LOCAL BALANCE OF CHARGED PARTICLES IN GAS-DISCHARGED PLASMA: history of the issue [[1]](#footnote-1)\*)

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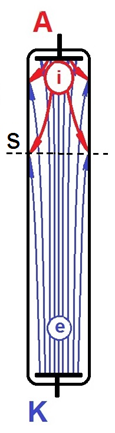
Wide investigations of gas discharge were started together with the use of discharge in glass tubes for outdoor light advertising at the beginning of the 20th century. A peculiarity of such discharges is an extended positive column (PC) that is homogeneous along the tube axis. When taking into account the balance of charged particles, it allows ignoring counter flows of charged particles that form electric current; since the parameters are uniform along the tube axis the number of particles passing through any section remains unchanged. Then in the stationary case we can say that for the selected tube section the number of generated charged particles is equal to the number of those that reached the walls or died as a result of recombination in the bulk. However, in fact, the particles recombining in the tube section (S) come from different parts of the gas discharge (see Fig.), positive ions (i) from the anode and electrons (e) from the cathode. This is especially noticeable at pressures of the plasma-forming gas exceeding 0.01 *Torr*, when there is a change in the discharge from free path of charged particles to diffuse one. Estimates show that the number of electrons passing through the tube section at a pressure of 1 *Torr* is several orders of magnitude greater than the number of electrons reaching the tube walls under the action of ambipolar diffusion, and this ratio increases proportionally to the gas pressure. At atmospheric pressure, the ratio of the electron flux along the tube axis to the flux to the walls for typical tube dimensions is 5-6 orders of magnitude. Qualitatively, the balance of charged particles does not change even when the recombination losses in the bulk are taken into account. Moreover, if there are bulk recombination losses a stationary glow discharge cannot physically exist at moderate and especially at atmospheric pressures.

Fig. Motion of charged particles in the tube.

In other words, the concept of local balance of charged particles in gas-discharge plasma originated in the study of discharges in tubes of sufficiently low pressures when the particles are in the free path mode. Only in this case we can speak of the balance as the equality of ionization and recombination, but not at a selected PC point (as it is now understood), but in a section of the discharge tube with a length of the order of its diameter. Subsequently, the concept of local balance of particles, with a greater “weight” and a slightly changed content, was used for discharges in the diffuse mode, with higher pressures and other geometries. In fact, now the local balance of particles simplifies calculations of a homogeneous PC by a mathematical trick, which (as one can see in the figure) for inhomogeneous discharges has no physical meaning, and there is no reason for using it in calculations. Thus, there is a need to change the paradigm of gas discharge modeling, from the local balance of charged particles [1] to ambipolar transport or plasma transport as a whole [2].

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References

1. Smirnov B.M. Usp. Fizich. Nauk 179 591 (2009).
2. Medvedev A.E. PLTP–2020 Book of Abstracts P. 50.

1. \*) [abstracts of this report in Russian](http://www.fpl.gpi.ru/Zvenigorod/XLVIII/Lt/ru/EL-Medvedev.docx) [↑](#footnote-ref-1)