Simulation of fast ion instability at Super KEKB

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Two-Stream2001

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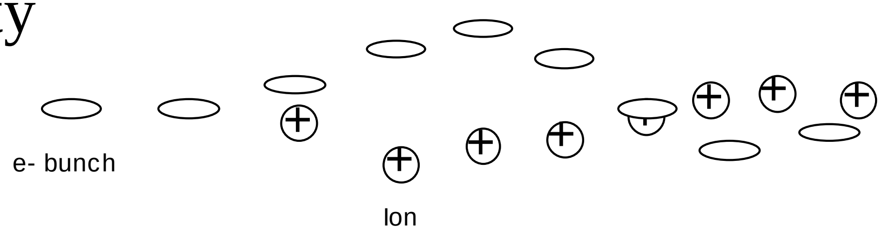
Introduction

beam-ion instability



- The electron beam in a storage ring creates ions by ionizing the residual gas in the vacuum chamber. The interaction of an electron beam with these ions results in transverse oscillations which are driven mutually.
- Super KEKB is upgrade plan of KEKB.
- Since Super KEKB has the high beam current of 10A, the ion-beam instability could be the problem to achieve a high luminosity.

Related parameters

	unit	KEKB	Super KEKB
Energy	GeV	8	3.5
I	A	1.1 (0.75)	10
Ne		1.4e10 (4.0e10)	1.3e11
total vacuum pressure	nTorr	1	2.3
Luminosity	$/cm^2/sec$	1E34	1E35
No. of bunch		∽5000 (1153)	∽5000
damping time of feedback	msec	0.5	0.5

() is present value for KEKB

Estimation by Linear theory

(Keil-Zotter)

	I [A]	$\tilde{\omega}_i\omega_0$	η□□	□□□□□□ □□□□
KEKB	1.1	139	8.1E-7	0.192
Super KEKB	10	299	2E-8	5

ω_i: ion frequency

ω_0: revolution frequency

η□□: neutralization factor ($=N_i^{th}/N_e$)

- Since η.. is extremely low, it is possible to cause an instability by ions which are produced and trapped in only one revolution.
- Super KEKB has the gap to abort the beam. The produced ions can be cleared during this gap passage.

partial filling

• • •

2nsec

gap to abort the beam
(5%～10%)

→Fast ion type instability could be the problems.

Simulation model (K. Ohmi)

- based on weak-strong model
- e- beam: rigid gaussian
- ion: macro particles

(The number of ions increase.)

- 2 -D code (The effect of bunch length and the synchrotron motion are not considered.)
- One collision point in the ring.

Simulation model

eq. of motion

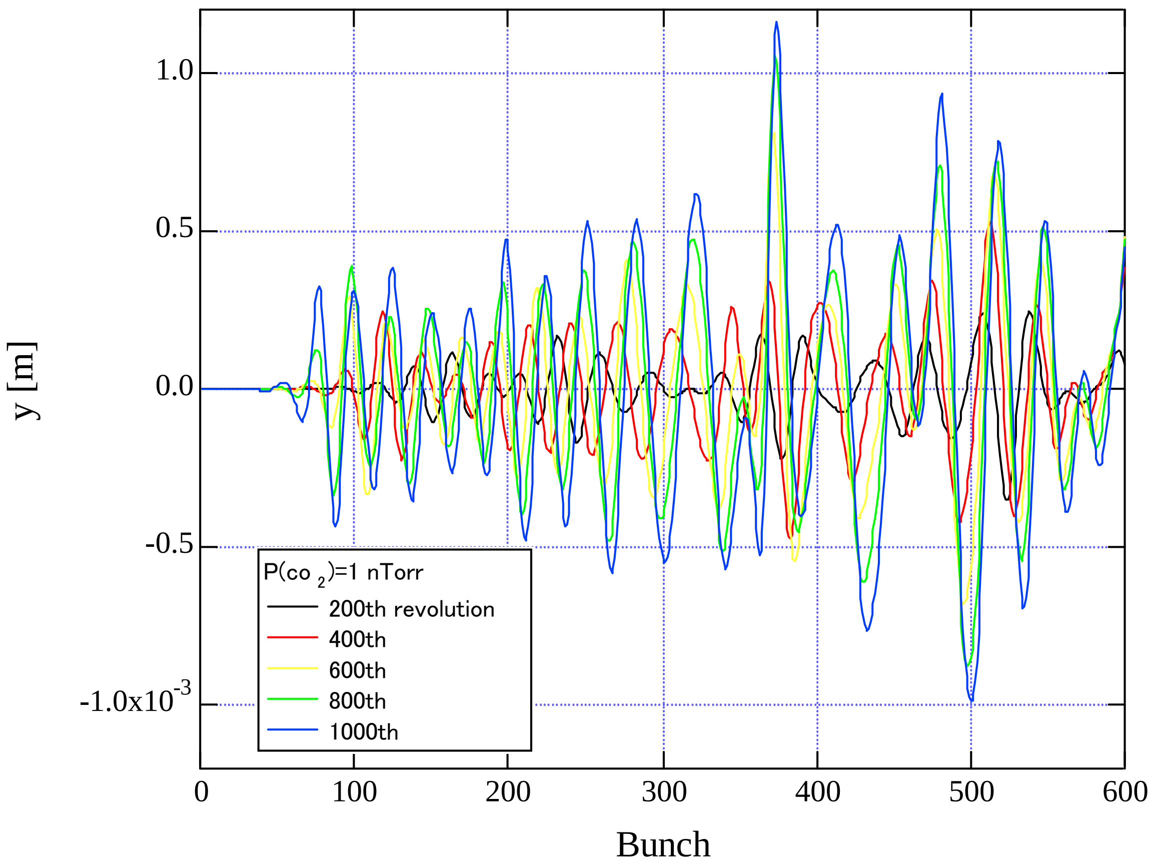
$$\frac{d^2\overline{x}_e}{ds^2} + K(s)\overline{x}_e = \frac{2r_e}{\gamma}\sum_a^{N_{ion}} F(\overline{x}_e - x_{i,j})$$

$$\frac{d^2 x_{i,j}}{dt^2} = \frac{2N_e r_e c^2}{M_i / m_e} F(x_{i,j} - \overline{x}_e)$$

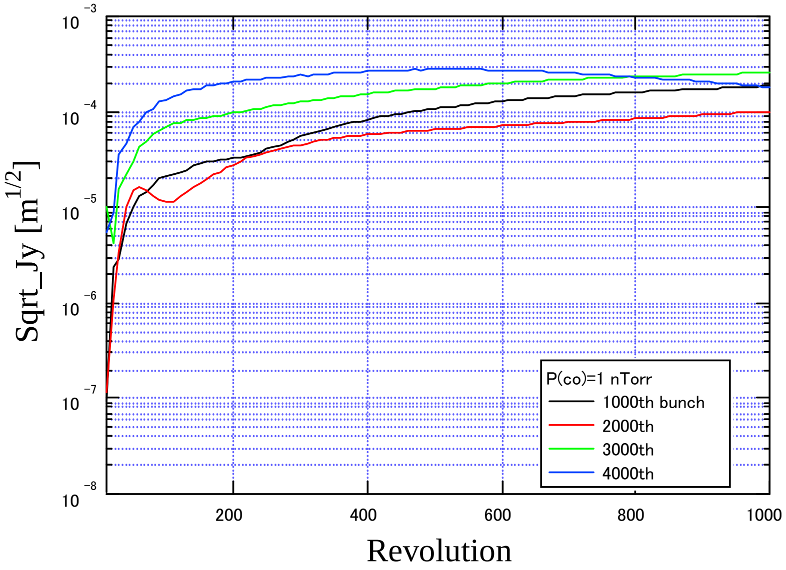
$$F_y(x) + iF_x(x) = \sqrt{\frac{\pi}{2(\sigma_x^2 - \sigma_y^2)}}\left[w\left(\frac{x+iy}{\sqrt{2(\sigma_x^2 - \sigma_y^2)}}\right) - \exp\left(-\frac{x^2}{2\sigma_x^2} - \frac{y^2}{2\sigma_y^2}\right) w\left(\frac{\frac{\sigma_y}{\sigma_x}x + i\frac{\sigma_x}{\sigma_y}y}{\sqrt{2(\sigma_x^2 - \sigma_y^2)}}\right)\right]\delta(s)$$

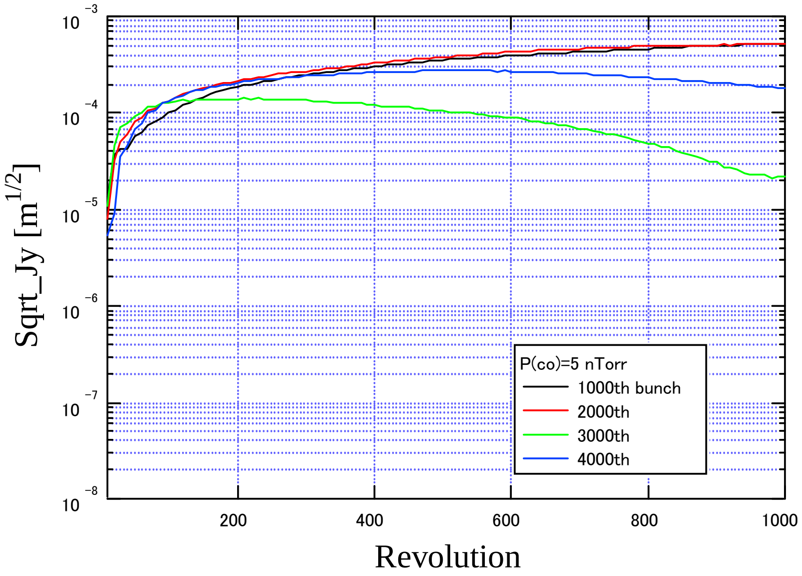
Simulation result

Coupled-bunch pattern due to the fast ion instability



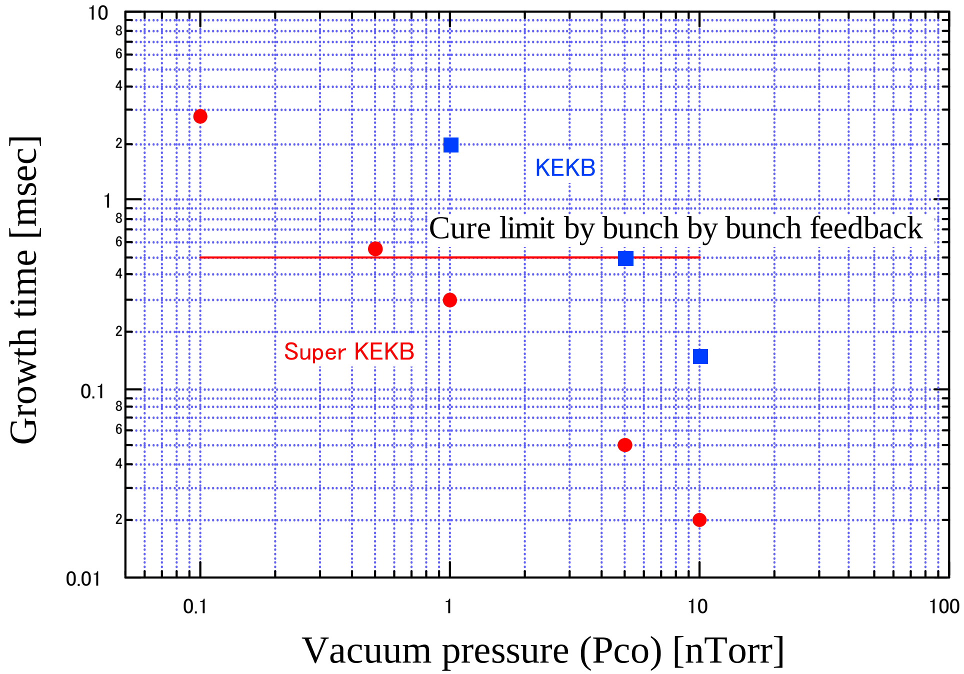
Simulation Result
(Time evolution of the amplitude)





- Growth time is about 30 turns (0.3 msec) and 5 turns (0.05 msec) for 4800 bunch at the Pco= 1 nTorr and 5 nTorr, respectively.

Relation between growth time and vacuum pressure at Super KEKB



Summary

- We have performed a simulation of fast ion instability at Super KEKB.
- The growth times of each bunch in the train were obtained in Super KEKB. The growth time was about 30 turns (0.3 msec) at the Pco=1 nTorr for 4800 bunch train.
- Since the damping rate of the feedback is designed to be 0.5 msec, the vacuum pressure for Super KEKB should be less than Pco=0.5nTorr.