

S DRIF 0 0.75

L DRIF 0 0.65

IV DRIF 3.1 6.8

IL DRIF 0 6.20

DV QUAD 1.2 0.75 -688.

FV QUAD 2.2 0.75 688.

END

ELEMENT LIST CURRENTLY CONTAINS 10 DEFINITIONS

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV L E M E L

FV S DV IV

FV S DV IV

FV S DV IV

FV S DV IV

FV S DV IV

FV S DV IV

FV S DV IV

FV S DV IV

END

MACHINE CONSISTS OF 1 PERIOD(S)

*

MATCHED FUNCTIONS FOR 1 PERIOD(S).

TOTAL LENGTH = 217.200 METERS. TOTAL BEND = 90.023 DEGREES
BETAX = 13.3720 METERS ALPHAX = -1.6354 NU X = 0.982
BETAY = 3.8127 METERS ALPHAY = -0.2396 NU Y = 0.002
ETA X = 0.3978 METERS ETA X = 0.0608 TR GAMMA= 19.627

NUX 0.8125
NUY 0.8125
ETAX 0.00
END

FIT PARAMETERS FOR A MACHINE OF 1. PERIOD(S)

VARIABLE TARGET VALUE

NU X 0.8125
NU Y 0.8125
ETA X 0.0000

ITERATION SUCCESSFUL. CONVERGED IN30 STEPS

VARIABLE INITIAL VALUE FINAL VALUE TARGET VALUE

NU X 0.9819 0.8125 0.8125
NU Y 0.0016 0.8125 0.8125
ETA X 0.3978 0.0000 0.0000

INITIAL AND FINAL VALUES OF ELEMENT PARAMETERS

ELEMENT VARY CODE INITIAL VALUE FINAL VALUE

IV 3.1 6.8000 5.7281
DV 1.2 -688.0000 -688.4045
FV 2.2 688.0000 689.2999

*

MATCHED FUNCTIONS FOR 1 PERIOD(S).

TOTAL LENGTH = 208.624 METERS. TOTAL BEND = 90.023 DEGREES
BETAX = 11.7480 METERS ALPHAX = -1.5094 NU X = 0.813 × 4
BETAY = 3.6404 METERS ALPHAY = -0.0823 NU Y = 0.812 × 4
ETA X = 0.0000 METERS ETA X = 0.0000 TR GAMMA= 19.311

*

ELEMT	LTH	SUM L	BETAX	ALPHAX	ETAX	ETA X	PSIX	X	BETAY	ALPHAY	PSIY	Y
	(M)	(M)	(M)		(M)	(RAD)	(DEG)	(CM)	(M)		(DEG)	(CM)

	0.	0.	11.75	-1.51	0.00	0.00	0.	1.1	3.64	-0.08	0.	0.6
FV	0.75	0.75	9.98	3.58	0.00	0.00	3.7	1.0	5.41	-2.55	10.3	0.7
S	0.75	1.50	5.38	2.54	0.00	0.00	9.6	0.7	10.01	-3.59	16.2	1.0
DV	0.75	2.25	3.61	0.09	0.00	0.00	20.0	0.6	11.78	1.52	19.9	1.1
L	0.65	2.90	3.61	-0.09	0.00	0.00	30.4	0.6	9.93	1.33	23.3	1.0
E	0.00	2.90	3.61	-0.10	0.00	0.00	30.4	0.6	9.93	1.34	23.3	1.0
M	5.50	8.40	13.04	-1.61	0.27	0.10	83.5	1.1	3.70	-0.21	88.5	0.6
E	0.00	8.40	13.04	-1.62	0.27	0.10	83.5	1.1	3.70	-0.21	88.5	0.6
L	0.65	9.05	15.27	-1.81	0.33	0.10	86.1	1.2	4.09	-0.39	98.1	0.6
FV	0.75	9.80	12.75	4.77	0.35	-0.07	89.0	1.1	6.61	-3.37	106.9	0.8
S	0.75	10.55	6.64	3.37	0.30	-0.07	93.7	0.8	12.71	-4.77	111.6	1.1
DV	0.75	11.30	4.12	0.39	0.30	0.07	102.4	0.6	15.26	1.78	114.5	1.2
L	0.65	11.95	3.73	0.20	0.34	0.07	112.0	0.6	13.06	1.61	117.1	1.1
E	0.00	11.95	3.73	0.20	0.34	0.07	112.0	0.6	13.06	1.62	117.1	1.1
M	5.50	17.45	9.90	-1.32	0.99	0.17	176.5	1.0	3.65	0.09	170.0	0.6
E	0.00	17.45	9.90	-1.33	0.99	0.17	176.5	1.0	3.65	0.10	170.0	0.6
L	0.65	18.10	11.75	-1.51	1.10	0.17	180.0	1.1	3.64	-0.08	180.3	0.6
FV	0.75	18.85	9.98	3.58	1.03	-0.35	183.7	1.0	5.40	-2.55	190.6	0.7
S	0.75	19.60	5.38	2.54	0.77	-0.35	189.6	0.7	10.00	-3.59	196.5	1.0
DV	0.75	20.35	3.61	0.09	0.63	-0.03	200.0	0.6	11.77	1.51	200.2	1.1
L	0.65	21.00	3.61	-0.09	0.61	-0.03	210.4	0.6	9.92	1.33	203.7	1.0
E	0.00	21.00	3.61	-0.10	0.61	-0.03	210.4	0.6	9.92	1.34	203.7	1.0
M	5.50	26.50	13.04	-1.61	0.72	0.07	263.5	1.1	3.71	-0.21	268.7	0.6
E	0.00	26.50	13.04	-1.62	0.72	0.07	263.5	1.1	3.71	-0.21	268.7	0.6
L	0.65	27.15	15.27	-1.81	0.77	0.07	266.1	1.2	4.09	-0.39	278.4	0.6
FV	0.75	27.90	12.75	4.77	0.68	-0.28	269.0	1.1	6.62	-3.37	287.1	0.8
S	0.75	28.65	6.64	3.37	0.47	-0.28	273.7	0.8	12.72	-4.77	291.8	1.1
DV	0.75	29.40	4.12	0.39	0.33	-0.10	282.4	0.6	15.27	1.79	294.7	1.2
L	0.65	30.05	3.73	0.20	0.27	-0.10	292.0	0.6	13.06	1.61	297.4	1.1
E	0.00	30.05	3.73	0.20	0.27	-0.10	292.0	0.6	13.06	1.62	297.4	1.1
M	5.50	35.55	9.90	-1.32	0.00	0.00	356.5	1.0	3.64	0.09	350.3	0.6
E	0.00	35.55	9.90	-1.33	0.00	0.00	356.5	1.0	3.64	0.10	350.3	0.6
L	0.65	36.20	11.75	-1.51	0.00	0.00	360.0	1.1	3.63	-0.08	360.6	0.6
FV	0.75	36.95	9.98	3.58	0.00	0.00	363.7	1.0	5.40	-2.55	370.9	0.7
S	0.75	37.70	5.38	2.54	0.00	0.00	369.6	0.7	10.00	-3.58	376.8	1.0
DV	0.75	38.45	3.61	0.09	0.00	0.00	380.0	0.6	11.76	1.51	380.5	1.1
L	0.65	39.10	3.61	-0.09	0.00	0.00	390.4	0.6	9.92	1.33	384.0	1.0
E	0.00	39.10	3.61	-0.10	0.00	0.00	390.4	0.6	9.92	1.34	384.0	1.0
M	5.50	44.60	13.04	-1.61	0.27	0.10	443.5	1.1	3.71	-0.21	449.0	0.6
E	0.00	44.60	13.04	-1.62	0.27	0.10	443.5	1.1	3.71	-0.21	449.0	0.6
L	0.65	45.25	15.27	-1.81	0.33	0.10	446.1	1.2	4.10	-0.39	458.6	0.6
FV	0.75	46.00	12.75	4.77	0.35	-0.07	449.0	1.1	6.63	-3.37	467.4	0.8
S	0.75	46.75	6.64	3.37	0.30	-0.07	453.7	0.8	12.73	-4.77	472.1	1.1
DV	0.75	47.50	4.12	0.39	0.30	0.07	462.4	0.6	15.28	1.79	475.0	1.2
L	0.65	48.15	3.73	0.20	0.34	0.07	472.0	0.6	13.07	1.61	477.6	1.1
E	0.00	48.15	3.73	0.20	0.34	0.07	472.0	0.6	13.07	1.62	477.6	1.1
M	5.50	53.65	9.90	-1.32	0.99	0.17	536.5	1.0	3.63	0.09	530.5	0.6
E	0.00	53.65	9.90	-1.33	0.99	0.17	536.5	1.0	3.63	0.10	530.5	0.6
L	0.65	54.30	11.75	-1.51	1.10	0.17	540.0	1.1	3.63	-0.08	540.9	0.6
FV	0.75	55.05	9.98	3.58	1.03	-0.35	543.7	1.0	5.39	-2.54	551.2	0.7
S	0.75	55.80	5.38	2.54	0.77	-0.35	549.6	0.7	9.99	-3.58	557.1	1.0
DV	0.75	56.55	3.61	0.09	0.63	-0.03	560.0	0.6	11.75	1.51	560.8	1.1

L	0.65	57.20	3.61	-0.09	0.61	-0.03	570.4	0.6	9.91	1.33	564.3	1.0
E	0.00	57.20	3.61	-0.10	0.61	-0.03	570.4	0.6	9.91	1.34	564.3	1.0
M	5.50	62.70	13.04	-1.61	0.72	0.07	623.5	1.1	3.72	-0.21	629.3	0.6
E	0.00	62.70	13.04	-1.62	0.72	0.07	623.5	1.1	3.72	-0.21	629.3	0.6
L	0.65	63.35	15.27	-1.81	0.77	0.07	626.1	1.2	4.10	-0.39	638.9	0.6
FV	0.75	64.10	12.75	4.77	0.68	-0.28	629.0	1.1	6.63	-3.37	647.6	0.8
S	0.75	64.85	6.64	3.37	0.47	-0.28	633.7	0.8	12.74	-4.77	652.3	1.1
DV	0.75	65.60	4.12	0.39	0.33	-0.10	642.4	0.6	15.29	1.79	655.2	1.2
L	0.65	66.25	3.73	0.20	0.27	-0.10	652.0	0.6	13.08	1.61	657.8	1.1
E	0.00	66.25	3.73	0.20	0.27	-0.10	652.0	0.6	13.08	1.62	657.8	1.1
M	5.50	71.75	9.90	-1.32	0.00	0.00	716.5	1.0	3.63	0.09	710.8	0.6
E	0.00	71.75	9.90	-1.33	0.00	0.00	716.5	1.0	3.63	0.10	710.8	0.6
L	0.65	72.40	11.75	-1.51	0.00	0.00	720.0	1.1	3.62	-0.08	721.1	0.6
FV	0.75	73.15	9.98	3.58	0.00	0.00	723.7	1.0	5.39	-2.54	731.5	0.7
S	0.75	73.90	5.38	2.54	0.00	0.00	729.6	0.7	9.98	-3.58	737.4	1.0
DV	0.75	74.65	3.61	0.09	0.00	0.00	740.0	0.6	11.74	1.51	741.1	1.1
L	0.65	75.30	3.61	-0.09	0.00	0.00	750.4	0.6	9.90	1.32	744.6	1.0
E	0.00	75.30	3.61	-0.10	0.00	0.00	750.4	0.6	9.90	1.33	744.6	1.0
M	5.50	80.80	13.04	-1.61	0.27	0.10	803.5	1.1	3.72	-0.21	809.5	0.6
E	0.00	80.80	13.04	-1.62	0.27	0.10	803.5	1.1	3.72	-0.21	809.5	0.6
L	0.65	81.45	15.27	-1.81	0.33	0.10	806.1	1.2	4.11	-0.39	819.1	0.6
FV	0.75	82.20	12.75	4.77	0.35	-0.07	809.0	1.1	6.64	-3.38	827.9	0.8
S	0.75	82.95	6.64	3.37	0.30	-0.07	813.7	0.8	12.75	-4.78	832.5	1.1
DV	0.75	83.70	4.12	0.39	0.30	0.07	822.4	0.6	15.30	1.79	835.4	1.2
L	0.65	84.35	3.73	0.20	0.34	0.07	832.0	0.6	13.08	1.61	838.1	1.1
E	0.00	84.35	3.73	0.20	0.34	0.07	832.0	0.6	13.08	1.63	838.1	1.1
M	5.50	89.85	9.90	-1.32	0.99	0.17	896.5	1.0	3.62	0.09	891.1	0.6
E	0.00	89.85	9.90	-1.33	0.99	0.17	896.5	1.0	3.62	0.10	891.1	0.6
L	0.65	90.50	11.75	-1.51	1.10	0.17	900.0	1.1	3.62	-0.08	901.4	0.6
FV	0.75	91.25	9.98	3.58	1.03	-0.35	903.7	1.0	5.38	-2.54	911.8	0.7
S	0.75	92.00	5.38	2.54	0.77	-0.35	909.6	0.7	9.97	-3.58	917.7	1.0
DV	0.75	92.75	3.61	0.09	0.63	-0.03	920.0	0.6	11.73	1.50	921.4	1.1
L	0.65	93.40	3.61	-0.09	0.61	-0.03	930.4	0.6	9.90	1.32	924.9	1.0
E	0.00	93.40	3.61	-0.10	0.61	-0.03	930.4	0.6	9.90	1.33	924.9	1.0
M	5.50	98.90	13.04	-1.61	0.72	0.07	983.5	1.1	3.73	-0.21	989.8	0.6
E	0.00	98.90	13.04	-1.62	0.72	0.07	983.5	1.1	3.73	-0.21	989.8	0.6
L	0.65	99.55	15.27	-1.81	0.77	0.07	986.1	1.2	4.11	-0.39	999.4	0.6
FV	0.75	100.30	12.75	4.77	0.68	-0.28	989.0	1.1	6.65	-3.38	1008.1	0.8
S	0.75	101.05	6.64	3.37	0.47	-0.28	993.7	0.8	12.76	-4.78	1012.8	1.1
DV	0.75	101.80	4.12	0.39	0.33	-0.10	1002.4	0.6	15.31	1.80	1015.7	1.2
L	0.65	102.45	3.73	0.20	0.27	-0.10	1012.0	0.6	13.09	1.62	1018.3	1.1
E	0.00	102.45	3.73	0.20	0.27	-0.10	1012.0	0.6	13.09	1.63	1018.3	1.1
M	5.50	107.95	9.90	-1.32	0.00	0.00	1076.5	1.0	3.62	0.09	1071.4	0.6
E	0.00	107.95	9.90	-1.33	0.00	0.00	1076.5	1.0	3.62	0.10	1071.4	0.6
L	0.65	108.60	11.75	-1.51	0.00	0.00	1080.0	1.1	3.61	-0.08	1081.7	0.6
FV	0.75	109.35	9.98	3.58	0.00	0.00	1083.7	1.0	5.37	-2.54	1092.1	0.7
S	0.75	110.10	5.38	2.54	0.00	0.00	1089.6	0.7	9.96	-3.57	1098.0	1.0
DV	0.75	110.85	3.61	0.09	0.00	0.00	1100.0	0.6	11.73	1.50	1101.8	1.1
L	0.65	111.50	3.61	-0.09	0.00	0.00	1110.4	0.6	9.89	1.32	1105.2	1.0
E	0.00	111.50	3.61	-0.10	0.00	0.00	1110.4	0.6	9.89	1.33	1105.2	1.0
M	5.50	117.00	13.04	-1.61	0.27	0.10	1163.5	1.1	3.73	-0.21	1170.1	0.6
E	0.00	117.00	13.04	-1.62	0.27	0.10	1163.5	1.1	3.73	-0.21	1170.1	0.6
L	0.65	117.65	15.27	-1.81	0.33	0.10	1166.1	1.2	4.12	-0.39	1179.6	0.6

FV	0.75118.40	12.75	4.77	0.35	-0.071169.0	1.1	6.65	-3.381188.4	0.8
S	0.75119.15	6.64	3.37	0.30	-0.071173.7	0.8	12.77	-4.781193.0	1.1
DV	0.75119.90	4.12	0.39	0.30	-0.071182.4	0.6	15.31	1.801195.9	1.2
L	0.65120.55	3.73	0.20	0.34	0.071192.0	0.6	13.09	1.621198.5	1.1
E	0.00120.55	3.73	0.20	0.34	0.071192.0	0.6	13.09	1.631198.5	1.1
M	5.50126.05	9.90	-1.32	0.99	0.171256.5	1.0	3.61	0.091251.6	0.6
E	0.00126.05	9.90	-1.33	0.99	0.171256.5	1.0	3.61	0.101251.6	0.6
L	0.65126.70	11.75	-1.51	1.10	0.171260.0	1.1	3.61	-0.081262.0	0.6
FV	0.75127.45	9.98	3.58	1.03	-0.351263.7	1.0	5.37	-2.541272.4	0.7
S	0.75128.20	5.38	2.54	0.77	-0.351269.6	0.7	9.95	-3.571278.3	1.0
DV	0.75128.95	3.61	0.09	0.63	-0.031280.0	0.6	11.72	1.501282.1	1.1
L	0.65129.60	3.61	-0.09	0.61	-0.031290.4	0.6	9.89	1.321285.5	1.0
E	0.00129.60	3.61	-0.10	0.61	-0.031290.4	0.6	9.89	1.331285.5	1.0
M	5.50135.10	13.04	-1.61	0.72	0.071343.5	1.1	3.74	-0.211350.3	0.6
E	0.00135.10	13.04	-1.62	0.72	0.071343.5	1.1	3.74	-0.211350.3	0.6
L	0.65135.75	15.27	-1.81	0.77	0.071346.1	1.2	4.12	-0.391359.9	0.6
FV	0.75136.50	12.75	4.77	0.68	-0.281349.0	1.1	6.66	-3.381368.6	0.8
S	0.75137.25	6.64	3.37	0.47	-0.281353.7	0.8	12.78	-4.781373.3	1.1
DV	0.75138.00	4.12	0.39	0.33	-0.101362.4	0.6	15.32	1.801376.2	1.2
L	0.65138.65	3.73	0.20	0.27	-0.101372.0	0.6	13.10	1.621378.8	1.1
E	0.00138.65	3.73	0.20	0.27	-0.101372.0	0.6	13.10	1.631378.8	1.1
M	5.50144.15	9.90	-1.32	0.00	0.001436.6	1.0	3.61	0.091431.9	0.6
E	0.00144.15	9.90	-1.33	0.00	0.001436.6	1.0	3.61	0.101431.9	0.6
L	0.65144.80	11.75	-1.51	0.00	0.001440.0	1.1	3.60	-0.081442.3	0.6
FV	0.75145.55	9.98	3.58	0.00	0.001443.7	1.0	5.36	-2.531452.7	0.7
S	0.75146.30	5.38	2.54	0.00	0.001449.6	0.7	9.94	-3.571458.6	1.0
DV	0.75147.05	3.61	0.09	0.00	0.001460.0	0.6	11.71	1.501462.4	1.1
IV	5.73152.78	11.75	-1.51	0.00	0.001521.6	1.1	3.64	-0.091523.7	0.6
FV	0.75153.53	9.98	3.58	0.00	0.001525.3	1.0	5.43	-2.561534.0	0.7
S	0.75154.28	5.38	2.54	0.00	0.001531.2	0.7	10.05	-3.611539.8	1.0
DV	0.75155.03	3.61	0.09	0.00	0.001541.6	0.6	11.83	1.521543.5	1.1
IV	5.73160.76	11.75	-1.51	0.00	0.001603.1	1.1	3.61	-0.081604.8	0.6
FV	0.75161.51	9.98	3.58	0.00	0.001606.9	1.0	5.36	-2.531615.2	0.7
S	0.75162.26	5.38	2.54	0.00	0.001612.7	0.7	9.93	-3.561621.1	1.0
DV	0.75163.01	3.61	0.09	0.00	0.001623.1	0.6	11.59	1.501624.9	1.1
IV	5.73168.73	11.75	-1.51	0.00	0.001684.7	1.1	3.64	-0.091686.3	0.6
FV	0.75169.48	9.98	3.58	0.00	0.001688.4	1.0	5.42	-2.561696.6	0.7
S	0.75170.23	5.38	2.54	0.00	0.001694.3	0.7	10.05	-3.611702.5	1.0
DV	0.75170.98	3.61	0.09	0.00	0.001704.7	0.6	11.84	1.511706.2	1.1
IV	5.73176.71	11.75	-1.51	0.00	0.001766.3	1.1	3.62	-0.081767.3	0.6
FV	0.75177.46	9.98	3.58	0.00	0.001770.0	1.0	5.37	-2.531777.7	0.7
S	0.75178.21	5.38	2.54	0.00	0.001775.9	0.7	9.95	-3.571783.6	1.0
DV	0.75178.96	3.61	0.09	0.00	0.001786.3	0.6	11.71	1.501787.3	1.1
IV	5.73184.69	11.75	-1.51	0.00	0.001847.8	1.1	3.62	-0.091848.9	0.6
FV	0.75185.44	9.98	3.58	0.00	0.001851.6	1.0	5.40	-2.561859.3	0.7
S	0.75186.19	5.38	2.54	0.00	0.001857.4	0.7	10.03	-3.601865.1	1.0
DV	0.75186.94	3.61	0.09	0.00	0.001867.8	0.6	11.81	1.511868.8	1.1
IV	5.73192.67	11.75	-1.51	0.00	0.001929.4	1.1	3.63	-0.081929.9	0.6
FV	0.75193.42	9.98	3.58	0.00	0.001933.1	1.0	5.39	-2.541940.2	0.7
S	0.75194.17	5.38	2.54	0.00	0.001939.0	0.7	9.98	-3.581946.1	1.0
DV	0.75194.92	3.61	0.09	0.00	0.001949.4	0.6	11.74	1.511949.8	1.1
IV	5.73200.65	11.75	-1.51	0.00	0.002010.9	1.1	3.61	-0.092011.5	0.6
FV	0.75201.40	9.98	3.58	0.00	0.002014.7	1.0	5.38	-2.552021.9	0.7

S	0.75202.15	5.38	2.54	0.00	0.002020.6	0.7	9.99	-3.592027.7	1.0
DV	0.75202.90	3.61	0.09	0.00	0.002030.9	0.6	11.77	1.502031.5	1.1
IV	5.73208.62	11.75	-1.51	0.00	0.002092.5	1.1	3.64	-0.082092.5	0.6

ELEMT	LTH	SUM L	BETAX	ALPHAX	ETAX	ETA X	PSIX	X	BETAY	ALPHAY	PSIY	Y
	(M)	(M)	(M)		(M)	(RAD)	(DEG)	(CM)	(M)		(DEG)	(CM)

TRANSITION GAMMA = 19.3110, NUX = 5.8125 × 4 NUY = 5.8125 × 4

MATRIX FOR LATTICE TO THE 1. POWER FOR 1 PERIOD IS

1.7772	-10.8537	0.0000	0.0000	0.0000	0.0000
0.2578	-1.0118	0.0000	0.0000	0.0000	0.0000
0.0000	0.0000	0.4587	-3.3633	0.0000	0.0000
0.0000	0.0000	0.2555	0.3067	0.0000	0.0000
0.0000	0.0000	0.0000	0.0000	1.0000	-0.5594
0.0000	0.0000	0.0000	0.0000	0.0000	1.0000

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