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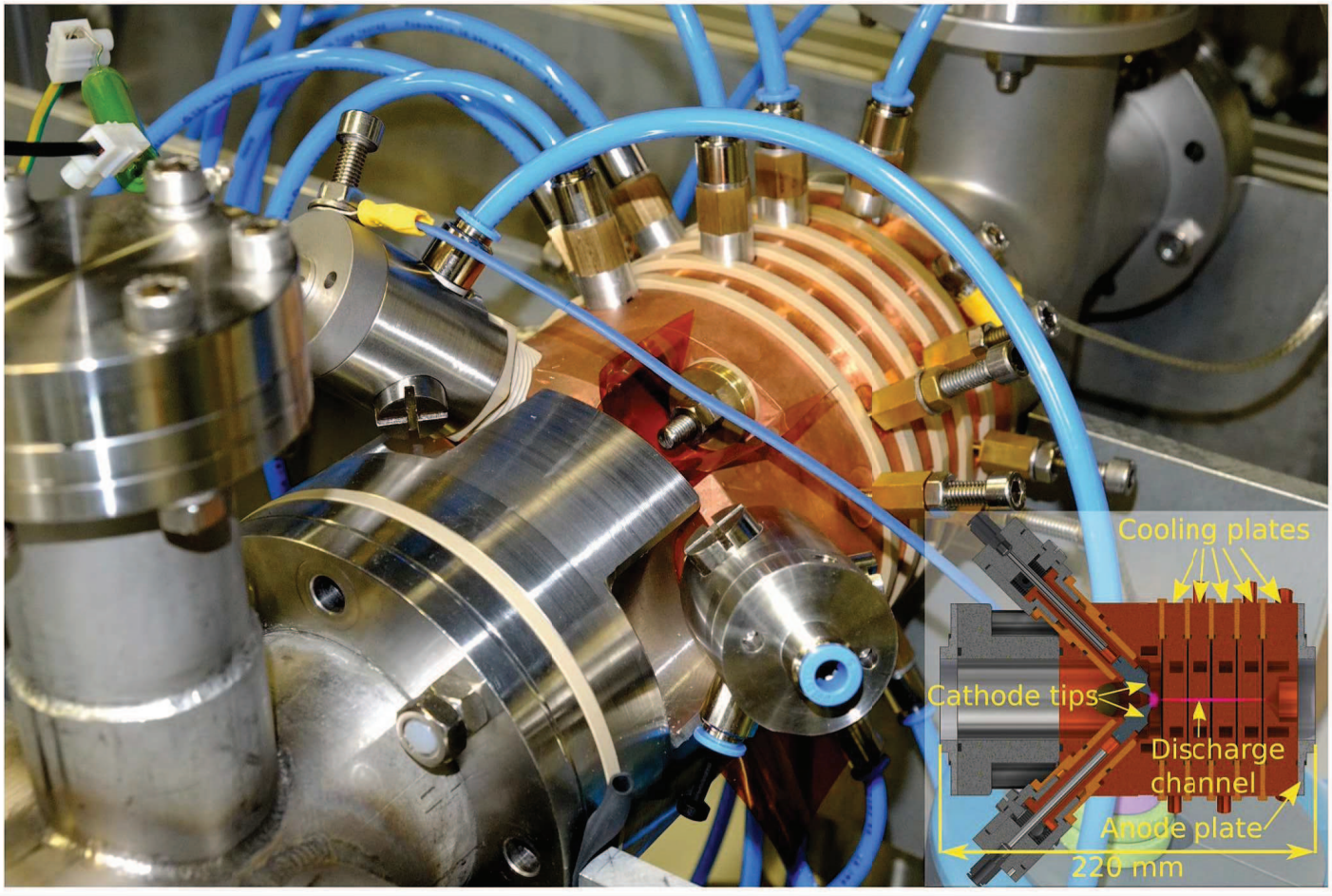
News and Reports from

High Energy Density generated by Heavy IOn and Laser Beams



HEDgeHOB Collaboration at FAIR - Report 2015

Force-force correlations in warm dense plasmas. Influence of the ion-structure *

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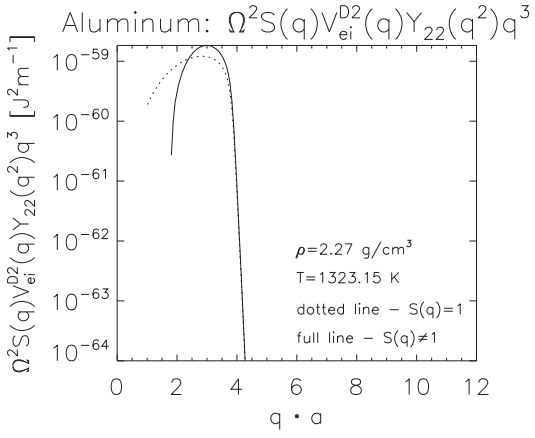
In warm dense matter, the transport coefficients of plasmas are strongly influenced by the ion distributions, i.e. by the ion-ion structure factor S [1-4]. The larger the ratio of the ion-ion potential energy to the ion kinetic energy Γ, the stronger the effect. On the other hand, it is believed that the hypernetted chain (HNC) approximation and the mean spherical (MS) approximation for S are applicable for systems with large Γ. Thus, in the present work, force-force correlation functions of ions and electrons in warm dense matter are calculated within Born approximation neglecting the ion-ion structure factor and considering it. In doing so, for S values are taken into account, which were observed in experiments or are calculated using HNC or MS approximations. It is found that the values of the correlation functions vary up to 20 percent in the special region of wave numbers $1 \leq qa \leq 4.5$, where a is the mean ion distance (see Fig. 1). The here obtained correlation functions may be used to calculate transport coefficients.

Numerical calculation

In Born approximation, i.e. in second order with respect to the interaction potential of the charged particles, one finds for the electron-ion force-force correlation functions

$$[M_{ei}^{(m)}; M_{ei}^{(n)}] = \frac{N m_e^2}{12\pi^3\hbar^3} \int_o^\infty I^{mn}(q)\, dq,$$



$$I^{mn}(q) = q^3 S(q) |V_{ei}(q)|^2 Y^{mn}(q^2),$$

where $V_{ei}(q)$ is the Fourier transform of the Debye potential screened by the electrons [4]. M_{ei}^0 are forces due to the particle current, and M_{ei}^2 - forces because of the heat current. The function $Y^{mn}(q^2)$ is given in [3] (Y^{02} has an additional summand $-2z$).

Figures 1 shows the function $I^{22}(q)$ in dependence on the normalized wave number aq. The calculations are performed for aluminum at 1323.15 K and electron densities of $5.07 \cdot 10^{28}$ m^{-3}. For the ion-ion structure factor $S(q)$, experimental data are used [5]. The chemical potential is estimated using the interpolation formula derived by Zimmermann [6]. In the work [7], the applicability of the Zimmermann formula was shown for electron gases at 12000 K and densities of 10^{24}-10^{30} m^{-3}. The full line in Figure 1 represent results taking the ion-ion structure factor into account and the dotted line shows results neglecting the structure factor.

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