DISCUSSION OF BEAM DYNAMICS IN THE PRESENCE OF IONS AND ELECTRONS

A. M. Sessler: It is interesting that the same analysis works on the Bevatron quite well. In this case, however, it was necessary to include the forces between the electrons as well as the forces between the electrons and protons. If this additional force were not included, then the theory predicted stability even for 100% neutralization, but when it was included instability was predicted for 25% neutralization. The observed instability therefore was some confirmation of the theory.

For the PS exactly the same theory was applied by the same authors and the theory predicted that the PS would be unstable and no such instability has been observed, even though they have tried to excite one by tickling the beam.

F. Amman: The same analysis applies also to e^+e^- beams, and you should have instability when the δQ drives you into the half-integer resonance and should observe oscillations. Now, if I am not wrong, at ACO they have observed coherent instabilities of the beams at the beam-beam limit, where the δQ takes the Q value to the integer.

J. Le Duff (Orsay): We observe coherent oscillations at the beam-beam limit, but also below the beam-beam limit and the oscillations are always very, very small. So I think that we cannot speak about instability.

Sessler: You think that it is stable or self-limiting at a small amplitude in the case of an electron beam with ions?

Le Duff: Yes, I think so.

Amman: Clearly the analysis is only the linear analysis.

B. Zotter: The question is: Is it self-limiting inside the vacuum chamber, or not? In the ISR we think that the electron amplitudes are much larger than the proton amplitudes, and that we lose many electrons suddenly. We saw bursts of background in the intersections simultaneous with the appearance of lines on the spectrum analyzer, at least before we introduced more clearing.

Sessler: When one applies the theory to the Bevatron the electron amplitudes are very much larger than the proton amplitudes, and so one may imagine the phenomena that you describe. That is, the proton beam wiggles a little and the electrons wiggle a lot, and in the eigenmode the electrons wipe off, then new electrons are made, the proton beam wiggles a little more and these electrons wipe off. So, in the course of time the proton beam builds up oscillations.

When one applies the theory to the PS, one finds that the eigenmode is such that the ratio of the electron and proton amplitudes is much closer to unity, so maybe this explains why one does not see the instability in that case. But I say "maybe" because there has been no experimental confirmation one way or the other, except that the instability cannot be seen.

This is all terribly relevant to electron-ring accelerators, where ion-electron instability is an important restriction on what can be done with an electron-ring accelerator. Of course, there you have lots of electrons and ions, and if it were self-stabilizing at very small amplitudes it would be completely different from assuming (as people have) that if there is linear instability the accelerator will not work. It would be very interesting to get information from electron storage rings that might shed some light on ERA.

Zotter: Most electron storage rings are bunched and you lose your ions out of the bunches very rapidly and, except for the ERA, it is hard to achieve the neutralization required.

P. L. Morton: I don't know if that is completely true because there seem to be indications at ACO and ADONE that they have ions present.

Amman: Yes, we certainly have ions in the electron beam. Proof can be the beam behavior for transverse instabilities. The electron beam is not unstable while the positron beam is unstable. The ions produce Landau damping for the electrons.

We have other proof that there are ions present in the electron beam.

Morton: I would like to ask another question, after hearing about how ions are accelerated to the wall of the vacuum chamber and produce avalanches of background gas or pressure bumps. Why don't we see this in SPEAR? The peak currents are as high as the ISR, so ions are accelerated to the wall with velocities similar to those in the ISR, and we certainly start with a much higher base pressure.

Zotter: You have an aluminum vacuum chamber and this may be the difference.

Amman: There is a couple of orders of magnitude of difference between the average current in SPEAR and the average current in the ISR.

Morton: I would think that the accelerating fields for the ions would depend on the peak current.

R. Miller (SLAC): It is true that the accelerating field is just as high, but the bunch length is much shorter, so the accelerating time is very short.

Morton: So you are saying that it is the average current that is important--not the peak current?

Zotter: No. In a potential well it is the peak current that is important, but you have a different vacuum wall.