MATERIALY X. ČS. SEMINÁŘE O FYZICE A TECHNICE PLAZMATU, ZVÍKOV 1979

RES. REP., IPPCZ - 228, AUGUST 1979

INTERACTION OF A RELATIVISTIC ELECTRON BEAM (REB) WITH AN INHOMOGENEOUS PLASMA

P.Šunka, K.Jungwirth, I.Kováč, V.Piffl, J.Stöckel, J.Ullschmied
Institute of Plasma Physics, Czechoslovak Academy of Sciences, Prague

Energy deposition of a REB in an inhomogeneous magnetized plasma is investigated. Measurements are performed on the improved REBEX machine /1,2/. The beam (500 keV, 20-30 kA, 70 ns, 30 mm in diameter) is injected along an applied magnetic field ($B_o = 0.5$ T) into a cylindrical vacuum chamber (D = 150 mm, L = 2.1 m) containing hydrogen plasma from a double conical gun loca-l near the foil anode of the accelerator. The generated plasma (70 mm in diameter) expands along the magnetic field with a velocity of $2\text{-}4 \times 10^4$ ms^{-1}. By varying the time delay t_d between firing the gun and the beam, two different regimes can be adjusted. Plasma density of a short column (0.6 m) is about 10^{21} m^{-3} ($t_d < 50$ μs) and it decreases to 2×10^{20} m^{-3} for the full plasma length ($t_d \gtrsim 100$ μs). In the latter case good propagation of the beam is observed. The beam energy loss detected calorimetrically (10-15% of the injected energy Q_b) is comparable with the measured value of the total transverse energy content Q of plasma particles (diamagnetic field). The two-stream instability is responsible for plasma heating in this regime. It was checked by using a movable collector that the critical interaction length is bellow 0.5 m.

For $t_d < 50$ μs most of the beam electrons are reflected by a virtual hode, performing in average 2-4 oscillations between the real and the virtual cathodes (accumulation of beam electrons). Only a vacuum critical current (1.5 kA) flows to the collector. Simultaneously, energetic ions (up to 1.2 MeV) are detected. Their total number increases with the enhanced accumulation. The beam reflection leads also to a higher energy deposition in a plasma. More than 20% of the injected energy Q_b is found in long plasma columns with a diffuse boundary. The plasma energy content reaches its maximum ($Q = Q_b/3 = 150$ J) in a short plasma column (L = 0.6 m) with a relatively sharp boundary. Then, the diameter of the hot plasma core exceeds roughly twice that of the injected beam and the plasma energy density is of the order of 10^{24} eV m^{-3}, being thus comparable with that of the applied magnetic field. The diamagnetic signal displays oscillations with a frequency corresponding to magnetosonic bouncing of the plasma column. By destroying the virtual cathode with a movable collector the heating efficiency falls by an order of magnitude.

The 1 1/2 dimensional simulation code OREBIA-REX provided us with more detailed data concerning the dynamics of the virtual cathode, reflexing beam phenomena and ion acceleration. In its final version we intend to investigate also the interaction of the oscillating electron cloud with a plasma.

REFERENCES

/1/ P.Šunka et al.: Plasma Phys. and Contr. Nucl. Fus. Res., IAEA Vienna, II (1977), 535.

/2/ P.Šunka et al.: Proc. of 8th Europ. Conf. on Contr. Fus. and Plasma Phys., Prague, II (1977), 108.