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A Fast Transition Jump Scheme at the Brookhaven AGS*

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I. Summary

An improvement plan is now underway which is designed to raise the intensity of the circulating beam in the AGS to 4 x 10^{13} protons. Part of the work involves minimizing losses at transition caused by the negative mass instability. We plan to use pulsed quadrupole doublets to speed up passage through transition. Existing magnets separated by 3/2 betatron wavelength appear adequate for the puspose. Computer modeling has been carried out, and this work is compared with experimental studies.

II. Introduction

At the present intensity of approximately 1.5 x 10^{13} protons per pulse, AGS beam losses at transition are now less than 5%. However, as improvement plans are implemented and the intensity is increased to 4 x 10^{13} protons per pulse, new mechanisms will become important and the losses will increase. This paper describes our effort directed to minimizing these losses by speeding up passage through transition. It follows the work of Werner Hardt.[1]

III. The γ_t Jump

Hardt's idea, which has been implemented at the CERN PS, was based on the observation that quadrupole pairs separated by 1/2 betatron wavelength and configured as doublets can alter γ_t of a synchrotron without affecting its tune. By arranging to cross transition while γ_t is rapidly decreasing, the bunch area blow-up caused by the negative mass instability can be substantially reduced. Figure 1 displays the results of Eq. 7.6 of Reference 1, using current AGS parameters. Here the attainable AGS intensity is plotted as a function of bunch area for several crossing speed enhancement factors, f'.

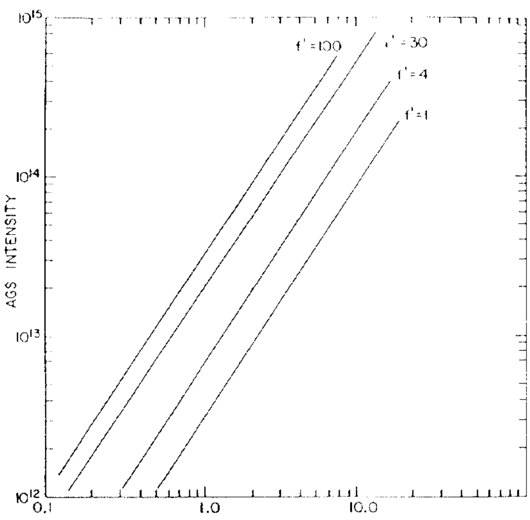

Fig. 1. AGS intensity for lossless transition as a function of bunch area and crossing speed enhancement factor, f'.

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Using the general accelerator design program MAD, [2] we have investigated several sets of quadrupole configurations which fulfill the 1/2 betatron wavelength separation requirement. We also set as a criterion realizable magnets and deployments (i.e., existing or easily constructed quadrupoles in real AGS straight sections). We soon realized that 3/2 betatron wavelength separation configurations could also change γ_t without substantially affecting the tune.

The most successful arrangement used six existing "slow" quadrupoles, configured as three doublets having 3/2 betatron wavelength separation: {B17+,D17-}, {F17+, H17-}, {J17+,L17-}, where the locations and polarities are indicated and the magnets comprising doublets are enclosed by brackets. The results of the computer simulation are given in the following table:

Quad Strength (K)	0.0+	0.2	0.25	0.30	0.35
Q_H	8.711	8.681	8.665	8.647	8.625
Q_V	8.800	8.796	8.793	8.790	8.787
$(\beta_x)_{max}$	22.5	35.8	40.0	44.4	49.0
$(\beta_y)_{max}$	22.3	27.3	28.7	30.0	49.0
$(dx)_{max}$	2.16	7.78	8.98	9.99	10.82
γ_t	8.449	9.667	10.366	11.247	12.336
$\Delta\gamma_t$	0.0	1.217	1.916	2.297	3.886

+Unperturbed AGS, as calculated by MAD, β and dx in meters.

We see that substantial changes in γ_t are possible without producing unacceptable changes in other machine parameters. (Since making this calculation, it has been brought to our attention that essentially the same configuration had been proposed earlier by L.C. Teng.[3])

In order to evaluate the potential improvement in AGS intensity, we must now consider the rise- and fall-time of the quadrupole pulse. Since the configuration being considered increases γ_t, transition must be crossed during the falling edge of the excitation pulse, when γ_t is decreasing.

IV. Experimental Results and Conclusions

Using existing power supplies, we were able to achieve $\Delta\gamma_t/\Delta t$=180/ms. (This corresponds to f'=3 on Fig. 1.) and a lossless transition with 2.3 x 10^{12} protons. Since the AGS bunch area is approximately 1 eV-second, this result is consistent with predictions.

We plan to modify our power supplies in order to get to $\Delta\gamma_t/\Delta t$=1800/ms (f'=30), leading to a prediction of lossless transition at 2 x 10^{13} protons. (Figure 2 illustrates the timing and magnitude of the proposed quadrupole pulse, as well as its relationship to the rest of the AGS cycle.) This is not yet at the desired goal of 4 x 10^{13} protons, but this can be reached if we take the additional step of using a high frequency rf cavity to double the bunch area before transition.[4]

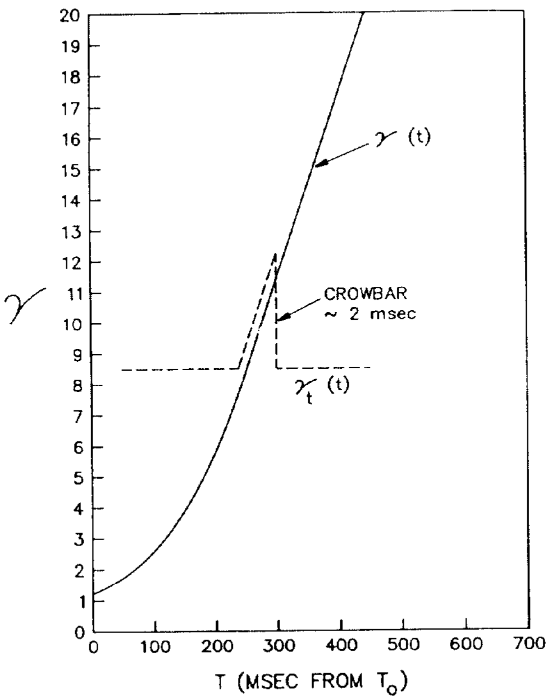

Fig. 2. Quadrupole pulse for altering γ_t in relation to the AGS cycle.

V. Acknowledgment

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References

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