IEEE Transactions on Nuclear Science, Vol.NS-22, No.3, June 1975

CHROMATICITY CORRECTION IN EPIC

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1. Introduction

In order to achieve a high luminosity in EPIC, the proposed UK e^+-e^- storage ring, low-β insertions will be used at each of the four interaction regions. The consequent increase in chromaticity, $\xi = (\Delta Q/Q)/(\Delta p/p)$, must be corrected by means of sextupoles, which in turn introduce third and higher order resonances. This effect sets an upper limit to the allowable β-values in the high-β quadrupoles of the interaction region.

2. Stable region requirements

The beam-stay-clear region in a normal cell F quadrupole is made up in the following way (β_x = 40m, β_y = 10m)

	Horizontal	Vertical
Betatron amplitude (10 σ)	± 37mm	± 7.5mm
Synchrotron amplitude (6.5σ_ε)	± 8mm	0
Closed orbit distortion	± 10mm	± 10mm
	± 55mm	± 17.5mm

Studies have been confined to a perfect machine with no closed orbit distortion.

3. Tracking studies

Originally it was hoped to have interaction region beta-values (at collision) of β_x^* = 0.4m, β_y^* = 0.1m. However, some lattice beta-values were found to change by up to 50% over the required momentum range of ± 5 x 10^{-3}, and it was impossible to obtain a linear Q vs momentum relationship after chromaticity correction. Furthermore, the sextupole strengths required for this were so large as to result in a very small stable region. The third order forcing terms could be cancelled by means of further sextupoles placed in the α_p = 0 region, but due to the large β-values pertaining here the fourth order effects were very large indeed.

The ratio of the β^*-values was therefore increased to 10:1 with a consequent large decrease in the maximum β_H-value. The chromaticity variation with β^*-values is shown in Figure 1. Working at β_x^* = 2.0m, β_y^* = 0.2m, the β-variation with Δp/p was now of the order of 25% and with sextupoles adjacent to all normal cell quadrupoles the stable region was greatly increased. With the addition of 3 more sextupoles in the α_p-matching region (Figure 2) the harmonic content was further reduced, thus resulting in a nominally stable region of greater than 40 σ in both planes (Figure 3). Unfortunately Q_v varies rapidly with horizontal motion amplitude (Figure 4), such as to pass through the integer 19 at x = 60mm (16 σ_x). This is a fourth order effect characterised by the Hamiltonian $g_{1111(0)}$ (Reference 1 and 2). The effect is predictable, but very difficult to eliminate (Reference 3). There is, however, very little direct x-y coupling at 10 σ amplitudes, so that vertical growth is only a few per cent.

The variation of Q_x and Q_y with Δp/p is small (Figure 5). Although little work has been done on the effect of momentum on stable regions, no problems are expected from this source, at least until there are large space-charge forces present in the interaction regions.

4. Conclusions

With the sextupole arrangements outlined above, it is expected that sufficient stable region can be provided at β_x^* = 2.0m, β_y^* = 0.2m. If these values are decreased significantly, the sextupole strengths required for correction will increase to a point where third and fourth order resonance widths are at an undesirable level. Unless a distinctly improved sextupole arrangement can be found, it would appear that there is a limit somewhere near β_x^* = 1.5m, β_y^* = 0.15m to which the interaction region β-values can be reduced.

References

1. R. Hagedorn. Stability and amplitude ranges of two dimensional non-linear oscillations with periodical Hamiltonians. CERN 57-1 (March 1957).

2. G H Rees, W T Toner, J V Trotman. Effects of beam-beam forces in large electron-positron storage rings. (These Conference Proceedings).

3. M R Harold. EPIC sextupoles: status report. EPIC/MC/65, RL-74-152.

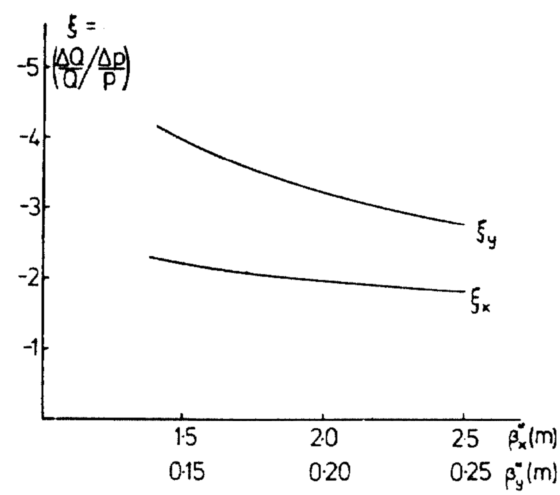

Figure 1. The variation of horizontal and vertical chromaticities with interaction region β-values.

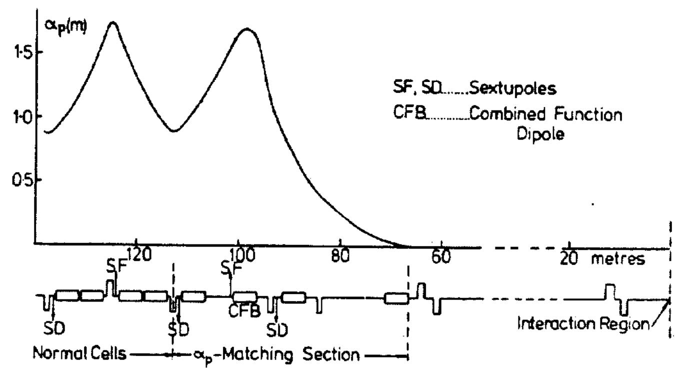

Figure 2. Part of the EPIC lattice, showing the sextupole positions. The sextupoles are in two electrical circuits, controlled independently.

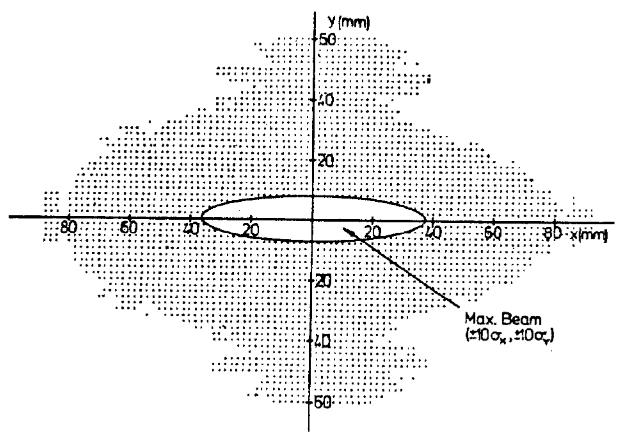

Figure 3. The initial coordinates of on-momentum particles which remain stable in EPIC after 100 turns (β_x = 40, β_y = 10).

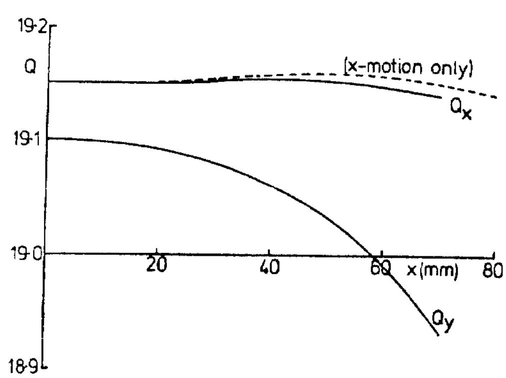

Figure 4. Variation of Q_x, Q_y with horizontal amplitude.

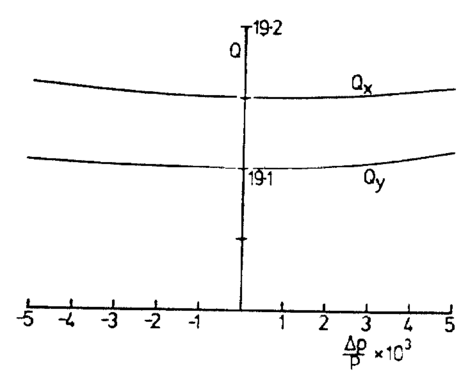

Figure 5. Variation of Q_x, Q_y with momentum.