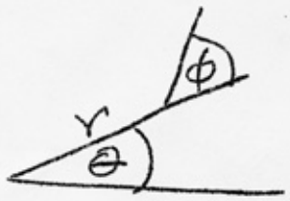
TRAJECTORIES IN A CYLINDRICALLY SYMMETRIC
MAGNET FIELD

$$\ddot{x} = \frac{H(r)}{P}\dot{y}$$

$$\ddot{y} = -\frac{H(r)}{P}\dot{x}$$



$$x\dot{y} - y\dot{x} = \frac{1}{P}\int_r^R H(r)r\,dr + R\sin\varphi_R = r\sin\varphi$$

$$\frac{d\theta}{dr} = \frac{1}{r}\tan\varphi$$

$$r\sin\varphi = R\sin\varphi_R + \frac{1}{P}G(r)$$

$$R = 365\text{ cm}$$

$$\ddot{z} = -z\frac{H'(r)}{P}\sin\varphi$$

$$P\ddot{x} = H_z\dot{y} - H_y\dot{z}$$
$$P\ddot{y} = H_x\dot{z} - H_z\dot{x}$$
$$P\ddot{z} = H_y\dot{x} - H_x\dot{y}$$

from $\nabla \times H = 0$

$$H_x = \frac{zx}{r}H'(r)$$

$$P\ddot{x} \approx H\dot{y}$$
$$P\ddot{y} \approx -H\dot{x}$$
$$P\ddot{z} \approx \frac{H'(r)}{r}(y\dot{x} - x\dot{y})z = -H'(r)\sin\varphi\, z$$

P for relativistic particles = 3335.7 x MeV

$P_{Mc} = 3.126 \times 10^6$

$P_{\mu c} = 4.70 \times 10^5$

$\mu = 276\ m$

$P_{mc} = 1704$

Orders of the Maniac

Logical Symbol	Order		n(A) = number in A; n(Q) = number in Q; m = number in memory at address.
	Symbol	Address	
m → Ac	AA	Address	Write m in A.
m → Ac-	AB	"	Write -m in A.
m → AcM	AE	"	Write |m| in A.
m → Ac - M	AF	"	Write -|m| in A.
m → Ah	BA	"	Add m to A.
m → Ah-	BB	"	Add -m to A.
m → AhM	BE	"	Add |m| to A.
m → Ah - M	BF	"	Add -|m| to A.
m → Q	EB	"	Write m in Q.
X	DA	"	Multiply m by n(Q). First 39 bigits of product appear in A. The 2^{-39} bigit of A is set = 1; Q is cleared.
X'	DB	"	Form m × n(Q). Write first 39 bigits in A, last 39 bigits in Q. Set sign in Q = 0.
÷	DD	"	Divide n(A) ÷ m. Write quotient in Q; Remainder in A.
T	CA	"	Transfer the control to the left hand order of address.
T'	CB	"	Transfer the control to the right hand order of address.
C	CC	"	Perform like T only if n(A) ⩾ 0.
C'	CD	"	Perform like T' only if n(A) ⩾ 0.
Q → m	EC	"	Write n(Q) into memory at given address.
A → m	DC	"	Write n(A) into memory at given address.
S → m	FA	"	Replace the bigits 8 to 19 of m by the corresponding bigits in A.

Logical Symbol	Order: Symbol	Order: Address	n(A) = number in A; n(Q) = number in Q; m = number in memory at address.
S → m'	FB	Address	Same for the 28 to 39 bigits.
HS → m	FC	"	Same for the 0 to 19 bigits.
HS → m'	FD	"	Same for the 20 to 39 bigits.
Rn	EE	Instead of address write here the number n	Replace the contents $\lambda_0 \lambda_1 \ldots \lambda_{39}$ of A and $\sigma_0 \sigma_1 \ldots \sigma_{39}$ of Q by $\lambda_0 \lambda_0 \ldots \lambda_0 \lambda_1 \ldots \lambda_{39-n}$ in A and $\lambda_{39-n+1} \ldots \lambda_{39} \sigma_0 \sigma_1 \ldots \sigma_{39-n}$ in Q.
Ln	DE		Replace contents as above by $\lambda_n \lambda_{n+1} \ldots \lambda_{39}\ 0\ 0 \ldots 0$ in A and $\sigma_n \sigma_{n+1} \ldots \sigma_{39} \lambda_0 \lambda_1 \ldots \lambda_{n-1}$ in Q.
a → Ac	EF		Write the 12 bigits of n in positions 0 to 11 and zero in positions 12 to 39 of A.
a → Ah	DF		Add into A the 12 bigits of <u>n</u> in positions 0 to 11.
DS	ED	Address	Set the 0 bigit of n(A) to 0.
Print	EA	"	Print m on teletype page printer.
Read	FF	"	Replace m by the next word on teletype tape.
Punch	CF	"	Punch <u>m</u> on teletype tape.
Stop	OFF	"	Stop computation.

$$\sin\vartheta_0 = \vartheta_0 - \frac{\vartheta_0^3}{6} + \frac{\vartheta_0^5}{120}$$

$$\cos\vartheta_0 = 1 - \frac{\vartheta_0^2}{2} + \frac{\vartheta_0^4}{24}$$

$$r_0 \to x$$

$$0 \to y$$

$$-\vartheta_0 + \frac{\vartheta_0^3}{6} - \frac{\vartheta_0^5}{120} \to \dot{x}$$

$$1 - \frac{\vartheta_0^2}{2} + \frac{\vartheta_0^4}{24} \to \dot{y}$$

$$0 \to s$$

$$x^2 + y^2 \to r^2$$

$$r^2 - 365^2$$

(+) Print x y $\dot{x}$ $\dot{y}$ Stop

(−)

$$0 \to n$$

$$r^2 - r_n^2$$

(−) $n+1 \to n$

(+)

$$H = \frac{H_{n+1} \times (r^2 - r_n^2) + H_n \times (r_{n+1}^2 - r^2)}{r_{n+1}^2 - r_n^2}$$

$$x + \sigma\dot{x} \to x \qquad \dot{x} + \sigma\frac{H}{P}\dot{y} \to \dot{x}$$

$$y + \sigma\dot{y} \to y \qquad \dot{y} - \sigma\frac{H}{P}\dot{x} \to \dot{y}$$

$$s + \sigma \to s$$

$$\ddot{x} = \frac{1}{P} H \dot{y}$$

$$\ddot{y} = -\frac{1}{P} H \dot{x}$$

Store into memory (34 positions)

Values of $H(r^2)$

$r^2 \times 10^{-4}$		$H(r^2)$
0	1	18300
	3.61	17600
	4.00	17300
3.61		16300
4.00		13700
4.41		10200
4.84		7400
5.29		5600
		4300
		3300
		2600
		2000
		1500
		1100
		600
		250
		0

$r^2 \times 10^{-4}$	H
0	18600
100	18000
2.89	17550
3.61	17400
4.00	17200
4.41	15500
4.84	12000
5.29	8500

$365 = 101101101$

$x \times 2^{-9}$

$y \times 2^{-9}$

$$\ddot{x} = \frac{1}{P} H \dot{y} \qquad \ddot{y} = -\frac{1}{P} H \dot{x}$$

Store into memory		Needed
Table of $H(r^2)$	$0 < r < 365$	40
P, r_0, ϑ_0		3
		[illegible]
		[illegible]

000 – 015 various quantities (variables)

$2^{-9}x$

$2^{-9}y$

$2^{-9}\dot{x}$

$2^{-9}\dot{y}$

0.000,0000,0100 .3333

~~2^{-9} 0040000000~~

$2^{-9} = 0040\ldots$

$1/3 = 2AAA\ldots$

$1/5 = 1999\ldots$

~~AA~~

$m \to Q \quad (2^{-9})$

$Q \to m \quad T_1 \quad 2^{-9}$

$X \quad \vartheta_0$

$A \to m \quad T_2 \quad 2^{-9}\vartheta$

$m \to Q \quad T_2$

$X \quad \vartheta_0$

$R \quad 001$

$A \to m \quad T_3 \quad 2^{-9}\vartheta^2/2$

$m \to Q \quad T_3$

$X \quad \vartheta_0$

$A \to m \quad T_4$

$m \to Q \quad T_4$

$X \quad 1/3$

$A \to m \quad T_4 \quad 2^{-9}\vartheta^3/6$

$m \to Q \quad T_4$

$X \quad \vartheta_0$

$R \quad 002$

$A \to m \quad T_5 \quad 2^{-9}\vartheta^4/24$

$m \to Q \quad T_5$

$X \quad \vartheta_0$

$A \to m \quad T_6$

$m \to Q \quad T_6$

$X \quad 1/5$

~~$A \to m \quad T_6$~~

~~$m \to A$~~

$A \to m \quad T_6 \quad 2^{-9}\vartheta^5/120$

$m \to Ac- \quad T_2$

$m \to Ah \quad T_4$

$m \to Ah- \quad T_6$

$A \to m \quad \dot{x} \times 2^{-9}$

$m \to Ac \quad T_1$

$m \to Ah- \quad T_3$

$m \to Ah \quad T_5$

$A \to m \quad \dot{y} \; (\times 2^{-9})$

TRAJECTORIES IN 170" SYNCHROCYCLOTRON

$\int_r^{365} H\,dr$	$\int_r^{365} dp \int_p^{365} H(p)\,dp$	r	H(r)	$518 \times 10^6 - \int rH\,dr$ G(r)	-H'(r)
		0	18600	518×10^6	0
		10	18600	517	3
		20	18500	514	6
		30	18400	510	6
		40	18300	503	6
		50	18300	495	6
		60	18200	485	6
		70	18200	473	6
		80	18100	460	6
		90	18000	444	6
		100	18000	427	6
		110	17900	408	6
		120	17850	388	6
		130	17800	365	6
		140	17750	342	6
		150	17700	316	6
		160	17600	288	6
		170	17550	259	7
		180	17500	229	10
870 500	3051×10^4	190	17400	196	15
697 500	2267	200	17200	163 33	95
534 000	1652	210	15500	129	260
396 500	1186	220	12000	100	350
294000	874	230	8500	77	285
220000	649	240	6300	59	180
164000	457	250	4900	46	130
121000	314	260	3700	35	100
87825	210	270	2900	26	70
61825	135×10^4	280	2300	19	60
41825	832×10^3	290	1700	13	50
26825	488	300	1300	8	38
15575	276	310	950	6	30
10875	144	320	630	3	22
5725	61×10^3	330	400	2	18
2475	20000	340	250	0	15
725	4000	350	100	0	11
75	100	360	30	0	7
		370	-30	0	6
		380	-100	0	5
		390	-130	0	4
		400	-170	1	3
		410	-190	2	2