VERTICAL INSTABILITIES IN ELECTRON STORAGE RINGS

Part II - SOME EXPERIMENTAL RESULTS FROM THE STANFORD ELECTRON STORAGE RING

G. K. O'Neill
Princeton University

Some experimental results* on vertical instability in the storage ring were obtained with the Stanford storage ring. This is a ring of about 140 cm radius, with an injection energy of 300 Mev. It has been possible to raise the energy in the ring up to 500 Mev. All measurements on the vertical instability were done, however, at about 310 Mev. The magnet structure has n values varying between 0 and 1.4 and thus corresponds roughly to a weak-focusing machine. Consequently, betatron frequencies are somewhat like those encountered in the Cosmotron. With the present pulsed inflectors it is possible to stack up to 30 ma in a time interval of about 3 minutes. This beam is completely radiation-damped and therefore the beam cross section, at least for small currents, is approximately 0.5 cm radially by approximately 0.1 cm vertically. The azimuthal length is about 60 cm. From this it can be concluded that the current densities encountered are relatively high. In this machine 8 clearing-field electrodes are used. These are located at the bottom of the vacuum chamber. With the clearing fields turned off, no vertical instabilities have been observed. This is consistent with the MURA experience. The beam cross section can be viewed by means of a TV system.

---

*D. Ritson studied some aspects of this problem from a theoretical point of view.

By observing the beam cross section during stacking, the vertical instability appears about as follows: nothing unusual happens up to about a level of 2 to 3 ma; between approximately 3 and 4 ma the vertical amplitude increases by about a factor of 2 ; and at 5 ma the beam blows up vertically without any signs of horizontal blow-up. This behavior is extremely slow because it takes at least several scans of the TV camera before the beam disappears.

Discussion

J.P. Blewett (BNL): How much beam is lost due to this effect?

G.K. O'Neill: About 60% to 70% of the beam is lost.

E.D. Courant (BNL): If one compares the beam cross section and stacked current, the current densities used at MURA and Stanford are about the same when the instability occurs.

M.Q. Barton (BNL): What is the frequency spread?

G.K. O'Neill: About 0.5 to 0.3%.

L.W. Jones (Michigan): It might be noted that the ν values are quite different at MURA and at Stanford.

F.E. Mills (MURA): There is some other evidence which is quite interesting, namely that of the effect of the presence of ions on the oscillation frequencies. Nonlinear effects were measured due to the ions. They may be a reason for stabilization by allowing the beam to grow incoherently.

G.K. O'Neill: The difficulty connected with this is that the amount of nonlinearity introduced by the ions is extremely small. Frequency spreads of 3 kc/s in 25 kc/s are encountered as compared with the normal spread of 0.5 kc/s.

E.C. Fowler (Duke): Is it certain that these effects seen at MURA and at Stanford are actually related? What about structure of the ring and geometries? Are these similar?

G.K. O'Neill: With regard to current densities used, it seems that the instability effect is observed at a similar current density at MURA and at Stanford. Converting the MURA parameters to apply to our case would lead to about 5 ma stacked current.

L.W. Jones: It might be worthwhile to compare between Stanford and MURA the geometries and parameters, such as the permeability of wall, etc. Actually, it might be highly fortuitous that the instabilities were observed at similar current densities. There might be different mechanisms responsible.

J.P. Blewett: It might be interesting here to mention a somewhat related effect; namely, by passage of a bunch of particles through a pickup electrode, signals are induced on the pickup electrodes at the cost of energy in the beam. Analyzing the sequence of events, one finds that the front end of the bunch will be accelerated somewhat and the rear end will be decelerated due to the induced fields in the gaps between grounded section and pickup electrode. If this occurs in a synchrotron above phase transition, this would constitute a bunching mechanism.

L.W. Jones: This effect would be complicated by the fact that the beam velocity through the pickup electrodes is larger than the velocity of propagation of the signal along the electrode.

J.P. Blewett: We recognize that there are some difficulties of this sort and this effect has not been studied to any extent. However, even allowing for the propagation effects, it still seems that this bunching mechanism is possible. In any case, in the AGS it was noticed that after going into a "flattop", turning off the rf and detuning the cavities, the beam sometimes rebunched very slowly after the usual debunching. Obviously, we should look for this effect below phase transition for comparison. We have not done so yet.