PANEL DISCUSSIONS ON LIMITATIONS ON BEAM QUALITY AND INTENSITY IN LINACS, SYNCHROTRONS AND STORAGE RINGS, PART I.

Panel Moderator : F.E. Mills

A. Experimental Observations

Panel Members : E. Courant, H. Grunder, P. Lapostolle, R. Little, E. Myae, T. Nishikawa, W. Schnell, A. Skrinsky, H. Zyngier.

B. Methods for Further Observations and Cures

Panel Members : E. Courant, W. Hardt, E. Keil, E. Myae, V.K. Neil, J.M. Paterson, A. Sessler, A. Skrinsky, S. Tazzari, L.C. Teng.

Summary of Discussion

1. Introduction

Although the two panels, with partially differing membership, did make an effort to distinguish between two aspects of these problems :

(a) experimental observations,

(b) methods for further observations and cures,

there was a considerable tendency for these aspects to be discussed together during both panels. Therefore a single summary is presented, covering various topics which arose during the course of both discussions.
Further details on these subjects are given in the papers which follow this summary.

In general, the essentials of all instabilities are now fairly well understood but this is not the case for their detailed mechanism and the causes for their occurrence. Despite this, rather satisfactory cures have been found for most instabilities but, again, without knowing exactly why or how they work. This is not too surprising, since the parameters responsible for the instabilities are usually not so accessible to adjustment and control as are those of the cures.

2. Nonlinear Resonances

Nonlinear resonance effects due to external fields are quite well understood and adequate measures to avoid them have become common practice. In situations of low Q-spread, tuning can be arranged to avoid higher order resonances or the stop bands may be compensated by introducing higher order fields of appropriate azimuthal distribution. In situations of high Q-spread (at injection and at high intensities) only the latter method is feasible.

Nonlinear resonance effects due to space-charge forces are less well understood but adequate cures have been found for practically all accelerators and storage rings.

Much effort has been devoted to calculations of the evolution of particle distributions.

3. Transverse Instabilities

Whereas transverse instabilities of unbunched beams have been sufficiently well explained, this is not yet true for bunched beams. In particular, for the "head-tail" effect more and clearer experimental data are required. Again the cures, sextupole and octupole fields, are found to be effective, without knowing clearly their exact action.

An interesting method of creating strong octupole fields in a proton accelerator by means of an intense coaxial electron beam was discussed but the opinions on its practicability were rather divergent.

However, multipoles have the detrimental effect of widening nonlinear stop bands and, in the long run, active feedback systems (already used or envisaged for several machines)may be the answer to this problem.

4. Longitudinal Instabilities

Longitudinal instabilities of many different types have been observed in several accelerators and storage rings. The splitting of the synchrotron frequencies has been more or less abandoned as a cure and, at present, one tends to treat these instabilities by Landau-damping (2nd harmonic of rf, or voltage reduction) or by active feedback.

5. Transition Problems

The mechanism causing the observed blow-up at transition is not fully understood; probably it is a mixture of several nonlinear effects. Therefore, calculations are difficult and refined numerical studies are necessary. The negative-mass instability may be quite important.

Some cures have been tried experimentally and work at present intensities. However, at higher intensities, their application may prove to be delicate. It would be highly desirable to find a solution in the form of a passive compensation, but this seems not to be for tomorrow.

6. Measurements

It is encouraging to notice that those who have been concerned with theoretical calculations are now taking an interest in measurement techniques. As a result methods now exist to measure environment properties as seen from the beam, by analysing the beam's response to an external and controlled excitation.

7. Vacuum

With increasing intensities, the vacuum becomes a more and more important parameter, not only in storage rings but also in accelerators. The action of localized pressure bumps, neutralization, oscillations of electrons or ions in the beam's field and degassing of the walls under this impact of ions, all offer a rich field for interesting calculations and experimentation.