JSR UNDULATOR EXPERIMENT

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ABSTRACT

JSR has an 1.5m long straight section for a insertion device. An undulator was installed in this straight section in July, `91. The first observation of spontaneous radiation from this undulator was performed in August. The wavelength change due to K-parameter change was measured at the beam energy of 138.9MeV and 174.6MeV, and also measured was the tune shift due to the undulator insertion. These experimental results are in good agreements with calculations.

INTRODUCTION

JSR is an electron storage ring which has the Chasman-Green lattice with a superperiodicity of three. There are long straight sections of ~1.5m even in the small ring (with circumference of 20.546m). These straight sections are shared by the RF cavity, the injection magnet and the insertion device. An injection beam energy of JSR is 130~150MeV. The stable beam storage is possible from lower than injection beam energy to 300MeV. Principal parameters of JSR are given in Table 1. Fig.1 shows the betatron and the dispersion functions.

The description of design, construction and performance of components such as magnets and RF cavity are given in the previous papers[1)2)].

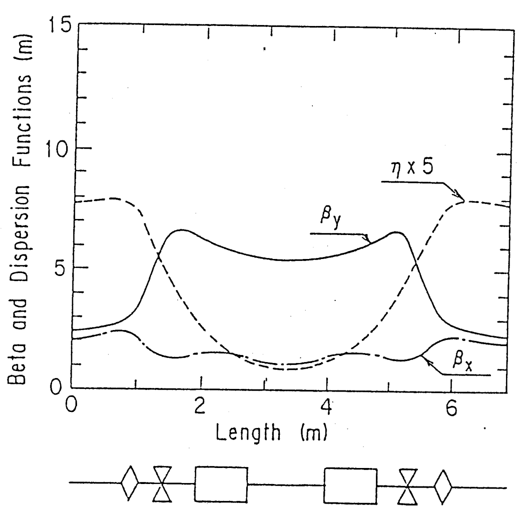

Fig.1 Betatron and dispersion functions

JSR UNDULATOR

Fig.2 shows a side view of JSR undulator. This undulator is a permanent magnet planar undulator. Principal parameters of the undulator are given in Table 2. The full length is 1.04m, λ_u is 8cm, the peak field strength are 0.28T for a gap of 45mm (present minimum gap). From field analysis for the undulator, the K-parameter as a function of the magnetic gap was determined and shown in Fig.3.

The undulator was installed in July, `91. A vacuum chamber which was newly manufactured for the undulator was also installed. A base pressure reached at ~3×10^{-10} torr without baking 1 month after the installation. Since the vacuum chamber was not sufficiently aged by synchrotron radiation or undulator radiation, an undesirable pressure rise occured due to photodesorption. All measurements described in this paper were carried out at the beam current of several mA.

Table 1 Principal parameters of JSR.

Injection Beam Energy		135~150MeV
Stored Beam Energy, E_b		100~300MeV
Circumference		20.546m
Bending Radius		0.835m
Tune	ν_x	2.23
	ν_y	0.83
Energy Loss(300MeV)		0.86keV/turn
RF Frequency		116.7MHz
Peak RF Voltage		45kV
Emittance(300MeV)		9.8×10^{-8}mrad

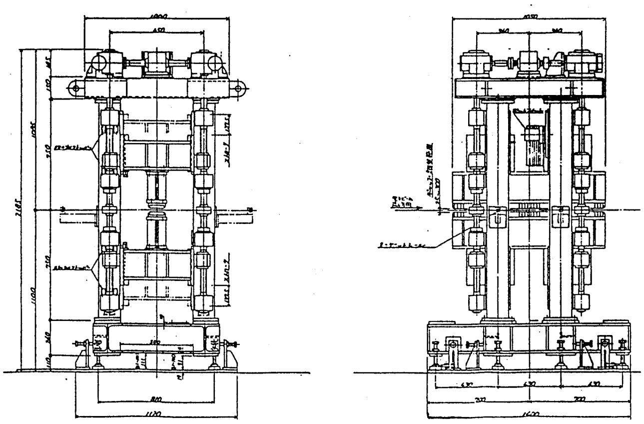

Fig.2 Side view of JSR undulator

Table 2 Principal parameters of JSR Undulator

Magnet material	Nd-Fe-B
Undulator Period, λ_u	8cm
Maximum Peak Field(Gap=45mm)	0.28T
Deflection Parameter Range, K	≤2.06
Number of Period, N	13
Length, L_{ID}	1.04m

TUNE SHIFT

Betatron tune shift of Y ($\Delta\nu_y$) is given as[3)];

$$\Delta\nu_y=\frac{\beta_y L_{ID}}{8\pi\rho^2} \quad (1)$$

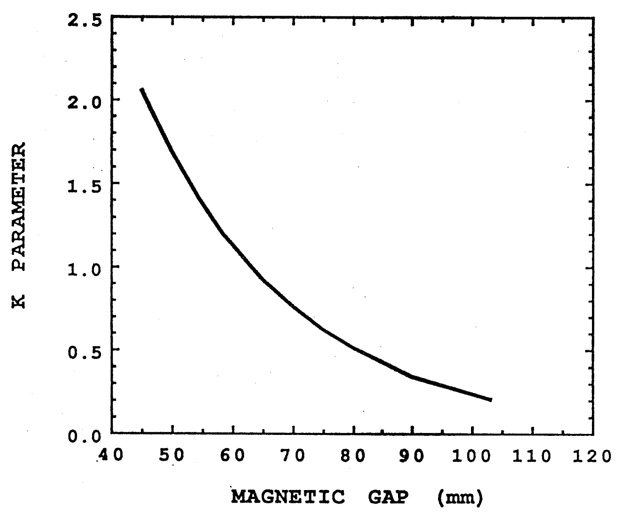

Fig.3 K-parameter as a function of magnetic gap

where β_y is the vertical betatron function at the undulator position and ρ is the minimum bending radius in the undulator. By computation β_y is given as ~2.5m.

The tunes are measured by the RF-KO(Radio Frequency Knock Out electrode) and 4-devided avalanche photodiode (Hamamatsu, S4402) which senses the synchrotron radiation light[4)5)]. The RF-KO gives a periodic perturbation either horizontally or vertically to the beam. The resonance occurs if the frequency of the RF-KO is in accord with the fraction of tune. Then the frequency and its amplitude can be measured by spectrum analyzer.

Fig.4 shows the calculated and measured tune shift. The Beam energy was 129.6MeV. The tune shift is in good agreement with the calculation.

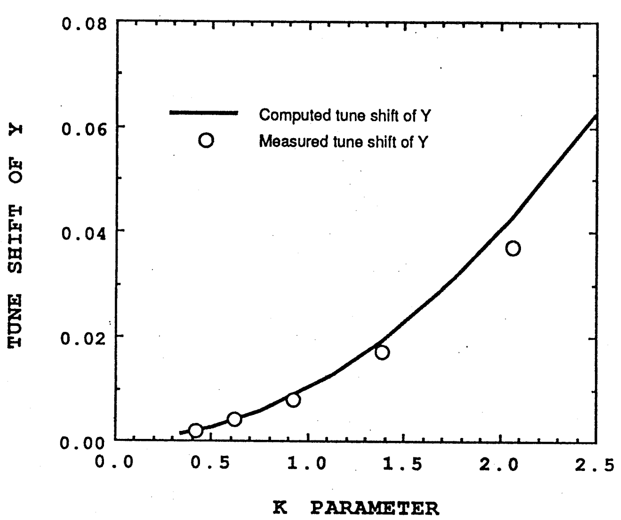

Fig.4 Calculated and measured tune shift

MEASUREMENT OF WAVELENGTH

The wavelength of undulator radiation in visible region was measured and compared with calculation. The wavelength of kth harmonics(λ_k, k:odd) follows[6)];

$$\lambda_k = \frac{\lambda_u\left(1+\frac{K^2}{2}+\gamma^2\theta^2\right)}{2k\gamma^2} \qquad (2)$$

where γ is Lorenz factor and θ is radiation angle. The undulator radiation was extracted from vacuum through the window, reflected by the mirror and injected to the monochromator. The window and the mirror were carefully selected for broad band transmission in visible region. The grating monochromator (Ritsu Oyo Kougaku,MC-20N) has a bandwidth of 400~1000nm. Total length from the undulator to the monochromator was 4.5m. The experiments were carried out with the beam energy (E_b) of 138.9MeV and 174.6MeV.

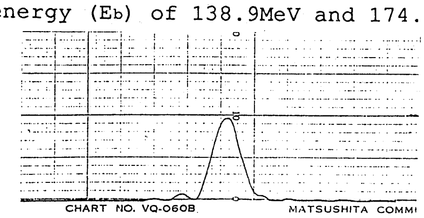

Fig. 5 Typical spectrum of undulator radiation central wavelength λ_1=692nm FWHM $\Delta\lambda_1$=50nm (E_b=138.9MeV, K=0.759, k=1, θ=0)

Fig.5 is a typical spectrum of E_b=138.9MeV, K=0.759, k=1. This shows the central wavelength λ_1=692nm, FWHM $\Delta\lambda_1$=50nm and bandwidth $\Delta\lambda_1/\lambda_1$=0.072. The bandwidth is close to 1/N. Fig.6 shows the wavelength against to the K-parameter for various beam energies. In this figure, lines stand for the calculations and points stand for the measurements. It shows that the measured results are in good agreement with the calculations.

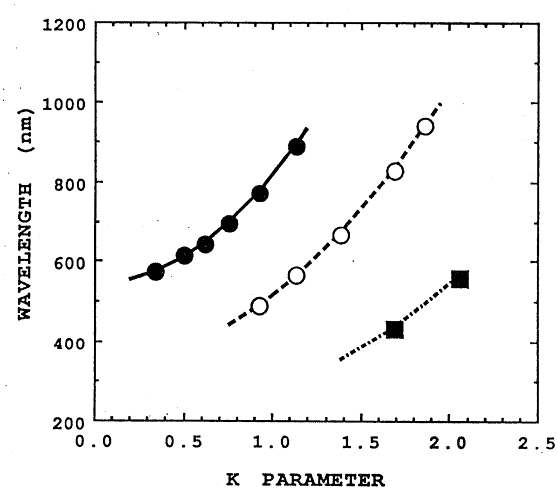

Fig.6 Wavelength against to the K-parameter for various beam energies (θ=0)

1st Harmonics(138.9MeV) (solid line)
3rd Harmonics(138.9MeV) (dotted line)
1st Harmonics(174.6MeV) (dashed line)
1st Harmonics(138.9MeV) (filled circle)
3rd Harmonics(138.9MeV) (filled square)
1st Harmonics(174.6MeV) (open circle)

CONCLUSION

Through the experiments JSR undulator is proved to work correctly. It is necessary to measure the absolute photon density in order to evaluate the beam emittance.

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