The calculations of thermophysical properties of low-temperature lead plasma [[1]](#footnote-1)\*)

DOI: 10.34854/ICPAF.2020.47.1.102

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Different thermophysical properties of plasma (equation of state and electronic transport coefficients) play important role in various fundamental tasks and application. Their study for the low temperature plasmas of metals and semiconductors is of especial difficulty, because, contrary to the case of gases, these plasmas are located under relatively high temperatures (higher 5kK), where the measurements are difficult to carry out. There are some obstacles for theoretical models as well, especially when the density is growing up to the values ~ 0.1 of the density at ambient conditions. For this case the interparticle interaction becomes important [1]. During recent years there have appeared new data, both experimental and theoretical, for a number of metals and semiconductors, which partially fill the gap [2]. For Pb (lead), however, there were no such data up to the most recent time, although this metal plays important role in various technologies [3].

The measurements and calculations for this element at high temperatures (>10 кК) [3,4] have been carried out at relatively high densities, at best higher than the critical one (the latter is estimated as ~ 3 g/cm3, the normal crystal density for Pb is 11.34 г/см3). Under lower densities the was only one publication [5], concerning only the electrical and thermal conductivity. The thermodynamics data were absent. Thus, evidently, this gap should be filled. So that was the aim of present work, namely to calculate the properties under study for Pb at the densities less than 3 g/cm3 and temperatures 10-100 кК.

Previously we have developed a model of calculation of the considered properties for different elements under these conditions (see [6] и reference therein). Within the present work this model has been modified to apply it to the low-temperature partially ionized plasma of Pb [7]. The chemical approach was used to obtain the thermodynamics and ionic composition of considered substances for given density and temperature. The relaxation time approximation, in turn, for known composition have allowed us to calculate the transport coefficients. We should mention that at the end of last year there have appeared the first measurements of the pressure, internal energy and electrical conductivity of Pb plasma under the considered conditions [8]. The comparison has shown that the results of our calculations are in good agreement with these new experimental data.

References

1. Fortov V. E., Yakubov I. T. Physics of Non-Ideal Plasmas. Hemisphere Publishing, New York, 1990.
2. Clerouin J., Noiret P. et. al., Phys. Plasmas, (2012) V. 19, 082702.
3. Tahir N. A., Deutsch C. et. al., Phys. Rev. Lett. (2005) V. 95. 035001.
4. Piron R., Blenski T., Phys. Rev. E (2011) V. 83. 026403.
5. Ebeling W., Fцrster A., Fortov V. E., Gryaznov V. K., Polishuk A. Y. Thermophysical Properties of Hot Dense Plasmas. B. G. Teubner Verlagsgesellshaft, Stuttgart, 1991.
6. Apfelbaum E. M., Phys. Plasmas, (2018) V. 25, 072703.
7. Apfelbaum E. M., Contrib. Plasma Phys., (2019) V. 59 e201800148.
8. Kondratyev A. M., Korobenko V. N., Rakhel A. D. JETP, (2018) V. 127, P. 1074/

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