

Emittance Growth and Coupling Due to Chromaticity Sextupoles in RHIC

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Introduction

In order to understand the non-linear effects of error field multipoles, it is ~~not~~^{useful} to first know what non-linear effects are present due to Chromaticity Sextupoles alone.

It will be seen that the sextupoles produce large non linear effects, about 10% growth in the emittances and about 40% growth in the betatron amplitudes. The additional emittance growth, due to random magnet field errors, is ^{usually} small compared to the emittance growth due to the sextupoles.

Coupling and Emittance Growth due to Sextupoles Only

Sextupoles only, no random field errors

Starting emittance, $\epsilon_x = 3.25$, $\epsilon_y = 3.25$
 $\chi_0 \approx 12.7 \text{ mm}$

Emittance growth

$$\epsilon_{x, \max} = 6.3$$

$$\epsilon_{y, \max} = 6.8$$

$$\epsilon_{T, \max} = 8.2$$

$$\frac{\Delta \epsilon_T}{\epsilon_{T, \max}} = \pm 1.4, \text{ shear}$$

Emittance Growth Survey in E_x and E_y

The emittance growth is computed for various points on the surface

$$E_{x_0} + E_{y_0} = 6.5$$

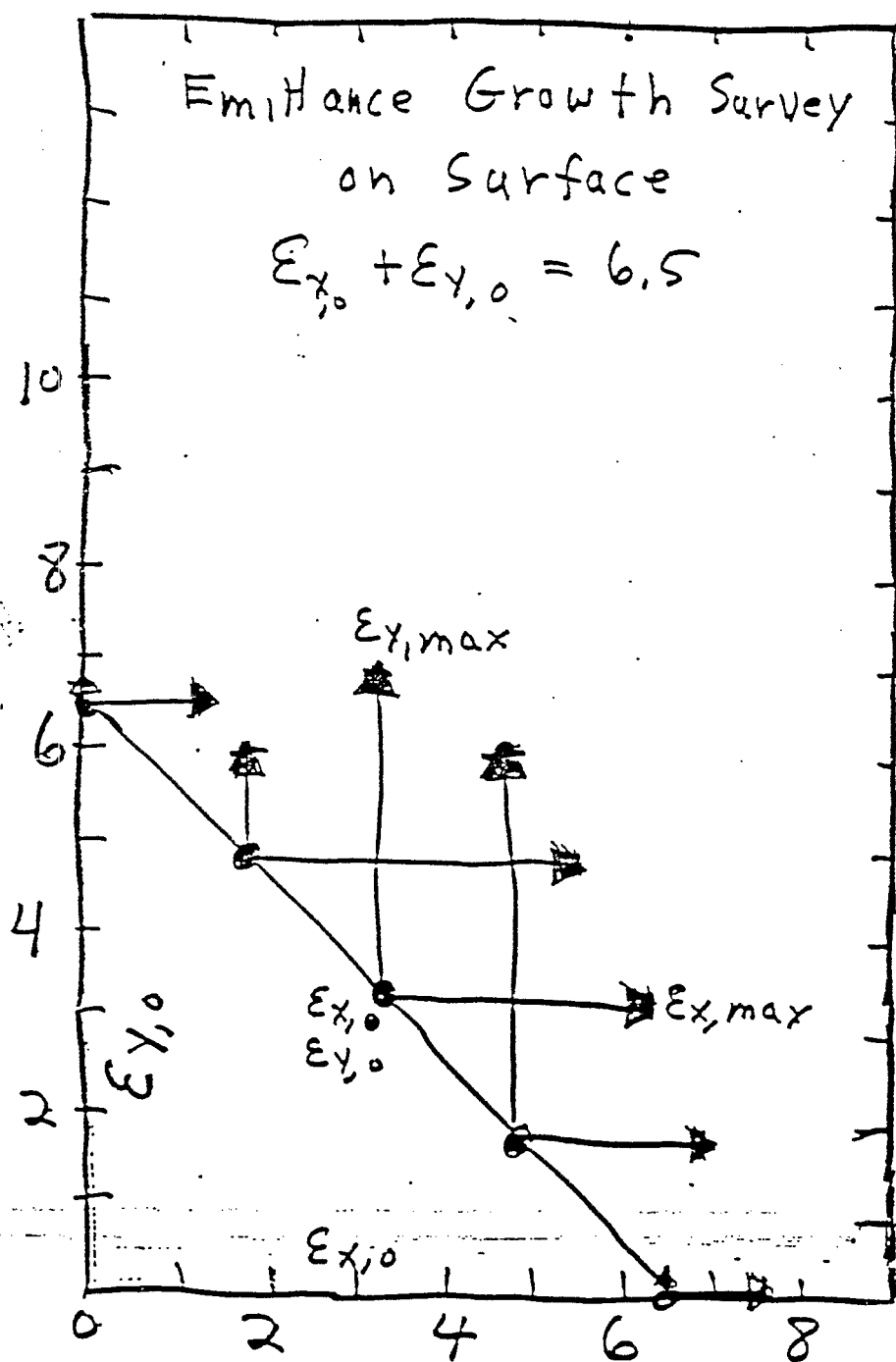
The ~~worse~~ largest growth occurs near $E_{x_0} \approx E_{y_0}$. (see figure 1.)
For smaller starting emittances

$$E_{x_0} + E_{y_0} < 6.5,$$

the emittance growth should be smaller.

In figure 1, the large dots \bullet show the initial emittances E_{x_0}, E_{y_0} .

The ~~lines~~ lines with arrows $\bullet \rightarrow \bullet$ show the maximum emittance attained, $E_{x_{max}}$ and $E_{y_{max}}$ for the give initial ~~emittances~~ emittances, E_{x_0} and E_{y_0} . $E_{x_{max}}$ and $E_{y_{max}}$ do not occur simultaneously; usually E_x becomes large when E_y becomes smaller and similarly for E_y .

Fig 4

(5)

Additional Emittance Growth due to Random Field Errors

Most of the emittance growth is due to sextupoles,

10 random multipoles present in runs done.

10 different sets of random errors studied.

Runs start with $\epsilon_x = \epsilon_y = 3.25$, $x' = y' = 0$

Growth due to Sextupoles alone ($x' = y' = 0$ run)

$$\epsilon_{x, \max} = 3.7$$

$$\epsilon_{y, \max} = 6.8$$

$$\epsilon_t, \max = 8.2$$

$$\Delta \epsilon_t / \epsilon_t = \pm .12$$

Growth due to Sextupoles + Random Errors, 10 runs

$$\epsilon_{x, \max} = 4.7$$

$$\epsilon_{y, \max} = 7.7$$

$$\epsilon_t, \max = 10.5$$

$$\Delta \epsilon_t / \epsilon_t = \pm .26 \text{ - (unusual, } \pm .19 \text{ more likely)}$$

Random errors cause about 15% more growth in the emittance. Most of the growth is due to the sextupoles.