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Referee report on the Ph.D. thesis of Tomiris Ismagambetova

Dear Prof. Maratbek Gabdullin,

the Ph.D. student Ms. Tomiris Ismagambetova from the Al-Farabi Kazakh National University visited the Institute of Physics of the University of Rostock, Germany, from September 20 to December 15 in 2018 based on the tripartite collaborative agreement for doctoral training with Professor M.T. Gabdullin and the Al-Farabi Kazakh National University in Almaty.
During the visit in my Statistical Physics Group she worked intensively on her Ph.D. thesis on "Structural and thermodynamic properties of non-ideal quantum plasma". She studied a classical-map HNC code for calculating the structural properties of non-ideal plasmas and a COMPTRA04 program package for obtaining transport and optical properties of non-ideal plasmas. In addition, she studied the theory for the ionization equilibrium in non-ideal plasmas, calculated ionization states for given densities and temperatures, and developed a corresponding program in C++ with the eventual goal to apply the obtained skills to calculate the structural and thermodynamical properties of non-ideal plasmas for conditions relevant for astrophysical objects like gas giant planets, brown dwarfs, and main sequence stars. She presented the results of her work in our weekly group seminar and in a poster session of the 16th International Conference on the Physics of Nonideal Plasmas in Saint Malo, France, before her stay in Rostock.
Ms. Ismagambetova submitted her Ph.D. thesis in the field of plasma physics under the supervision of Prof. Dr. Maratbek Gabdullin and in consultation with me. The main goal of the Ph.D. thesis was to study the structural and thermodynamic properties of sense quantum plasmas based on models for the effective interaction between the particles. In her thesis, Ms. Ismagambetova used several methods for that purpose. First, she applied linear dielectric response functions to obtain effective interaction potentials. Second, the method of integral equations was used for calculating the radial distribution functions (RDF) using these effective potentials. The RDFs were subsequently employed to calculate important thermodynamic

functions such as the equation of state of dense quantum plasmas for a wide range of densities and temperatures.

One of the main results of the Ph.D. thesis work of Ms. Ismagambetova is the derivation of a novel effective interaction potential between semiclassical ions in quantum plasmas by taking into account the screening effects of the electrons and in addition the quantum effect of ion diffraction. Based on this effective interaction potential, the RDFs and the thermodynamic properties of a one-component hydrogen plasma were calculated. In the second part of her Ph.D. thesis, the influence of the Pauli exclusion principle on the structural properties and the thermodynamic functions was studied in the framework of the effective screened interaction potential of particles in a two-component plasma with semiclassical electrons and classical ions.

The results obtained in the Ph.D. thesis work of Ms. Ismagambetova contribute to a better understanding of dense quantum plasmas and can thus be applied to astrophysical objects as well as to practical applications of plasma physics. A sound knowledge of the interaction between the particles in a dense quantum considering screening and diffraction effects is also important for the interpretation of state-of-the-art shock-wave compression experiments using high-power lasers, heavy ion accelerators, and intense X-ray beams. For instance, in close ion-ion collisions the wave nature of the target ions should be considered. Another important problem is to take into account the nonideality of ions along with the partial or complete degeneracy of electrons on the basis of the effective ion interaction potential derived in this work. The study of the influence of quantum effects on the structural and thermodynamic properties of plasma makes it also possible to determine the dynamic and transport properties which are necessary for designing and modeling compression pathways in Inertial Confinement Fusion (ICF) experiments.

Tomiris Ismagambetova has worked independently on these challenging topics of theoretical plasma physics and executed all tasks successfully. The submitted Ph.D. thesis is of very good quality and meets all requirements of an international Ph.D. standard. The results were published in four international journals and in three national publications.

With best regards

R Redmer

Prof. Dr. Ronald Redmer

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