BEAM STRETCHING IN THE JINR PHASOTRON BY PHASE DISPLACEMENT

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Abstract

This is the first time, when phase displacement is used for the beam stretching in a phasotron. The experimental results encourage in continuation of investigations, but just now the beam stretched in this way can be used in experiments.

An accelerated beam in the JINR phasotron |1| has a pulsed time structure - 30÷40 μs pulses of protons are separated with 4 ms time intervals. To improve the beam time structure we use the so called beam stretching by postaccelerating the beam with a C-electrode |2|. The beam postacceleration is provided by the method of synchrocyclotron acceleration, namely: a stopped (accumulated) beam is captured by the C-electrode separatrix and slow accelerated up to the extraction radius.

So, the beam is stretched up to 85% of the modulation period, i.e. up to 3.3 ms (of 4 ms). The time frequency program of the C-electrode rf voltage is shown in fig. 1, and the time dependence of the beam intensity in fig. 2. In this case the beam capture efficiency, i.e. the stretched/unstretched beam intensity ratio is equal to 75%. Increasing the C-electrode rf voltage one could improve the efficiency, but this is difficult because of rf power limitations. Besides, the separatrix surface is proportional to the square root of the C-electrode voltage.

The phase displacement mechanism |3| could be used unstead of usual synchrocyclotron postacceleration |4|. The idea of the phase displacement method is as follows. Let us imagine the stored beam with the uniform particle distribution in the phase interval of 2 (fig.

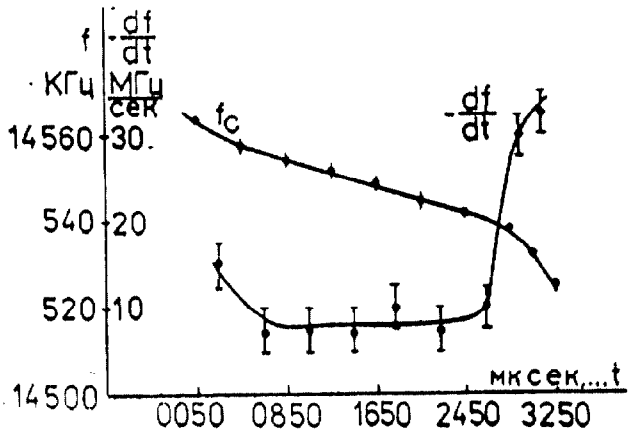

Fig. 1. Time dependence of the frequency (f) and its derivative df/dt at the C-electrode, in the synchrocyclotron postacceleration mode.

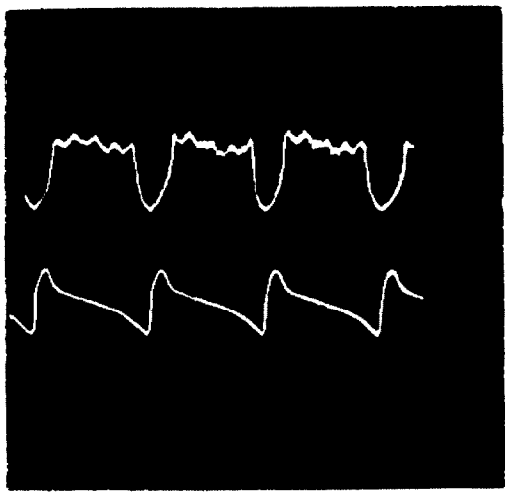

Fig. 2. The stretched beam (top) and the frequency program (bottom) in the synchrocyclotron postacceleration mode.

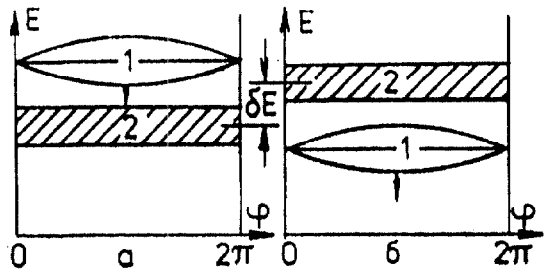

Fig. 3. Illustration of the phase displacement mode. 1 - stability region; 2 - beam on phase surface; E - energy displacement of beam due to passing through separatrix.

3a). Then suppose that the C-electrode voltage frequency is changed so that the synchronous energy moves down. After the separatrix passes through the beam, the mean particle energy should increase (fig. 3b) because the separatrix (rf bucket) push the particles up to the higher energy. This energy displacement will equal $S/2$, where S is the surface inside the separatrix. Computer calculations are necessary to estimate the efficiency of this method. But taking into account the fact that realization of the phase displacement method requires nothing but changing the C-electrode frequency program, it was decided to carry out the experimental investigation.

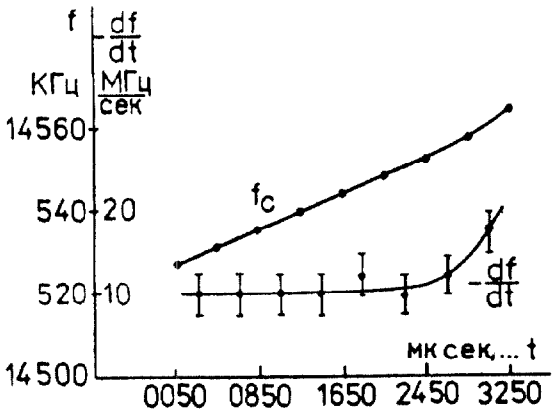

Fig. 4. Time dependence of the frequency (f) and its derivative df/dt at the C-electrode in the phase displacement mode.

Fig. 5. The stretched beam (top) and the frequency program (bottom) in the phase displacement mode.

The frequency program of the first experiment on the beam stretching by the phase displacement is shown in fig. 4, and the stretched beam intensity in fig. 5.

It turned out that the stored beam intensity (2 μA) was not less than the one (1.8 μA) after usual synchrocyclotron postacceleration. In addition, it was found that the beam intensity is not so much sensitive to the voltage amplitude at the C-electrode.

In the near future we are going to carry out a more careful investigation of that beam stretching mode. But ever now the beam stretched in this way can be used in experiments.

References

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