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Trip Report:
Sixth Advanced ICFA Beam Dynamics Workshop
"Synchro-Betatron Resonances"

Funchal, Portugal, October 1993

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SUMMARY

Foreign Travel Trip Report

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Dates of Trip: October 23 - 31, 1993

Destination: Funchal, Portugal.

Purpose of Trip: To attend the Sixth Advanced ICFA Beam Dynamic Workshop, topic: "Synchro-Betatron Resonances".

Abstract:

This workshop fell far short of the high standard of excellence achieved by the other Advanced Beam Dynamics Workshops organized by the International Committee for Future Accelerators. In fact, the workshop was a strong contender for the worst organized workshop in my experience. Even discounting the abominable local organization, there were 2 major flaws. First, the 27 attendees met jointly in all sessions, and not in small groups. This strongly inhibited the open and frank exchange of information and viewpoints that is the hallmark of successful workshops. Second, the assumed scope of "Synchro-Betatron Resonances" was artificially and narrowly defined by the relatively small set of people who ended up intellectually dominating the workshop. Most of these people came from CERN, so it is not surprising that the incipient problems of the LEP 200 upgrade were heavily stressed.

Those participants, like myself, who came from hadron laboratories were therefore rather alienated from such discussions of Synchro-Betatron Resonances in RF Dominated Large Electron Storage Rings. Most of these "hadronic participants" came from North America. Although we met with some success in our attempts to broaden the discussions, the lack of small working groups prevented an effective exchange concerning the new and exciting hadron accelerator developments.

CESR sees $Q_x - Q_y + n/2\ Q_s$ synchro-betatron sidebands of the diagonal - spaced by $1/2\ Q_s$ - driven by beam-bean interactions. This is the first reported observation of these long predicted resonances, between the much stronger resonances $Q_x - Q_y + n\ Q_s$ that are seen even with single beams. Two skew sextupoles (two pairs?) on either side of the collision region have been used to essential completely suppress the $3\ Q_y + Q_s$ and $Q_x - Q_y + Q_s$ single beam resonances. This may be very significant, but the representation from CESR was not adequate to provide plausible explanations. Cornell also reported on the strong dependence of the $2\ Q_x - 2\ Q_s$ and $5\ Q_x + Q_s$ resonances on the vertical chromaticity. The loss rate was observed to change by as much as 3 orders of magnitude for moderate chromaticity changes. To quote "some - the most dangerous - resonances are affected by chromaticity". Maximum luminosity ar CESR is $2.5 \times 10^{32}\ cm^{-2}\ sec^{-1}$. Future upgrade plans call for 3 trains of 9 bunches apiece, possibly with a crossing angle of 2.5 milliradians.

Hirata reported on the implementation of a Lorentz boost in his beam-beam simulation code to handle "large" crossing angles - with significant technical complications. It was not clear to the audience in general whether or not this was really necessary to correctly handle the deviation of cos(crossing angle) from one, since the square of the crossing angle is certainly much less than one, and since many test particles anyway have comparable collision angles, even with zero bunch crossing angle.

The relative importance of closed orbit and dispersion errors in RF cavities was a topic that arose repeatedly. Neither effect is important in smaller electron storage rings, and there was some conflict of opinion about the differing experiences of LEP and PETRA. No conclusion was reached, except that it is usually easy to avoid the $Q_x - n\ Q_s$ and $Q_y - n\ Q_s$ resonances that are primarily driven.

The topic of controlled experiments invoking external modulation was first introduced by SY Lee in his discussion of a subset of the CE22 and CE48 experiments that have been (and will be) performed at the University of Indiana proton cooling ring. Later on I discussed the controlled Fermilab beam dynamics experiments E778 and E850. One presentation extended the recently published E778 tune modulation results to 2-D, and preliminarily addressed the apparent controversy of different perspectives on the tune modulation "phase diagram".. A second presentation focused on practical and theoretical aspects of one option to make use of synchrobetatron resonances in E850 to slowly and parasitically extract protons from the Tevatron using crystal channeling. No other experimental observations reported at the workshop came close to the quality and rigor of the results from these controlled experiments.

LEP news. The recent hardware and software upgrade of the control system has been successfully completed. It is now possible to answer the need to correct the closed orbit many times an hour (see below). There is no truth to the rumor that is widespread in the US that the civil construction problems with the underground stream in the north east are close to unmanageable. In fact the problems have subsided (no pun intended), as the stream has apparently found another path. In one case the water pressure behind an alcove decreased from 12 bars to 2 bars in a 24 hour period. Further strong support for extensive beam dynamics measurements in the RHIC sextant test came from the observation that, if the nickel plating problem in the LEP vacuum chamber had not been inferred from beam dynamics measurements in their octant test, it would have been impossible to store beam in LEP. The synchrotron frequency in LEP, f_s, must avoid the very strong 600 Hz line (12 times the fundamental) during the energy ramp, in order to avoid losing beam - presumably due to longitudinal phase oscillations. Pretzel orbits will be dropped in the future, possibly with the adoption of bunch trains, as in CESR.

LEP closed orbit. "The most important constraint on LEP operation is the constant wandering of the closed orbit." Control system records show that a new setting of the dipole correctors is typically calculated about 200 times a day, and a new setting is loaded about 100 times a day - every 10 minutes or so during beam storage! The exact cause for the fluidity of this motion is not well understood. The final IR quadrupoles on cantilevers inside the experiments are one source. They have been placed on motorized jacks, and their (mostly thermal) contributions are understood. Long hydrostatic levels, such as geologists use, have been placed around the experiments, to assure vertical alignment and avoid line of sight problems. However, the orbit motion is partly systematic and partly random. Thermal effects varying as a function of the time of day, and of the time into the fill (magnets warming up) have been identified. Random sources such as the construction excavations of RF klystron galleries are mentioned, but not very enthusiastically. Plans are reported to implement a slow feedback loop on the closed orbit in software - continuously measuring and correcting the closed orbits.

Albert Hoffman reported the simultaneous and rapid measurement of the dispersion function at all beam position monitors by the excitation of longitudinal dipole oscillations, using intentional RF phase modulation. This requires all of the beam position monitors to have turn-by-turn capabilities, over at least one synchrotron period. The method is similar to the one proposed for pilot bunch testing in RHIC. The method could easily be extended to measure chromaticities in real time - up the energy ramp, for example. He also reported measuring displacements between BPM and quad centers as large as 1 mm , by modulating the strength of individually controllable quadrupoles at about 10 Hz.

Yuri Orlov reported at great length on "The Logical Origins of Quantum Mechanics". In the treatment about to be published he draws a strong analogy between the mathematical formalism of quantum mechanics and that of logic. In doing so he significantly extends the mathematical treatment of Logic beyond the results of Classical Logic. Although this is (presumably) quite profound, it is not clear whether Logic contains the Origin of Quantum Mechanics, as he claims, or whether the probabilistic ideas of quantum states are merely transportable to Logic. He developed these ideas in isolation, in prison camp in Siberia.

Tong Chen reported results from the fast beam beam simulation that he and John Irwin and Bob Siemann have been developing, and that avoids tracking the boring electrons near the core of the beam in favor of the more important large amplitude electrons. When an electron falls back in through an ellipsoidal surface in 3-D action space, it is randomly placed at another part of the surface, according to a density distribution of outgoing paths obtained during a previous phase of the program. It is possible to leap frog out, layer by layer, to very large amplitudes without losing accuracy compared to brute force tracking. This saves orders of magnitude of cpu time when four such layers are used. There was uncertainty as to the the true original source of this idea (Novosibirsk?),which has been around for several years without a complete implementation.

Present limitations of HERA performance come from a longitudinal instability in DESY III due to broadband impedance. A feedback system is being built. The transverse and longitudinal emittances of the protons often increase during the energy ramp in the HERA-p ring, despite the use of net chromaticities as large as 20 . Chromaticity is crudely measured through the ramp by using two successive ramps with different $\Delta p/p$ values. There are occasional sudden decreases in the electron current lifetime in HERA-e, for example dropping from 6 or 8 hours to 10 or 30 minutes. If the beam is dumped and immediately reinjected, the lifetime returns to 6 or 8 hours. This could be heavy ions or dust, but the vacuum engineers don't think so. However, the replacement of a single vacuum chamber did raise the critical current for such behavior from 3 mA to about 20 mA. Similar effects have been seen in DORIS III. Investigations continue, as does a program of replacing vacuum chambers.

KEK accelerator theory news. A quadrupole was recently found during a resurveying iteration that was misplaced by 5 mm! There are plans being discussed for the construction of a 150 meter circumference electron damping ring, a critical component for a future linear collider. The monolithic accelerator design code SAD is being rewritten in C++, and "perhaps one day we will use it in a B-factory control system". Perhaps. It includes capabilities for Differential Algebra, beam-beam

simulation, polarization, and final focus design, but its input format appears to be in a relatively unfinished state, and is not compatible with other accelerator codes.

SLAC news. The SLC has produced 50,000 Z's in 1993, so far, with a polarization of 60%. There was an unresolved comment from the LEP representatives about an apparent controversy concerning the three SLC polarimeters - they claim it is unclear whether the actual polarization was 60% or 75%, an uncomfortably large difference. There is a "sawtooth" current limit in the SLC damping rings, in which the σ_p/p of the beam regularly blows up and exponentially decays, without beam loss, above a certain current. A longitudinal multibunch instability in SPEAR has been cured by decreasing the design dispersion in the RF cavities, presumably removing a synchro-betatron mechanism.