ORBIT CALCULATIONS FOR THE IPCR SSC

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In advance of construction of a SSC at IPCR several computer codes are developed, and orbit dynamics has been investigated. An outline of the orbit calculations for the SSC is presented.

A 1/4 scale model magnet, which is composed of two 50° magnets, was constructed, and magnetic field distributions at the median plane were measured at different field strength.[1] Since the model magnet, however, is not exactly of a 1/4 scale in the radial direction, the data have to be not only scaled up but also exapnded to that of the full scale magnet.

Equilibrium orbits are determined for various particles using the magnetic field distribution at the corresponding field strength. All of ray tracing calculations are performed within one sector from a valley centerline to another, because of the four-fold symmetry of magnet structure.

The linear characteristics of the magnet system are calculated on betatron frequencies, eigen-ellipses, phase plots and so on. An isochronous field is produced numerically in such a way that a base field is increased gradually in the radial direction to make the correction for a revolution time. However the relative distribution in the azimuthal direction is not changed for convenience because of lack of the informations on the field shape of trimming coils. Betatron frequencies are shown in Fig. 1 for typical four examples.

In the calculation for accelerated orbits, informations have to be prepared on the isochronous fields, geometrical shape of dee structure and acclerating voltage. Since a linear accelerator is used as one of injectors, matching conditions between the linac and the SSC should be satisfied. The isochronous field has been obtained in the previous stage. The field, however, can be corrected to achieve better beam acceleration. For dee structure a two-dee system with delta-shape cavities is designed.[2] The accelerating gap is taken to be constant (10 cm). Dee angle is basically 20° because of a fundamental harmonic number h = 9. This angle can be changed for more effective acceleration. Radial- and frequency- dependence of the accelerating voltage are introduced based on relative radial distribution measured at various frequencies using a 1/2 scale model cavity.

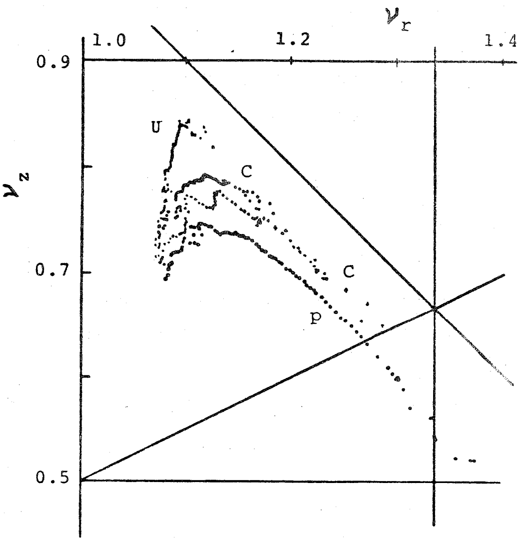


Fig. 1 Betatron frequencies for typical four nuclei. Injection and extraction radii are taken to be 82.5 and 375.0 cm, respectively. Symbols x, ●, + and o represent 0.84 MeV/A $U^{40+}$, 4.0 MeV/A $C^{6+}$, 7.0 MeV/A $C^{6+}$ and 10.0 MeV $P^{+}$, respectively.

The minimum voltage along the accelerating gap is taken to be 250 kV.

Properties of an accelerated reference orbit and linear characteristics of associated orbits are investigated. Injection conditions of an accelerated reference orbit are determined to minimize the coherent radial oscillation amplitude. It corresponds to minimization of the phase slip of oscillation of a rotating particle against radio-frequency. Fig. 2 shows phase slip of 4 MeV/A $^{12}C^{6+}$ for the first several decade turns. The quality of an accelerated beam is evaluated by ray tracing calculations in six-dimensional phase space. As an example, transformation of phase space pattern projected on the (r,r') plane is shown in Fig. 3 on the above beam up to several hundred MeV.

When a cyclotron is used as one of injectors, extensive studies have to be performed.

References


1) N. Kumagai et al: IPCR Cycl. Progr. Rep. 12, 10(1978)
2) H. Nakajima et al: ibid., p 16


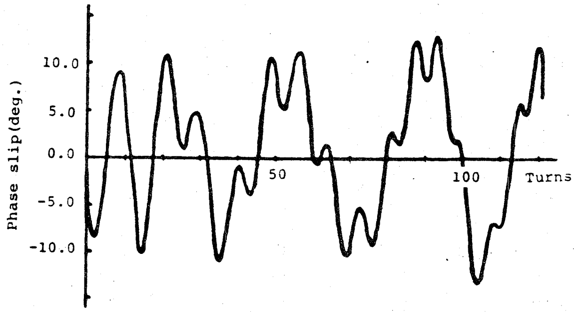


Fig. 2 Phase slip of a particle against the radio-frequency. A 4 MeV/A $C^{6+}$ particle is injected onto its first equiliblium orbit. Initial injection conditions are not optimized at all.

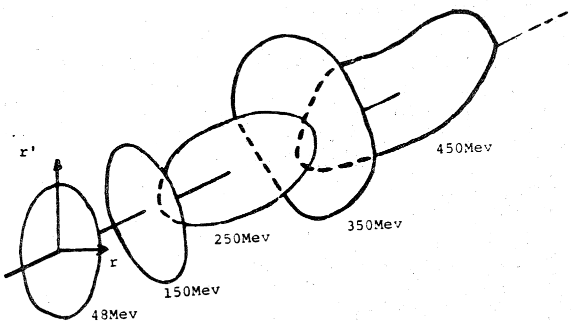


Fig. 3 Transformation of a radial phase area with an initial emittance of 2.5π mm mrad. A 4 MeV/A $C^{6+}$ particle is injected onto its first equiliblium orbit without any optimizations of acceleration conditions.