a calculation, we estimate at first the total value of power P_{ei}^{cal}, transferred from electrons to the ions owing to the collisions, taking into account the real dimensions of the system and assuming a priori the electron temperature at least double the ion one in the whole plasma volume. This P_{ei}^{cal} loss channel, together with experimentally determined ohmic and radiative powers, is depicted versus plasma density for discharges with $q(a) = 6{\cdot}9$ ($I_p = 17$ kA; $B_T = 1{\cdot}3$ T) in fig. 3, as an example of the power balance on the CASTOR tokamak.

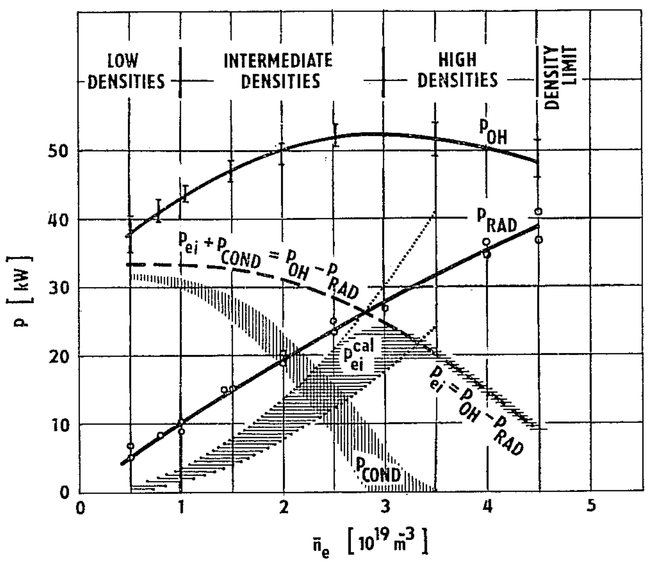

Fig. 3. Power balance of the electron component versus line average density $\bar{n}_e$ for discharges with $I_p = 17$ kA. Ohmic heating P_{OH} and radiated P_{RAD} powers are determined experimentally. For low and intermediate density regimes the power P_{ei}^{cal} transferred to ions is estimated according to the formula $P_{ei}^{cal} \sim \bar{n}_e^2/T_i^{1/2}$ (horizontally dashed area). The limit values of the ion temperature T_i were taken as 50 or 150 eV, according to the previous measurements [1]. The thermal conductivity losses P_{COND} through the plasma boundary were determined as $P_{COND} = P_{OH} - P_{RAD} - P_{ei}^{cal}$ (vertically dashed area). For high density regimes the conductivity losses seem to be negligible and, therefore, P_{ei} was enumerated from the experimental power balance $P_{ei} = P_{OH} - P_{RAD}$.

Comparison of the ohmic and radiative powers and the quantity P_{ei}^{cal} shows that it is possible to distinguish three qualitatively different regions with respect to $\bar{n}_e$:

1) Low density region with $n_e \lesssim 10^{19}$ m^{-3}.

The ohmic power substantially exceeds P_{RAD} and P_{ei}^{cal} in this density range, which indicates that the main part of energy supplied to the plasma escapes through the electron thermal conduction channel to the liner (or wall). In fig. 4 the power $P_{COND} = P_{OH} - P_{RAD} - P_{ei}^{cal}$, transported through the plasma boundary due to the thermal conduction at densities $\bar{n}_e \lesssim 10^{19}$ m^{-3}, versus the plasma current I_p is presented. The same power, but calculated according to the formula

$$P_{COND}^{cal} = \frac{3}{2} \frac{\langle n_e T_e \rangle V}{\tau_{Ee}^*},$$

is given by the dotted line. For this computation the average electron temperature was estimated according to the Spitzer conductivity formula taking $Z_{eff} = 2$. Here V denotes the plasma volume, τ_{Ee}^* the electron energy confinement time connected with the losses due to the thermal conductivity, $\tau_{Ee}^* = a^2/4K_e$, where $K_e = 2{\cdot}5 \times 10^{19}/\bar{n}_e$ [m^2 s^{-1}, m^{-3}]. The value of the constant in K_e was chosen to ensure the best fit of P_{COND}^{cal} with the curve P_{COND}. This value is the half of that in the Alcator scaling (see (eq. (1)). In spite of somewhat rough estimate the difference is not so great.

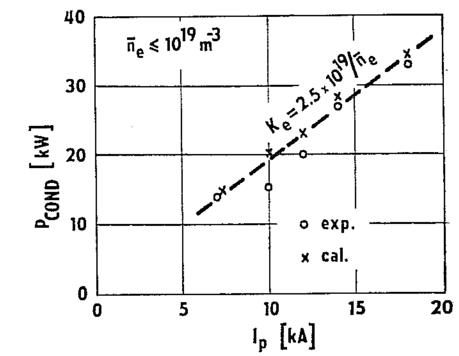

Fig. 4. The thermal conductivity losses through the plasma boundary P_{cond} versus plasma current for low density regimes ($n_e = 1 \times 10^{19}$ m^{-3}).

Finally it is interesting to note that in this density range, see fig. 3, the quantity P_{COND} is for the given current practically independent of $\bar{n}_e$. It indicates that K_e is really inversely proportional to $\bar{n}_e$, as the Alcator scaling predicts.

2) Intermediate density region $1 \times 10^{19} \lesssim \bar{n}_e \lesssim 3 \times 10^{19}$ m^{-3}.

While for densities $\bar{n}_e \lesssim 10^{19}$ m^{-3} the main part of the plasma energy escapes through the plasma boundary due to the thermal conductivity, for densities $\bar{n}_e > 10^{19}$ m^{-3} the influence of this channel upon the energy balance is significantly weaker. The decrease of P_{COND} shown in fig. 3 could be a consequence of the flattening of the electron temperature profile at the column periphery, maybe connected just with an enhancement of the radiative losses and transfer of energy from electrons to the ions in this region. Indeed, in this range of $\bar{n}_e$, the effect of mechanisms mentioned would be quite decisive as the total power loss by radiation represents more than the half of the ohmic one and the power transferred to the ions already approaches a value of about (10–20) % of the input power at $\bar{n}_e = 2{\cdot}5 \times 10^{19}$ m^{-3}. If the density increases up to $\bar{n}_e = 3 \times 10^{19}$ m^{-3}, the effect of the thermal conduction seems to be quite negligible.

3) High density regime with $\bar{n}_e \gtrsim 3 \times 10^{19}$ m^{-3}.

The investigation of the energy balance at still higher densities is more questionable. Brief comparison of the established power losses with ohmic input shows that even neglecting conductivity losses, we obtain a discrepancy in the quasistationary power