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SPECTRA OF HIGH-FREQUENCY OSCILLATIONS IN THE TUMAN-3M TOKAMAK *)

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The importance of study of high-frequency oscillations in tokamaks ($\omega_{ci} < \omega < \omega_{ce}$) is due to fundamental interest, as well as the possibility of using waves in this range for diagnostics of runaway electrons (RE) and potentially for preventing the formation of powerful RE beams that are dangerous for tokamak vacuum vessels [1].

In the ohmically heated low-density plasma in the TUMAN-3M tokamak, in addition to the Alfven [2] and ion-cyclotron oscillations [3,4], three types of higher-frequency magnetic oscillations were observed. The range of oscillation frequencies described in this report lies between the ion and electron cyclotron frequencies: ω_{ci} and ω_{ce}, respectively. This range corresponds to whistlers [5]. Experiments to observe these oscillations were carried out in hydrogen and deuterium plasmas at $\overline{n}_e \leq 1{,}5 \cdot 10^{19}$ м$^{-3}$, $B_t \leq 1{,}0$ Тл, $I_p \leq 160$ кА, $R_0 = 0{,}53$ м и $a_l = 0{,}22$ м. The measurements were carried out using an array of 16 magnetic probes, located equidistantly along the poloidal direction on the inner wall of the vacuum vessel. The signals were digitized using 12-bit ADCs with a sampling rate of 64, 250 or 3000 MHz.

The oscillations of the first type had a duration of up to 1 ms and were observed in the frequency range from 120 to 290 MHz, which corresponds to (10-20)ω_{ci} and lower than $\omega_{LH}/2$. The oscillations appeared in the form of several spectrum lines separated by gaps from 18 to 60 MHz. The evolution of frequency allowed us to conclude that the oscillations were of a whistler type [6].

The oscillations of the second type appear in the form of short bursts with a duration of 10-20 μs and were characterized by a clear harmonic structure containing up to 7 harmonics. In this case, the frequency of the fundamental harmonic 18-40 MHz is significantly lower than that of the oscillations of the first type, but higher than ω_{ci}. With an increase in the average density from 0.87 to $1.18 \cdot 10^{19}$ m^{-3}, a splitting of the harmonics into subharmonics with a gaps of ~ 4.2 MHz was observed. The number of subharmonics reached 6. Due to the short duration of the bursts of oscillations, it was impossible to determine the dependence of their frequencies on B_t and $\overline{n}_e$ [6].

The oscillations of the third type were detected in discharges with a lower density than in the previous cases: $\overline{n}_e \approx 0{,}5 \cdot 10^{19}$ м$^{-3}$. The spectra of the signals were measured using an ADCs with a sampling frequency of up to 3 GHz. In these spectra, the above-mentioned oscillations are concentrated in the range of $f < 300$ МГц. In the higher-frequency part of the spectra – $f > 300$ МГц – a “comb” of peaks of variable amplitude was detected. The gaps between the peaks are increasing from 15 MHz at lower frequencies up to 26 MHz in the 1 GHz region. The experiments demonstrated a correlation between the appearance of whistlers and the presence of RE. Additional experiments are planned to study the relationship of this oscillations with the RE.

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*) abstracts of this report in Russian