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# No coupling window in the choice of chromaticity in the AGS Booster

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# NO COUPLING WINDOW IN THE CHOICE OF CHROMATICITY

# IN THE AGS BOOSTER

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## I. Introduction

This paper points out that there exists a window in the choice of chromaticity in which the coupling and emittance growth due to the chromaticity sextupoles become small. It is also noted that the present choice of the location of the sextupoles, which reduces the periodicity of the sextupoles from 24 to 6, considerably reduces the width of the non-coupling window.

It has been found[1] that when the chromaticity sextupoles are set to make the chromaticity equal zero, $C_x = C_y = 0$, then the horizontal and vertical betatron oscillations are strongly coupled. When the initial emittances are $\varepsilon_x = \varepsilon_y = 50$ mm - mrad, the coupling is about 807. in the emittance which means that $\varepsilon_x$, $\varepsilon_y$ will grow by about 80% over the initial value of 50. This coupling appears to be undesirable. It produces a loss in aperture.

A systematic tracking study was done of the dependence of the coupling and emittance growth on the choice of chromaticity. The sextupole arrangement of the present design has a periodicity of 6, and 4 half-cells in each superperiod have no sextupole. In this case a narrow non-coupling window was found which was centered at the chromaticity $C_x = C_y = -5$. For $C_x = C_y = -5$ the emittance growth is about 16%. The results are much improved by putting in the 4 missing sextupoles and restoring the periodicity of the sextupoles to 24. In this case, the no coupling window is much larger; the emittance growth is less than 12%, in the chromaticity range $C_x = C_y = -10$ to $C_x = C_y = 0$.

The study reported on in this paper is much indebted to the work of G. F. Dell who found that several choices of the chromaticity lead to a much smaller emittance growth.

## II. Tracking Study Results

The results of the tracking study are shown in Figure 1. In this study the motion is started with the initial emittance $\varepsilon_x = \varepsilon_y = 50$. The chromaticity is varied, holding $C_x = C_y$, by varying the strengths of the chromaticity sextupoles, and for each choice of $C_x = C_y$ the largest emittance, $\varepsilon_{max}$, achieved by either $\varepsilon_x$ or $\varepsilon_y$ is plotted versus $C_x = C_y$.

In this study the eddy current sextupole fields are present, and four runs are done to find $\varepsilon_{max}$. These four runs have different initial values of x, x′, y, y′ but they all have initial emittances $\varepsilon_x = \varepsilon_y = 50$.

Two cases are plotted in Figure 1. In one case, the sextupole arrangement is the present arrangement with periodicity = 6. The second has a sextupole in each half-cell and has periodicity = 24. one sees that the periodicity =6 case shows little emittance growth near $C_x = C_y = -5$. The results for the periodicity = 24 show considerably less emittance growth, and allow the accelerator to operate with $C_x = C_y = -10$ to $C_x = C_y = 0$ with not much emittance growth.

The results shown in Figure 1 are for initial emittances $\varepsilon_x = \varepsilon_y = 50$. The emittance growth will be smaller than that shown in Figure 1 for all initial emittances below the line.

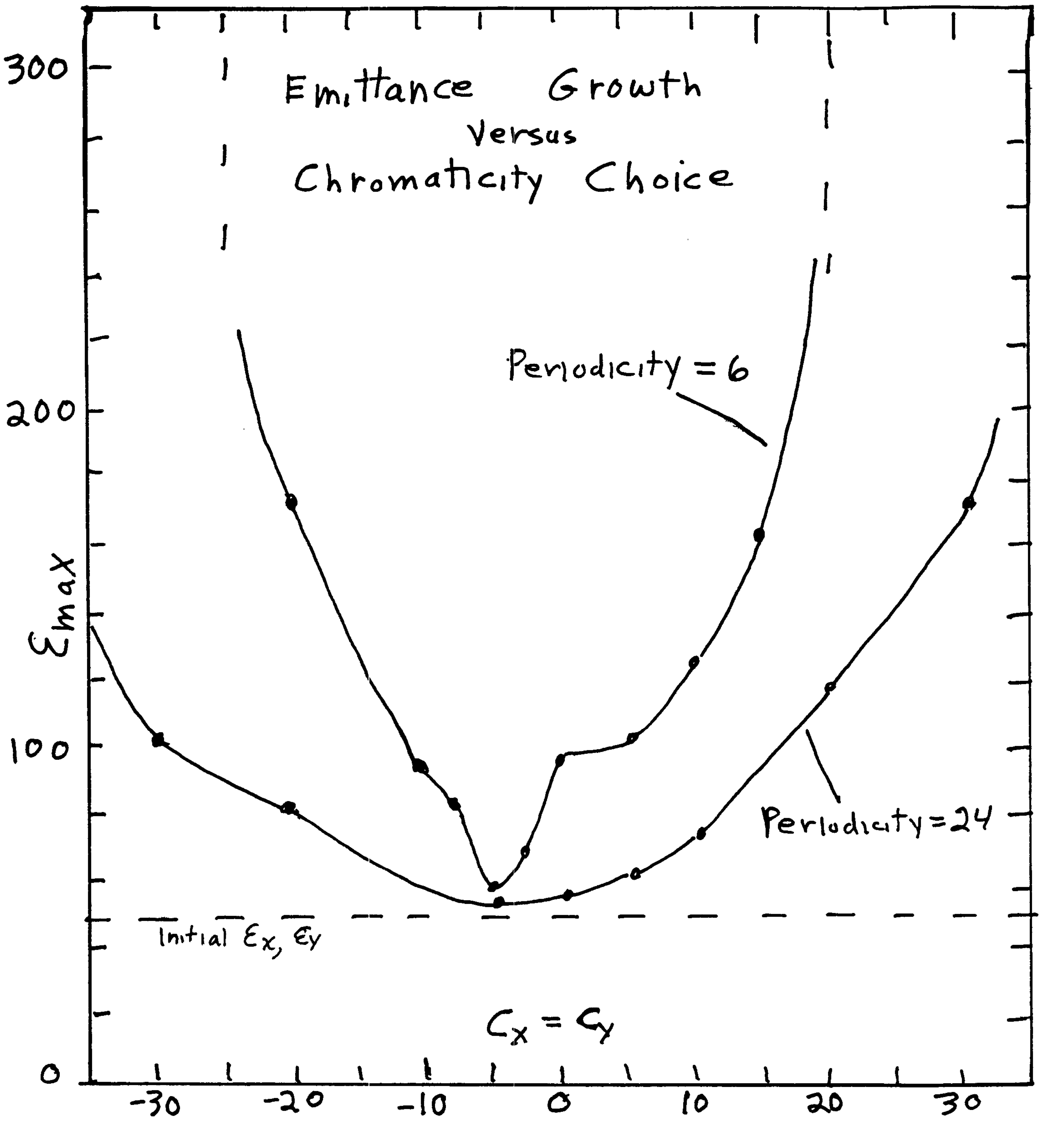
$$\varepsilon_x + \varepsilon_y = 100$$

For initial emittance above the line $E_x + E_y = 100$, the emittance growth will be proportionally larger.

## III. Dependence on $\nu$-Value Choice

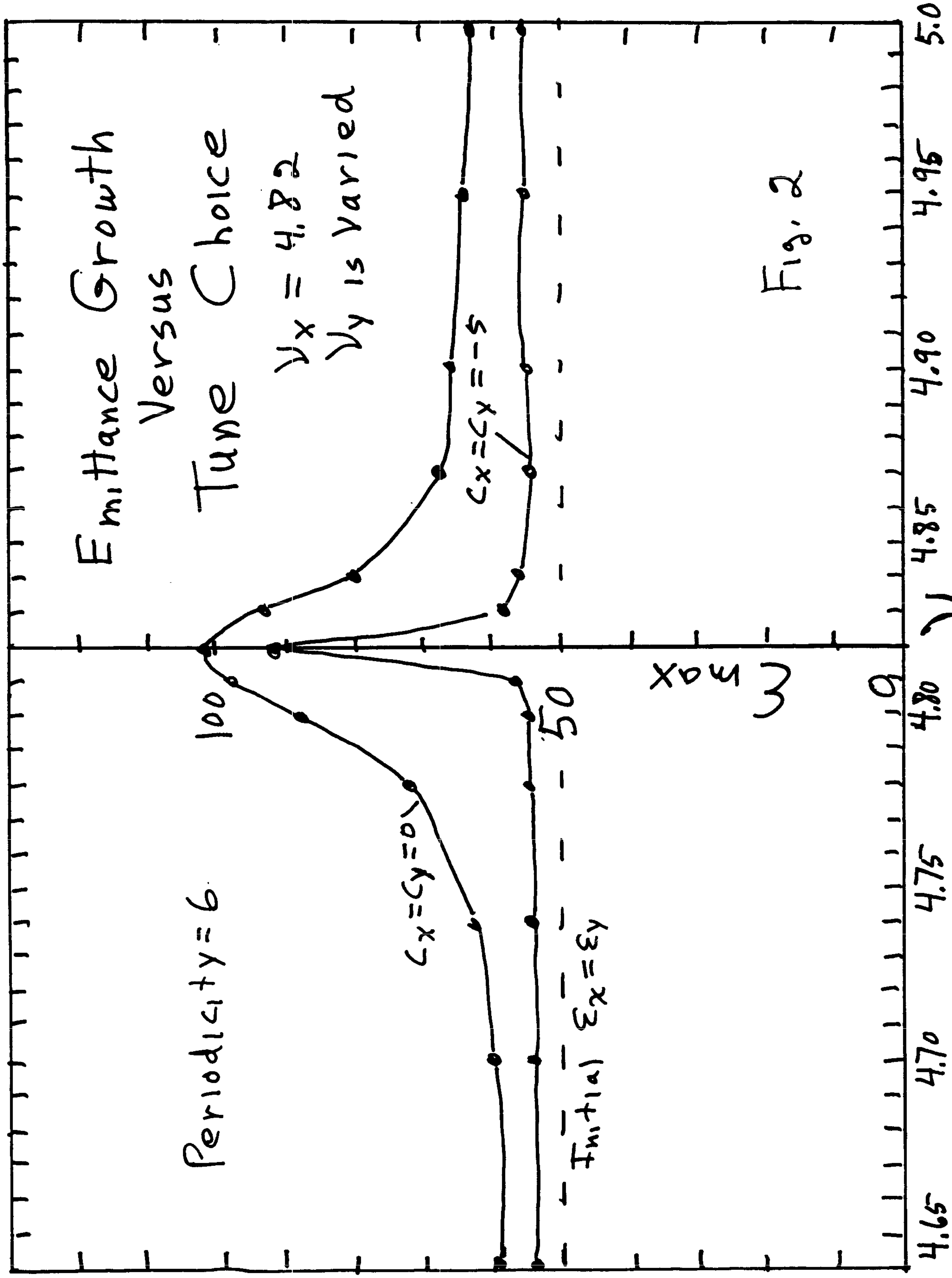
Lee, Tepikian, Zhao[2] and Parsa[3] have emphasized the importance of the $\nu_y - \nu_x = 0$ resonance. The emittance growth can be reduced by moving away from the resonance line. However, the improvement is a slow function of the $\nu$-values, as shown in Figure 2. In Figure 2, the emittance growth is plotted against $\nu_y$ where $\nu_x$ is held fixed at 4.82 for the case where $C_x = C_y = -5$ and $C_x = C_y = 0$ and for the present periodicity = 6 lattice. In order to make the emittance growth for the $C_x = C_y = 0$ case comparable to that in the $C_x = C_y = -5$ choice, one would have to move quite a distance away from the $\nu_x = \nu_y$ resonance line. At a distance of .04 from the $\nu_x = \nu_y$ resonance line, the emittance growth for $C_x = C_y = 0$ is still about 40%.

In contrast, the periodicity = 24 sextupole arrangement has a low emittance growth for $C_x = C_y = 0$ even at a distance of .01 from the resonance line.



Emittance Growth
versus
Chromaticity Choice
Periodicity = 6
Periodicity = 24
Initial εx, εy
Cx = Cy
εmax
300
200
100
0
-30
-20
-10
0
10
20
30


Fig. 1.


Emittance Growth
Versus
Tune Choice
νx = 4.82
νy is Varied
Fig. 2
Periodicity = 6
Cx=Cy=0
Cx=Cy=-5
Initial εx=εy
εmax
100
50
0
νy
4.65
4.70
4.75
4.80
4.85
4.90
4.95
5.0

References

1. G. Parzen, Booster Tech. Note 24 (1986).
2. S. Y. Lee, S. Tepikian and X. F. Zhao, Booster Tech. Note 72 (1987).
3. Z. Parsa, private communication.