The microfield model for optics and thermodynamics of dense plasma

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The accuracy of gas-dynamic calculations is restricted by not enough knowledge about properties of substances. The gas-dynamic equations are accurate but coefficients of these equations described properties of substances are not accurate. Thus for increasing accuracy of calculations we need more accurate information about substances. There are several databases of properties of substances. The SESAM database was made in the USA. The database of Institute for High Energy Densities and the TEFIS database of Institute for Mathematical Modeling were made in Russia. One of the main sections of the TEFIS is the section described thermodynamic properties of substances under extreme conditions.

The model of ionization equilibrium with microfield corrections to thermodynamics is used in the TEFIS when the temperature effects dominate to pressure effects in plasma. In this model the hypothesis is made plasma microfield is selfconsistent field of Coulomb interactions of charged particles. It allows calculating corrections on non-ideality to all thermodynamic functions of plasma. These corrections are described by simple formulas and satisfy to all thermodynamic relations. The model does not predict plasma phase transitions such as plasma condensation for any conditions (significant effects of plasma non-ideality in thermodynamics are predicated in many publications, but experiments did not find out such effects).

Numerical calculations with this model for different substances were carried out. Maximum non-ideality is achieved for Cs in region of first ionization. But even for this case pressure and energy differ from pressure and energy of full ideal plasma only for a few percent. Only for degree of ionization the difference exceeds 10%. This agrees with facts that in all thermodynamic experiments the effects of non-ideality were not still covered. Thermodynamic effects of plasma non-ideality are always weak in this model of non-ideal plasma.

The model of plasma non-ideality is constructed on the basis of the original model of plasma microfield. The model of plasma microfield is constructed “ab initio”: the dimension principle for scale of plasma microfield and effects of similarity. This theory shows plasma microfield distribution is Maxwell distribution but not Holtsmark. This distribution of microfield is described by simple formula in enormous range of temperatures and densities. This formula is reasonable confirmed by luminosity of lines in experimental spectra of high-dense plasma.