CALCUATION OF the THERMOPHYSICAL PROPERTIES OF IRON PLASMA

E.M. Apfelbaum

Joint Institute for High Temperatures, Russian Academy of Sciences, Moscow Russia, apfel\_e@mail.ru

The thermophysical properties of various substances, such as the pressure, internal energy, transport coefficients (conductivity) etc. have been investigated for more than a century because of their importance in practical and fundamental tasks. The high temperature region is especially difficult for measurements as far as it is the problem to obtain the equilibrium state at T > 5000 K without any other measurements. Thus in this region, containing the metallic plasma too, the number of measurements are significantly smaller than the number of calculations. Nevertheless, during recent twenty years new measurements of the pressure, internal energy and conductivity have appeared [1–5]. They are whether the shock-wave measurements [1, 2], or the conductors (wire or foils) explosion measurements [3–5]. The former are carried out along the Hugoniot adiabat, at the densities, as a rule, more than the critical one. In the latter one can penetrate in the region of less density. At the same time the conductivity can be measured. But in both cases the temperature can not be measured directly. That is why the hybrid approach (experiment + calculation) should be used to find the temperature [3, 4]. Nevertheless, the new measurement data allows one to check the existing calculation models.

Previously we have constructed corresponding model to calculate the thermophysiscal properties of the plasma state, which have been applied to noble gases, semiconductors and number of metals. [5-8]. Within its frame the chemical (ionic) composition of the plasma, pressure, internal energy and electronic transport coefficients (conductivity, thermal conductivity and thermal power) can be calculated. The composition and thermodynamics are relied on the mass action law equations (see, for instance, [1, 2, 9]). The transport coefficients are calculated within the time relaxation approximation. At present study. this model is used to calculate the above considered properties in the plasma of Iron. The conductivity measurements of Fe plasma are presented for a number of isotherms in [3, 4] at T = 10–30 kK and in density range from 0.1 to 1–2 g/cm3. We emphasize again that the condition of isothermality have been established by the hybrid approach mentioned above. In more recent experiments [5] the caloric equation of states (the dependence of the pressure on internal energy) and electrical conductivity have been obtained along the isochors from ρ0/7 to ρ0/2 (ρ0 = 7.874 g/cm3 is the Iron density at T = 300 K and P = 1 atm). This region corresponds to the low temperature, partially ionized plasma. Our calculations have been performed under these conditions as well. The obtained results are in good agreement with the results of measurements and calculations of other researchers.

References

1. Gryaznov V. K., Fortov V. E., Zhernokletov M. V. et. al., JETP, (1998) V. 87, 678.
2. Gryaznov V., Iosilevski I., Fortov V. E., Contr. Plasma Physics, (1999) V. 39, 89.
3. DeSilva A. W., Rakhel A. D., Contributions to Plasma Physics, (2005) V. 45, 237.
4. DeSilva A. W., Vunni G. B., Phys. Rev. E, (2011) V. 83, 037402.
5. Korobenko V. N., Rakhel A. D., Phys. Rev. B, (2013) V. 88, 134203.
6. Apfelbaum E. M., Contributions to Plasma Physics, (2011) V. 51, 395.
7. Apfelbaum E. M., Contributions to Plasma Physics, (2013) V. 53, 317.
8. Apfelbaum E. M., Phys. Plasmas, (2015) V. 22, 092703.
9. Kuhlbrodt S., Holst B., Redmer R., Contributions to Plasma Physics, (2005) V. 45, 73.