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REB ACCUMULATION AND ION ACCELERATION ON REBEX MACHINE

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Main results of the experimental study of oscillating relativistic electron beam and collective ion acceleration, performed on the REBEX accelerator, are presented. The existence of virtual cathode and of oscillating electron cloud in various regimes is confirmed by experimental data obtained from capacitive probes, collectors of counter-streaming electrons, witness plates, and detectors of accelerated ions. Movable collector and X-ray probes measuremer made it possible to determine the accumulation rate and the effective length of the virtual cathode both in foil-terminated and diffuse-boundary plasmas. Particular systems are compared from the point of view of efficient beam accumulation.

Ion acceleration to MeV energies in the region of the virtual cathode is investigated, the electron beam being injected into a puff of neutral gas or into a short independently produced plasmoid. Diagnostics of high-energy ions used on REBEX is briefly mantioned, namely the foil-collector technique, time-of-flight and absorption methods, and nuclear target measurements ($C^{12}(d,n)$ and $Li^{7}(d,n)$ reactions).

The total number, energy spectrum, time and place of origin of accelerated ions (E_i 60 keV) are discussed. While the maximum particle number (N_i =1 protons or deuterons) is found at injecting the beam into neutral gas of optimum pressure, the highest ion energy ($E_{i\ max} = 3 - 4\ E_b$) is measured in vacuum with foilless hollow dielectric anode.

In neutral gas, the dependence of the acceleration efficiency on the gas pressure, external magnetic field strength, and the anode foil thickness is studied. The gas pressure is adjusted by varying the time delay between the pulse valve action and the beam injection. The optimum acceleration occurs at the pressure near the anode foil of 50 - 100 Pa. Unlike other experiments, the acceleration efficiency falls down at least by an order of magnitude when the magnetic field is switched off. Just a lower-energy part of the ion spectrum depends on the foil thickness, the number of accelerated ions increasing with thinner foils. Apparently, these ions originate at later stages of virtual cathode history, and they are affected by beam accumulation processes.

In externally produced plasmas, the virtual cathode shifts with the instant position of the plasma-vacuum boundary. Both the acceleration efficiency and the maximum ion energy decrease with the increasing plasma column length. Short spikes /10 ns/ of transversally accelerated ions with energy above 400 keV, and originating in the elongated virtual cathode region, have been discovered. These ions represent the direct evidence of the non-stationary character, and of the complicated spatial form, of the virtual cathode arising at the diffuse plasma boundary.