10th European Conf. on Controlled Fusion and Plasma Physics, Moskva 1981

LOWER-HYBRID HEATING EXPERIMENT ON THE TM-1-MH TOKAMAK

Ďatlov J., Jakubka K., Kopecký V., Körbel Š., Kryška L., Magula P., Stöckel J., Žáček F.

Institute of Plasma Physics, Czechoslovak Academy of Sci., Pod vodárenskou věží 4, 182 11 Prague 8, Czechoslovakia

During preliminary experiments on the plasma heating in the LHR region in the TM-1-MH device HF power up to 100 kW at the frequency of 616 MHz has been injected into the tokamak by means of a loop fed by a coaxial line. The process of HF field-plasma interaction has been found strongly nonlinear in the whole 3-100 kW power range. It takes place predominantly at the periphery of the plasma column. Electron density increase during the heating process has been reduced by working at various temperatures of the liner up to 300°C.

The parameters of the TM-1-MH tokamak are as follows: R=0,4m; a=0,075m; B_o = up to 1,6T; I_p=15-30kA; hydrogen. The results of our heating experiments at $f \doteq 2f_{LH}$=1,25 GHz, P_{HF}=40kW carried out on this tokamak have been reported [1]. Under such conditions the increase of the ion temperature up to $\Delta T_i/T_i \simeq 1$ was measured. The nonlinear character of this process with a threshold power of 20kW has been found.

Recently we started the LHR heating experiments with the klystron power source up to 100kW at 616MHz (P_{HF}=(1-3) P_{OH}). Due to small dimensions we could not use the waveguide grill [2,3,4]. A simple loop coupler with the front dimensions 4x1,5cm has been used, similarly to [5]. From this at 50 kW of HF power the power flow density of 5kW/cm^2 and vacuum electric field intensity of several kV/cm in the vicinity of the coupler can be estimated. The ratio of oscillating velocity to the thermal velocity of electrons $v_E/v_{Te} \gtrsim 5$, which gives the conditions for the highly nonlinear wave-plasma interaction. This is corroborated by the broad downshifted frequency spread of HF spectra (Fig. 1a,b). We suppose that the L.F. spectra are generated by

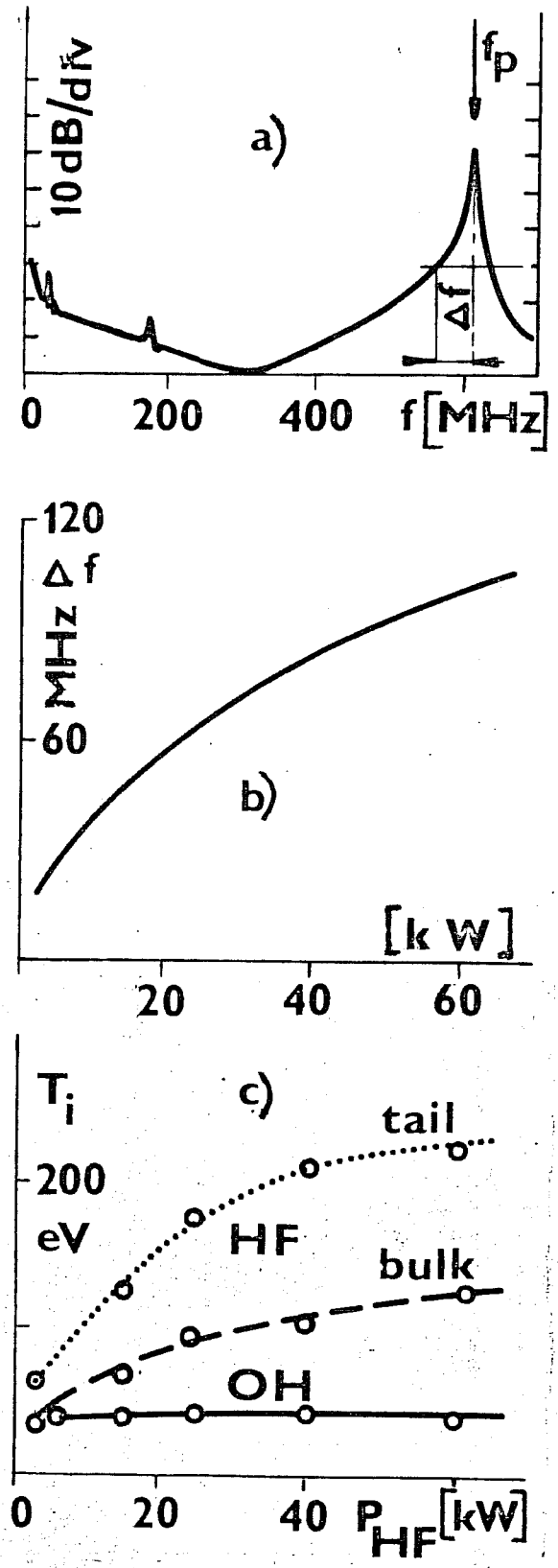

FIG. 1

the decay parametric instabilities. The threshold power for this instabilities seems to be lower than 3kW (the lowest power used in our experiments). In Fig. 1c is shown the power dependence of the temperatures of the bulk part and tail of energy distribution function of ions as measured by C.X. 5-channel analyzer. The threshold power for the heating effect, if does exist, must be lower than the lowest power used.

The total energy of the plasma loop was evaluated from the diamagnetic measurements. In the Fig. 2a,b,c are given the time dependences of the kinetic pressure $\bar{p}_\perp$, of the radial shift ΔR of the plasma column in a typical tokamak discharge and of the electron density $n_e(0)$ on the axis. The dashed lines correspond to the OH regime, the full lines are the values during the HF heating. The picture 2 corresponds to the case in which a substantial increase of density during the HF pulse is the predominant cause of the increase of $\bar{p}_\perp$ and radial shift ΔR. The increase of T_i can be caused by the higher transport of energy from electrons to ions. The electron density in-

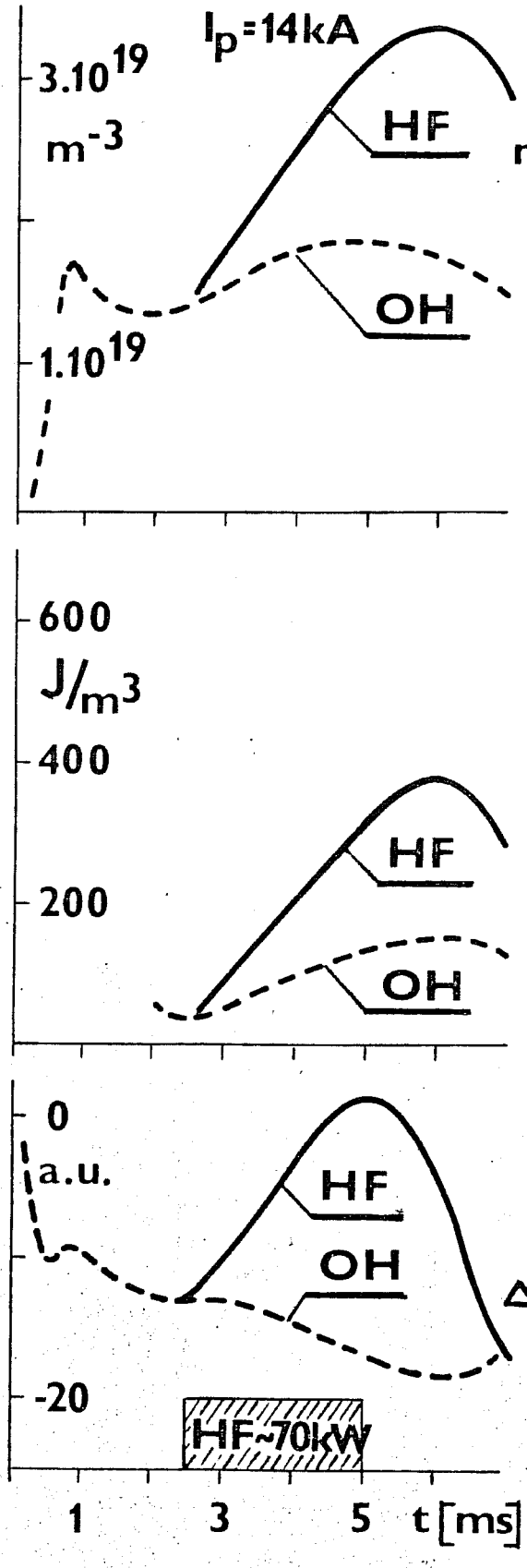
I_p=14kA
3.10^{19}
m^{-3}
HF
OH
1.10^{19}
600
J/m^3
400
200
HF
OH
0
a.u.
HF
OH
-20
HF~70kW
1
3
5
t [ms]

FIG. 2

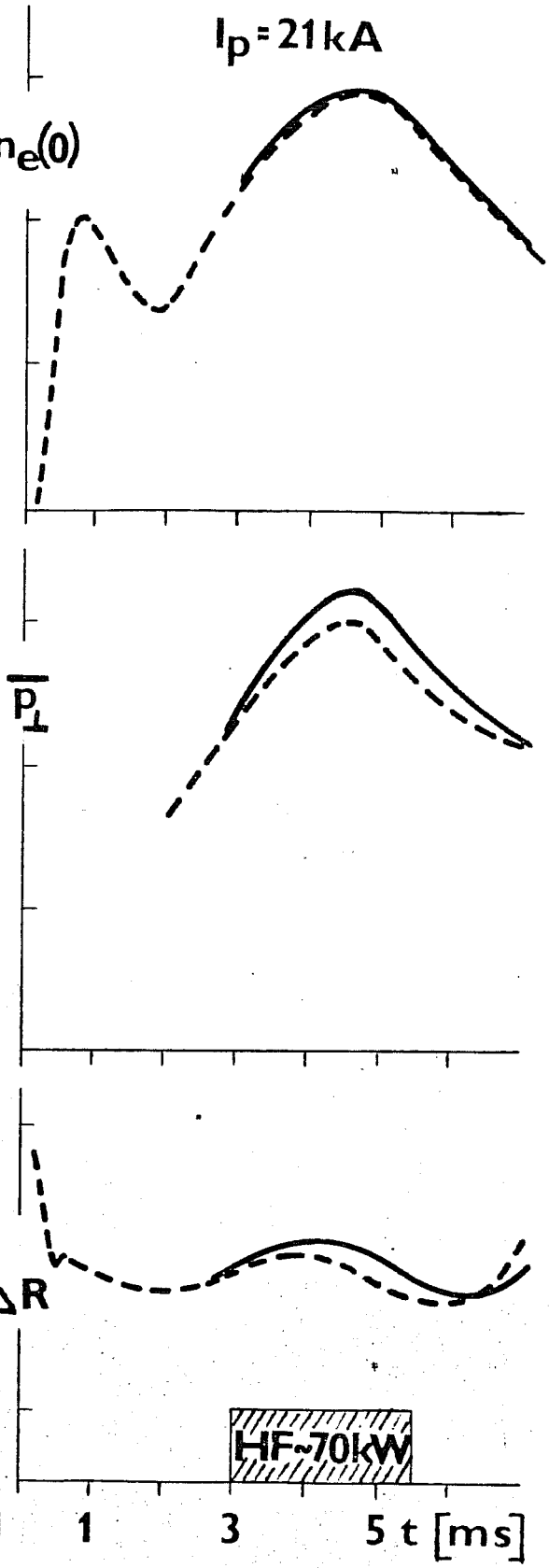
I_p=21kA
$n_e(0)$
$\overline{p_\perp}$
ΔR
HF~70kW
1
3
5 t [ms]

FIG. 3

crease is due to neutral gas release from liner walls under the intense bombardment by energetic particles during the HF-plasma interaction.

This density increase during the HF heating pulse has been removed by working with the liner at elevated temperature, up to 300°C. The effect of this procedure was similar to the gettering with titanium evaporation as used see e.g. [2]. The density does not increase in this case, as shown in Fig. 3. Than the resulting increase of the kinetic pressure can be interpreted as the increase of the temperature of the bulk ions of the plasma column with correspondence to C.X. neutral measurements. However, due to strong nonlinear absorption at the plasma periphery, the heating efficiency for the ion component of plasma remains also in this case relatively low, of the order of ten percent.

Authors would like to thank Drs. Klíma and Preinhaelter for stimulating discussions and the technical staff of the TM-1-MH device for the skilful assistance.

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