TM-1246
0102.000
February 1984

HOW MUCH RANDOM SEXTUPOLE FIELD CAN WE HAVE IN THE PRESENCE OF BEAM-BEAM INTERACTIONS ?

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During the workshop, two estimates of the random sextupole components in the SSC dipoles have been presented, one from Berkeley and the other from Brookhaven:

1. Berkeley (by R. Meuser, LBL-17050)

   coil radius = 2 cm
   normal sextupole $(b_2)_{rms} = 1.04/m^2$
   skew sextupole $(a_2)_{rms} = .765/m^2$

2. Brookhaven (by J. Herrera, private communic.)

   coil radius = 1.5 cm
   normal sextupole $(b_2)_{rms} = 2.4/m^2$
   skew sextupole $(a_2)_{rms} = 1.8/m^2$

The resulting resonance width $2\varepsilon_G$ (For the definition of this parameter, see a separate report in the proceedings of this workshop.) is calculated for four third-integer resonances using the lattice designed by the Berkeley group, "SSC Parameter List", DRAFT, 11/9/83, original design date 10/28/83. In order to compare the width with the results from CERN $Sp\bar{p}S$ beam studies (see below), we use the CERN-style emittance corresponding to 2σ (86.5%) instead of $\sqrt{6}\sigma$ (95%):

normalized emittance = $(2/3)\times 10.7\pi\times 10^{-6}$ m·rad.,

at 1 TeV, emittance = $6.7\pi\times 10^{-9}$ m·rad.
at 20 TeV, = $3.3\pi\times 10^{-10}$ m·rad.

Table 1a: resonance width ($2\varepsilon_G$) at 1 TeV

	Berkeley magnet	Brookhaven magnet
$3\nu_x$	.00162	.00372
$\nu_x + 2\nu_y$	.00316	.00729
$3\nu_y$	.00118	.00279
$2\nu_x + \nu_y$	.00232	.00545

Table 1b: resonance width ($2\varepsilon_G$) at 20 TeV

	Berkeley magnet	Brookhaven magnet
$3\nu_x$	.000362	.000833
$\nu_x + 2\nu_y$	.000706	.00162
$3\nu_y$	.000265	.000625
$2\nu_x + \nu_y$	.000518	.00122

In the CERN $Sp\bar{p}S$, beam studies on the $\bar{p}$ lifetime have been performed with p and $\bar{p}$ bunches separated by menas of electrostatic separators. Detailed descriptions of the studies are given in a report by N. Garrel and W. Scadale,

"Experimental results on ppbar separations", SPS/DI-MST/ME-83-9, 27th August, 1983.

In one experiment, the lifetime of $\bar{p}$ was reduced from 65 hours to 32 hours with a separation. Since the lowest-order nonlinear field created by the separation is sextupole-like, one can calculate the corresponding resonance width $2\varepsilon_G$:

	$3\nu_x$	$\nu_x+2\nu_y$	$3\nu_y$	$2\nu_x+\nu_y$
$2\varepsilon_G$ =	.00176	.00044	.00147	.00078

In the second experiment, the lifetime was reduced from 22 hours to 12 hours. Resonance widths are:

$3\nu_x$	$\nu_x+2\nu_y$	$3\nu_y$	$2\nu_x+\nu_y$
.00199	.00051	.00167	.00087

Comparing these numbers to those in Table 1b, we may conclude that, if the beam-beam interaction is comparable in the $Sp\bar{p}S$ and SSC (that is, linear tune shift = .003/interaction, total .02), the SSC at 20 TeV with the Berkeley sextupole errors seems safe. The Brookhaven sextupole errors may be on the borderline.

If one looks at the width given above, which is obtained from the formula by Guignard, it is difficult to understand how particles are lost because of the third-integer resonances. Note that the beam occupied the tune range

	first exp.	second exp.
ν_x	26.685 to .703	26.688 to .710
ν_y	27.678 to .695	27.675 to .695

One explanation could be that the very strong octupole-like field of the beam-beam interaction is reducing the central stable area of the phase space. This octupole field creates stable outer islands but, once a particle is trapped in those outer islands, it may grow to a large amplitude very slowly. Some higher-order effects (for example, overlapping of chaotic areas when high-order resonances are crossed) may be responsible for that. The effects of octupole-like field are included in re-examining the resonances $3\nu_x = 80$ and $3\nu_y = 83$. Results for the first experiment are shown in Fig. 1. The meaning of two lines labeled "G" and "S" is as follows: For a given tune value, a particle with the initial emittance larger than "G" will be outside the central stable area regardless of its initial phase. A particle below the line "S" will be inside the central stable area regardless of its phase. Between "G" and "S", particles could be stable or unstable depending on their initial phase. Since the beam emittance (normalized) was 23π mm-mr, some particles were clearly outside the central stable area and they may grow to a large amplitude.

It will be interesting to see the effects of the octupole-like field on the coupling resonances as well. In any case, it is clear that one must include the effects of octupole-like field in evaluating the resonance width of a sextupole resonance. Otherwise, the

* Operated by Universities Research Association, Inc. under contract with the U.S. Department of Energy.

value of width will be useful only for a relative comparison of two machines.

Fig. 1.