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Stopband Correction of the AGS Booster Harmonic Component of C.O.D.

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AGS Complex Machine Studies **(AGS Studies Report No. 292)** **Stopband Correction of the AGS Booster** **Harmonic Component of C.O.D.**
Study Period: April 30, 1993
Participants: C. Gardner and Y. Shoji
Reported by: Y. Shoji
Machine: User3; 1.7 kG flat porch; low intensity (middle 5, 60 degrees)
Aim: To observe C.O.D. and estimate the contribution to the half-integer resonances.

In order to estimate the contribution from C.O.D. to the stop bands, C.O.D. was measured for the different dRset (= set value of RF radial steering) at the zero-dB/dt porch. The C.O.D. contributes to not only the integer resonance. The half-integer stop bands (2Qx=9 and 2Qy=9) can be produced by the combination of C.O.D. and sextupole field. The combination of imperfection of the dispersion function (6*n+3 harmonic component) and the chromaticity control sextupole field can produce the dependence of half-integer resonance correction on dR.

In this report we use the definitions and results reported in the previous studies reports without indications. These reports are:

Shoji, Gardner, "14th normal sextupole correction", AGS SR-286
Shoji, Gardner, "2Qx=9 correction data before May 7", AGS SR-287

I C.O.D.

The FFT amplitudes of C.O.D. are listed in Table I. The values were average of two measurement at dRset=-0.1 and 0.4. Amplitudes were roughly 1mm.

Table I Harmonic amplitude of C.O.D.

harmonics	amplitude (mm) horizontal	vertical
0th	0.147	1.004
1st	0.689	0.826
2nd	1.364	0.961
3rd	1.502	1.095
4th	1.837	0.905
5th	0.214	1.570
6th	1.908	1.165
7th	0.415	0.778
8th	1.093	0.305
9th	1.222	0.628
10th	0.113	0.537

To make an order estimation of a half integer stop band, we assume that existing sextupole field are only the chromaticity control sextupoles, which just cancel the natural chromaticities. The combination of the dispersion function and the chromaticity control sextupoles changes the tune by 5 for dP/P=1. At that time the averaged displacement at the PUEs are 2.09m, which is identical to the average of the dispersion function. The stop band width of 9th half integer resonance is twice the tune shift by the 9th error field. When the amplitude of 9th C.O.D. is 1mm the produced stop band width is:

$$2 * 5 * (1\text{mm}/2.09\text{m}) = 0.0048 .$$

This stop band corresponds to the quadrupole correction

$$0.0048 * 10^5 * (0.7\text{GeV/c}) = \qquad 340$$

at the 1.7KG flat porch. This value is comparable or even larger than the long-term fluctuation of the correction currents of 2Qx=9. If the C.O.D. and the chromaticities are constant throughout the cycle, the change of C.O.D. appears as a change of B terms of the correction currents. The change of B terms; Cb and Sb produced by the change of 1mm C.O.D. is

$$340 \ / \ 1.7\text{kG} \quad = 200 .$$

That is comparable to the measured Cb and Sb.

The change of correction current for 2Qx=9 by the change of chromaticity had been measured to be

$$\delta Co = -58 \text{ and } \delta So = 105 \quad \text{for } \delta\,\xi x = 1.068$$

at the same flat porch. The order of these changes are consistent with the order of the amplitudes of C.O.D.

The small change of C.O.D. will change the half integer stop-band significantly.

II Dispersion Function

Dispersion function was calculated as the difference of measured C.O.D. at dRset=1.9cm and dRset=-0.6cm. To investigate the harmonic component, we calculated

R2+	≡ (A2+B2+C2+D2+E2+F2)/6	= 10.919 mm
R4+	≡ (A4+B4+C4+D4+E4+F4)/6	= 21.584
R6+	≡ (A6+C6+D6)/6 + B6/2	= 23.153
R8+	≡ (A8+C8+D8)/6+(B8+F8)/4	= 11.361
R2_	≡ (A2-B2+C2-D2+E2-F2)/6	= 0.245
R4_	≡ (A4-B4+C4-D4+E4-F4)/6	= -0.004
R6_	≡ (A6+C6+D6)/6 - B6/2	= 0.151
R8_	≡ (A8+C8+D8)/6-(B8+F8)/4	= 0.052 .

The R+ series contains 6*n harmonic components of dispersion function. And the R_ series contains 6*n+3 harmonic components of dispersion function, which might be zero if the machine was perfect. The amplitude of 6*n+3 harmonic components were about 1/100 of normal dispersion function.

We will calculate how much Sr and Cr will change by this imperfection. The relation between dRset and dP/P is

$$\delta(dP/P)/\delta(dRset) = 0.000314 \qquad (/cm)$$

Then the change of correction current by the change of dRset by 1cm is

$$0.000314 * 2 * 5 * (1/100) * 10^5 * (0.7GeV/c) = \qquad 2.2 \;.$$

This is the Cr and Sr produced by the imperfection of the dispersion. But the measured Cr and Sr at the same flat porch was -96 and -47 for 2Qx=9. The imperfection of dispersion function less contributed to the residual loss of the half integer resonance. This result is consistent with the experimental result; the residual loss did not depend on the chromaticities.

The other possible origin of the Cr and Sr is 6*n+3 harmonic sextupole error, which does not come from the chromaticity control sextupoles. To produce as large Cr and Sr as 100, the amplitude of error sextupoles should be comparable to the amplitude of the chromaticity control sextupoles. Then the bare chromaticities should have changed significantly. We must remember that the measured bare chromaticities are ξx=-1.568 and ξy=-0.623 [W. Van Asselt]. They are much different from the expected chromaticities.