Dynamics of plasma bunches generated and confined in a mirror magnetic trap

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Gyromagnetic autoresonance ensures (GA) the phase stability of the charged particle under the electron cyclotron resonance (ECR) conditions in a magnetic field gradually increasing in time is. With the growth of electron energy to relativistic values, the ECR conditions are violated, which prevents further increase in energy. The increase in the magnetic field leads to the automatic maintenance of resonant conditions and an increase in the average energy of the electron according to the law of the magnetic field growht. During the GA process, plasma bunch with a high-energy electronic component are generated. The parameters of the bunch depend on the amplitude and rate of increase of the magnetic field, the electric field strength of the electromagnetic pump and the stationary magnetic field of the mirror trap.

The experimental setup [1] is an axisymmetric system in which the high-frequency cavity (discharge chamber) and pulsed magnetic field coils are placed in the interpolar space of an electromagnet creating a stationary magnetic field of a mirror magnetic trap. The unit operates in pulse-periodic mode. After the microwave pulse is applied, a high-frequency breakdown occurs in the chamber and the initial stage of the ECR starts. At some point, the pulse current generator is turned on, the total magnetic field begins to increase in a harmonic law and the particles are captured in the GA mode. The relativistic plasma bunch formed under GA conditions interacts with the plasma-forming gas and generates bremsstrahlung radiation. A spectrometric and radiometric studies gives the parameters of generated bremsstrahlung and makes possible to approximate the energies of the bunch particles.

The measurements showed a significant presence of particles with energies of about 0.5 MeV in the clots. The results of the experiments were compared with the calculation by the model of particles in the cell. The simulation results are shown in the figure. Here, the curve 1 corresponds to the energy spectrum of the electron bunch at the end of the magnetic field pulse, the curve 2 шы the spectrum of uncovered electrons. The numerical experiment shows that the fraction of particles captured in the GA mode is about 10% of the total number of plasma electrons. This is confirmed by radiometric measurements of bremsstrahlung.

After the decay of the pulsed magnetic field there is a decrease in the average electron energy of the bunch due to decompression - curve 3. However, the level of this energy of the order of 0.3 MeV significantly exceeds the maximum possible energy of plasma particles observed in the ECR at the same parameters of the field of the mirror trap and microwave pump.

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References

1. V.V. Andreev, D.V. Chuprov, V.I. Ilgisonis etc. // Physics of Plasmas 24, 093518, 2017.