The calculations of thermophysical properties of low-temperature tantalum plasma

Apfelbaum E. M.

JIHT RAS, Moscow, Russia, [apfel\_e@mail.ru](mailto:email@email.ru)

The thermophysical properties of metals such as the equation of states and electronic transport coefficients play important role in fundamental and applied tasks. Thus their investigations in various areas of the phase diagram, including the plasma area, have been carried out for more than a century. But their study at high temperatures (> 5000 K, where the low-temperature plasma is located) is of especial difficulty as far as it is the problem to obtain the equilibrium high-temperature state itself in experiments even without any other measurements. In the theories there are also hinders since the analytical expansions, valid for the weakly coupled plasma, becomes incorrect under compression. Nevertheless during last two dozen years there have appeared the new measurements and calculations, including the *ab initio* ones, which have sufficiently complimented our knowledge of these properties of a number of metals (see, for instance, [1] and references therein). However the tantalum plasma is still less studied in comparison with other elements. There the data for it obtained in the measurements in shocks [2] under relatively high densities, namely more than the half of the normal value ρ0 (ρ0 = 16.69 g/cm3, the Ta melting temperature Тm=3290 K). To analyze these experiments the special semi-empirical equation of states have been alaborated as well [3]. Besides there are the conductivity measurements in the wire explosion process [4], where a substance has been expanded down to 0.01ρ0, while the temperature can reach ~40 kK. After all, there are the *ab initio* calculations [5] of the pressure of Ta plasma at Т <20 kK и ρ> 1.67 g/cm3. However, there are no the pressure data at lower densities.

Earlier we have developed a model to calculate the equation of states and the electronic transport coefficients (electrical conductivity, thermal conductivity and thermal power) for the low temperature plasma, which has been successfully applied to several metals [6,7]. This model is constructed on the basis of the so-called chemical approach, when the substance under study is considered as a mixture of the electrons, positive ions, atoms and more complex particles. The composition and thermodynamics of this mixture can be obtained by means of the acting mass law (see [6]). The electronic transport coefficients were calculated within the relaxation time approximation. The region of correct applicability of this model was established as well. In present study our approach was modified to apply it to the tantalum plasma. The considered properties have been calculated in the temperature range from 10 to 100 kK and for the densities less than 3 g/cm3. The comparisons of our results with the data of non-numerous measurements and calculations have shown good agreement in this region.

References

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