ORBIT ANALYSIS OF A RING CYCLOTRON (I)

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Abstract

Computer programs for the orbit analysis of a ring cyclotron have been developed and being used for the design study of the RCNP ring cyclotrons. The iron fields used for the study are the measured field of the 1/3.5 scale model magnet and the artificial fields calculated with computer code FIGER. The betatron frequencies, ν_R and ν_Z, eigen ellipses, phase plot and the stability limit are studied for various types of sectors.

Computer programs for the orbit analysis

Computer programs developed for the design study of the RCNP AVF cyclotron[1] was revised for the study of the ring cyclotron. The first trial isochronous fields are calculated with conventional method[2] based on the lengths of the equilibrium orbits. However, the lengths of the orbits in injection and extraction region must be extrapolated from the intermediate region. These fields are isochronized better than 10^{-5} after 5 iterations. The isochronous fields for various magnets are used to study the orbit properties of the beams with and without acceleration. The orbit properties of the accelerated beams are discussed on the separated report[3]. The results of the calculation can be printed out graphically with the numerical tables by using a laser printer in RCNP computer center.

Results

The calculated betatron frequencies, ν_R, ν_Z, of protons for the 32° straight sector and the spiral sector are shown in Fig. 1. At extraction radius 370 cm, protons can be accelerated up to 250 MeV and 290 MeV with the straight sector and the spiral sector respectively. The proton beams are accelerated through $\nu_R = 4/3$ resonance in the both cases. The phase plots across the $\nu_R = 4/3$ resonance for the spiral sector magnet are shown in Fig. 2. Fig. 3 shows the eigen ellipses and the azimuthal dependence of α, β and γ functions near injection radius and extraction radius.

References

1) T. Yamazaki, K. Hosono, M. Kondo, S. Kakigi and
    K. Fukunaga, RCNP Report KBJ-T-14 (1969).
2) A.A. Garren, Nucl. Instr. & Meth. 18 and 19 (1962) 309.
3) Y. Kadota et al., Orbit Analysis of a Ring Cyclotron
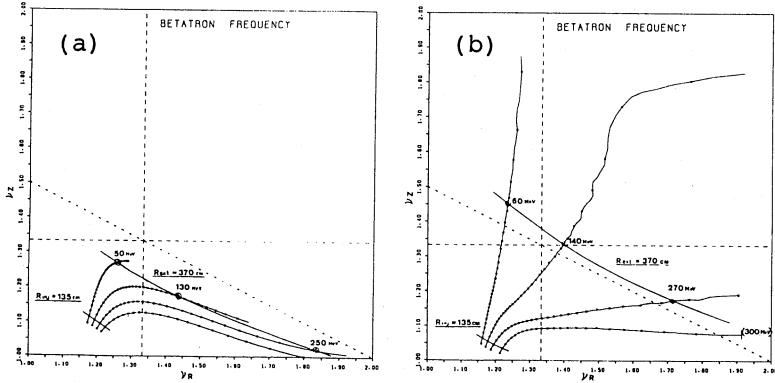   (II), in these proceedings.

Fig. 1. Betatron frequencies for various operation modes for proton are shown injection radius 135 cm to extraction radius 370 cm. (a):four 32° radial straight sectors. (b):four spiral sectors.
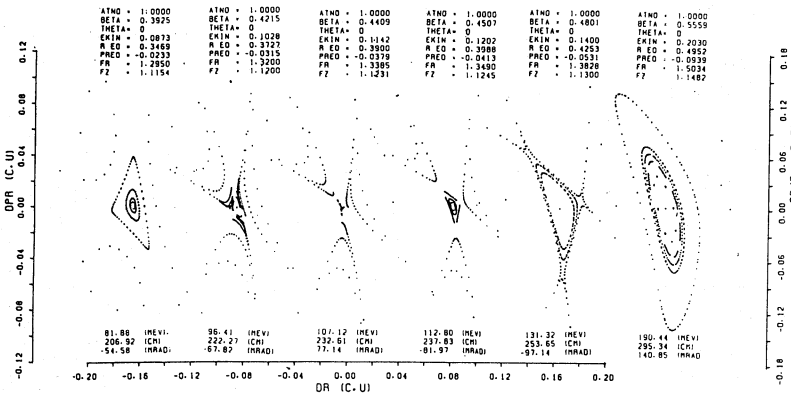

Fig. 2. Phase plots of the proton beams accelerated up to 270 MeV in the spiral magnet. The 3rd phase plot from left shows $\nu_R = 4/3$ resonance.
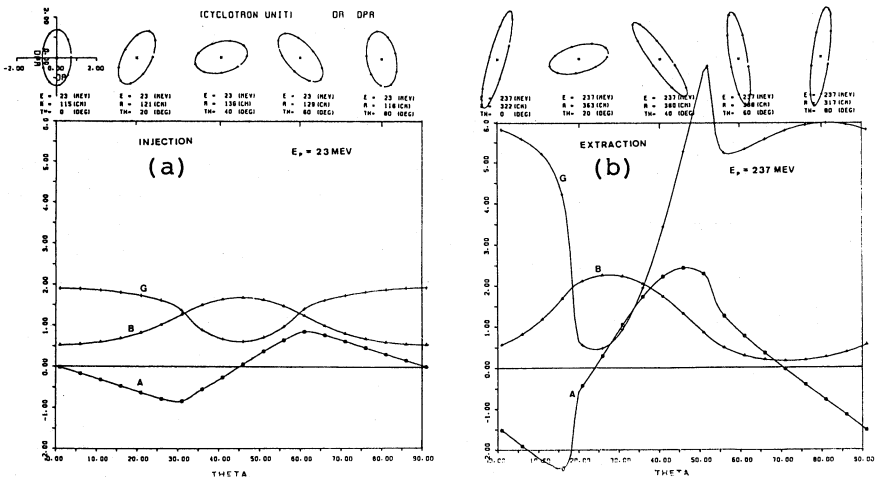

Fig. 3. Azimuthal dependence of the eigen ellipses are shown on the top. Alpha (A), beta (B) and gamma (G) functions are also shown for the spiral magnet. (a):near injection radius. (b):near extraction radius.