OBSERVATION OF THE BEAM IN SOR-RING

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SOR-RING is a 400-MeV electron storage ring dedicated to spectroscopy.[1) The characteristics of the stored beam should be known well to carry out the optical experiments or introduce transvers wigglers having a narrow gap. Table 1 shows the parameters of the beam at the center of the straight section of SOR-RING calculated according to the actual operating point measured by RF-KO method. The horizontal beam size was found to be larger by a factor of about 3 than the vertical one from the photographic measurement, so that the vertical emittance was estimated as 10 % of the horizontal emittance under the assumption that the emittance is approximately propotional to the square of the beam size.

The measurement of the beam sizes, σ_x and σ_z, was made using destructive monitors, DM_x and DM_z, mounted at the center of the straight section. DM_x or DM_z has an arm rotatable in the horizontal or vertical plane, respectively. When the distance $A_{x,z}$ between the center of the cross section of the beam and the arm of DM_x or DM_z is made smaller, the beam lifetime may be shorter. The lifetime due to quantum fluctuation is reduced by making the distance $A_{x,z}$ smaller as tha following equation,

$$\tau_{qx,qz} = \tau_{x,z}\left(\frac{\sigma_{x,z}}{A_{x,z}}\right)^2 \exp\frac{1}{2}\left(\frac{A_{x,z}}{\sigma_{x,z}}\right)^2$$

where $\tau_{x,z}$ is the damping time of the horizontal or vertical direction, respectively. The beam sizes, $\sigma_{x,z}$ can be estimated if $\tau_{qx,qz}$ are known. When the beam current is so low that the Touschek effect maybe negligible, the overall lifetime is given by

$$\tau_{ox,oz} = \left(\tau_{qx,qz}^{-1} + \tau_R^{-1}\right)^{-1}$$

where τ_R is the lifetime determined by the scattering by residual gases. Figure 1 shows the dependence of the overall lifetime τ_{ox} represented by a full line on the distance A_x. The measurement was made at the stored current of 5 mA, the beam energy of 300 MeV and $P \simeq 2 \times 10^{-9}$ Torr. As shown in Fig. 1, τ_{ox} has a constant value T when A_x is large enough. The dotted line represents τ^* given by

$$\tau^* = \left(\tau_{ox}^{-1} - T^{-1}\right)^{-1}$$

If τ_R would be independent of the distance A_x, τ_R might be equal to T, τ^* being equal to τ_{qx}. The chained lines represent quantum lifetimes τ_{qx} calculated with various σ_x values. However, none of them fits in the τ^* curve. Only the line with $\sigma_x = .87$ mm coincides fairly with it at the smaller A_x region. This result shows that τ_R has a strong dependence on the distance A_x. From the analysis of residual gases, CO molecules are predominant in the vacuum system of SOR-RING. In the case of CO molecules, τ_R is given by

$$\tau_R = \left(\tau_{RAx}^{-1} + \tau_{RE}^{-1}\right)^{-1}$$

$$\tau_{RAx} = 1.88 \times 10^{-6} \times \{A_x(\mathrm{mm})\}^2 / P(\mathrm{Torr})$$

where P is the pressure in Torr, τ_{RAx} is the lefetime determined by the angle of the elastic scattering with residual CO molecules and τ_{RE} is the lifetime determined by the energy loss of stored electrons caused in the scattering process. τ_{RE}, which is assumed to be independent of the distance A_x, is nearly equal to T above mentioned. The broken line shows τ_{RAx} at $P \simeq 2 \times 10^{-9}$ Torr. τ^* is found to fit in τ_{RAx} at the large A_x region. It is concluded that τ^* is determined by τ_{qx} and τ_{RAx}, i.e.,

$$\tau^* = \left(\tau_{qx}^{-1} + \tau_{RAx}^{-1}\right)^{-1}$$

These results mean the elastic scattering effect by CO molecules plays an important role in determination of lifetime in addition to the quantum-fluctuation effect. As shown in Fig. 1, τ_{qx} (σ_x = .87 mm) coincides with τ^* at the small A_x region, so that the horizontal beam size σ_x was estimated as .87 mm.

Figure 2 shows the dependence of the overall lifetime τ_{oz} on the distance A_z. As shown in Fig. 2, τ_{RAz} coincides fairly with τ^* at each measured point, so that the overall lifetime is found to be determined mainly by τ_R. The vertical beam size σ_z cannot be estimated directly since τ_{qz} is unknown. In the figure, the overlap is observed between the τ_{qz} (σ_z = .25 mm) line and the τ^* curve in the small A_z region. Thus we could speculate the σ_z is smaller than .25 mm.

References

1) T. Miyahara et al., Particle Accelerators 7 163 (1976)

Table 1 Parameters of the beam at the center of the straight section

ϵ_x	.13π mm mrad	ϵ_z	.013π mm mrad
$\sigma_{x\beta}$	.48 mm	$\sigma_{z\beta}$	.16 mm
$\sigma_{x'\beta}$	.27 mrad	$\sigma_{z'\beta}$	.08 mrad
$\sigma_{x\epsilon}$	.40 mm		
σ_x	.62 mm	σ_z	.16 mm
$\sigma_{x'}$	.27 mrad	$\sigma_{z'}$	.08 mrad

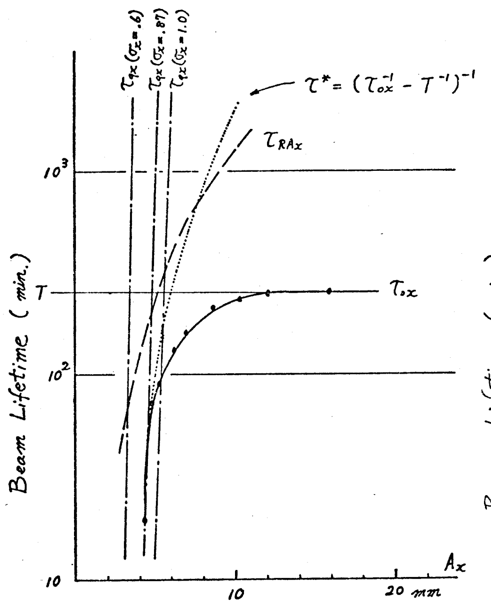

Fig. 1

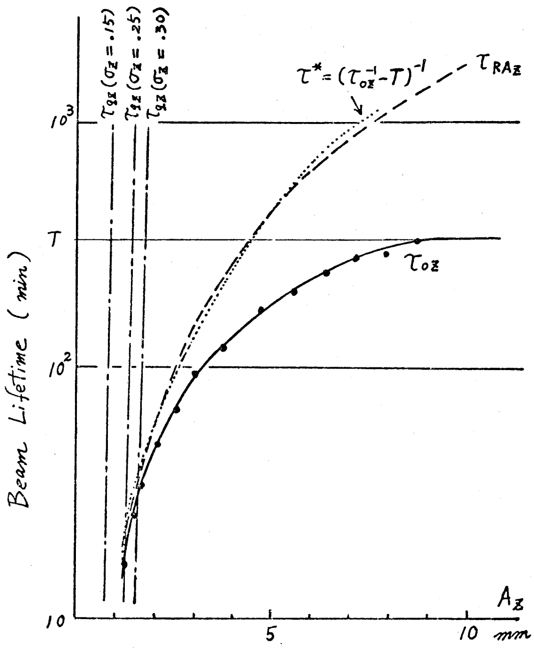

Fig. 2