island width for $m = 2$ mode on the parameter α is shown, assuming the current profile $j(r)$ in the form $j(r) = j(0) . (1 - r^2/a^2)^\alpha$. The calculation was carried out on the basis of the quasilinear theory [11]. A more detailed description of the simulation for the CASTOR tokamak is presented in [12]. The value of the safety factor on the plasma boundary was taken 6·5 in this calculation.

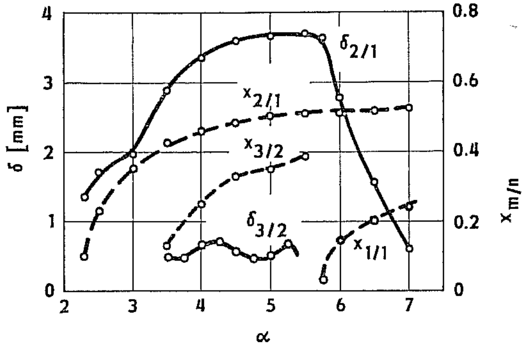

Fig. 9. Calculated resonant radius $x_{m/n} = r_{m/n}/a$ and the island width δ for modes $m/n = 1/1$, 2/1, 3/2 versus parameter α, characterizing a width of the model current density profile $j = j(0)(1 - r^2/a^2)^\alpha$; safety factor at limiter $q(a) = 6{\cdot}5$.

As we can see from fig. 9, the resonant radius is shifted from the plasma centre to the periphery with the sharpening of the $j(r)$ profile. Simultaneously the island width grows and achieves the value of about (3 – 4) mm. Note that the value of island width for $m = 3$, $n = 2$ is substantially smaller and so decisive contribution to the MHD activity gives mode $m = 2$, $n = 1$ only. It follows from calculations that the maximum value of δ in this mode is reached at the sufficiently sharp current profile. Such a profile sharpening could be caused by a high level of radiative losses as it was demonstrated in section 2.2. The strong profile sharpening could even result in the appearance of the $m = 1$ mode in the central plasma region. The simultaneous existence of two modes $m = 1$ and $m = 2$ could lead to a minor disruption. An analysis of signals from the magnetic probes shows that, at the moment of disruption, the oscillations of mode $m = 2$ are transformed into the oscillations with a higher frequency (see fig. 8a), which may be connected just with the $m = 1$ mode existence.

4. CONCLUSION

The total radiative power P_{RAD} has been measured in a broad range of plasma parameters on the CASTOR tokamak. It has been found that the radiative power losses P_{RAD}:

(i) are practically independent of the plasma current;
(ii) increase proportionally to the plasma density.

The only linear increase of P_{RAD} with density indicates some decrease of the effective charge Z_{eff} (this has been corroborated by spectroscopic measurements). Moreover, measuring the ohmic input P_{OH} and estimating the power transferred to ions P_{ei} simultaneously, we were able to estimate the power losses by the thermal conductivity P_{COND} of the electron component and, in some sense, to establish a global energy balance of this component. It has been found that in the low density regimes ($\bar{n}_e \lesssim 10^{19}\,\mathrm{m}^{-3}$) the conductivity channel is comparable with the ohmic input, while the high density discharges with $\bar{n}_e > 3 \times 10^{19}\,\mathrm{m}^{-3}$ can be considered as radiation dominated. Decrease of the conductivity losses with increasing density can lead to a decrease of the plasma-limiter interaction (improvement of thermoisolation of the plasma column) and consequently to a decrease of an impurities influx (and consequently a decrease of Z_{eff}) as it is indicated by the experiment.

The relatively high level of the radiative power losses at high density should have an influence on the local parameters of the plasma as well. A simple analytic model of the energy balance has demonstrated a contraction of the radial electron temperature profile caused by increasing ratio $\phi = P_{\mathrm{RAD}}/P_{\mathrm{OH}}$. Some experimental aspects of this effect are reported. As the electron temperature radial profile is connected with a radial distribution of the toroidal current, at high density regimes we have observed phenomena caused by a shrinking of the current channel as enhancement of the MHD activity, followed by disruptive instabilities. Simultaneous experimental and numerical studies of a disruptive discharge with relatively high $q(a) = 6{\cdot}5$ have shown that it is possible to interpret the observed MHD activity as a formation of a magnetic island $m=2$ with the width reaching the value of (3 – 4) mm just before the minor disruption. The corresponding calculated radius of the resonant surface $r_s = a/2$ implies a model current distribution $j = j(0)\,(1 - r^2/a^2)^\alpha$ for $\alpha = 5-6$. However, the resonant surface $m = 1$ is appearing in the central region of the plasma column for such a rather contracted current profile. Simultaneous existence of both above-mentioned modes can lead to the minor disruption under our conditions.

From experimental data (shown in fig. 8b) it is possible to estimate a rotational velocity of the magnetic island $m = 2$ as $v_\varphi(r_s) = 2\pi r_s f/m = 2{\cdot}5 \times 10^3$ m/s just before the disruption. Supposing v_φ to be connected with the existence of a radial electric field E_r and the toroidal magnetic field B_T, we can estimate $E_r = v_\varphi B_T \cong 3 \times 10^3$ V/m at $r = a/2$. On the other hand, the observed value of v_φ well agrees with the velocity of a diamagnetic plasma rotation at the radius $r = r_s = a/2$:

$$v_{\mathrm{diamag}} = \frac{\left.\frac{\mathrm{d}p}{\mathrm{d}r}\right|_{r=r_s}}{n_e(r_s)\,eB_T} \cong \frac{2\,T_e(0)}{aB_T} \quad [\mathrm{m\,s^{-1}, m, eV}]$$

for $T_e(0) \cong 150$ eV ($p = n_e T_e$ is the plasma kinetic pressure).

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