The nuclear stopping calculation in the semiclassical approximation

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<u>P.Yu. Babenko</u>, A.N. Zinoviev

Ioffe Institute, Saint Petersburg, Russia
e-mail: babenko@npd.ioffe.ru

Abstract

The results of calculating nuclear stopping in the semiclassical approximation for the systems H-Be, H-C, H-W, O-C, O-Be, O-Al are presented. It was found that in the presence of a well in the interatomic interaction potential, an additional maximum appears in the dependence of the nuclear stopping on the energy of the bombarding particles. When using the universal potential without a well, this feature is absent. It is shown that by scaling the data obtained for systems with hydrogen are recalculated for collisions with the participation of hydrogen isotopes D and T. The results obtained are in good agreement with classical calculations, which is explained by the fact that large scattering angles make the main contribution to the nuclear stopping, and the applicability criterion changes to the condition: angular momentum ℓ >> 1.

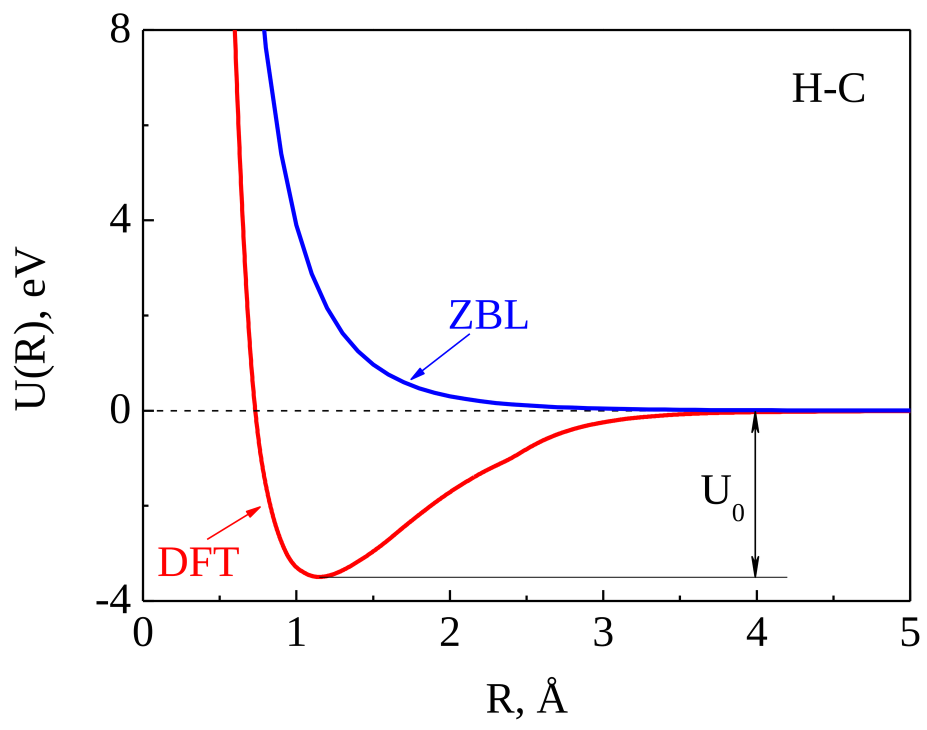

Fig. 1. The interaction potential dependence on the distance between atoms for the H-C system. The blue line is the ZBL potential, the red line is the DFT potential. The depth of the well in the potential is denoted by U_0.

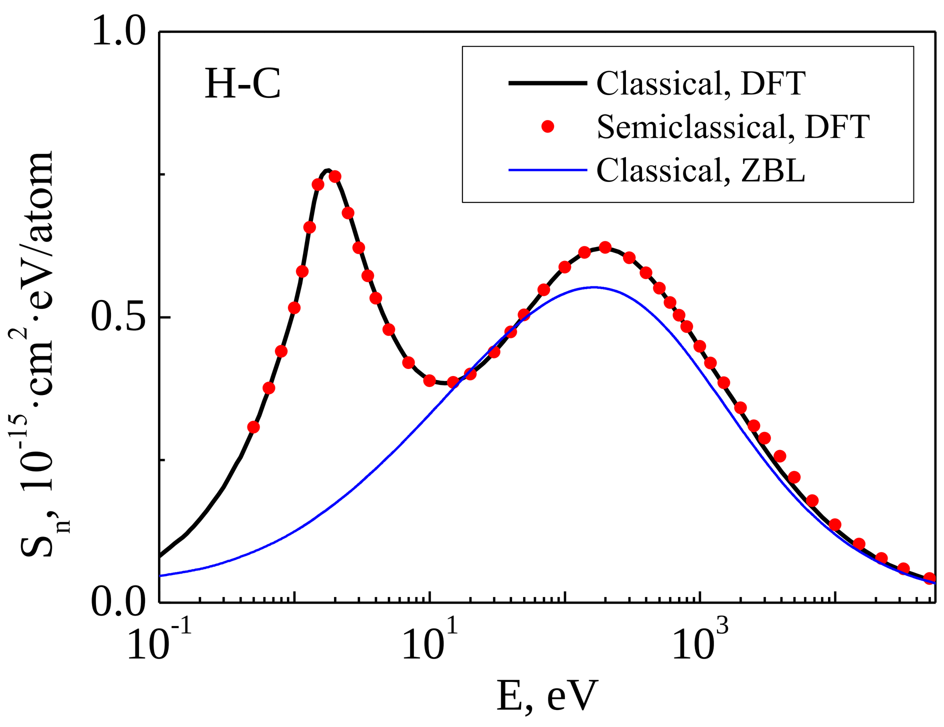

Fig. 2. The nuclear stopping cross section dependence on the incident particle energy for the H-C system. Blue line - "classic" and potential of ZBL, black line - "classic" and potential of DFT, dots - "quasi-classic" and potential of DFT.

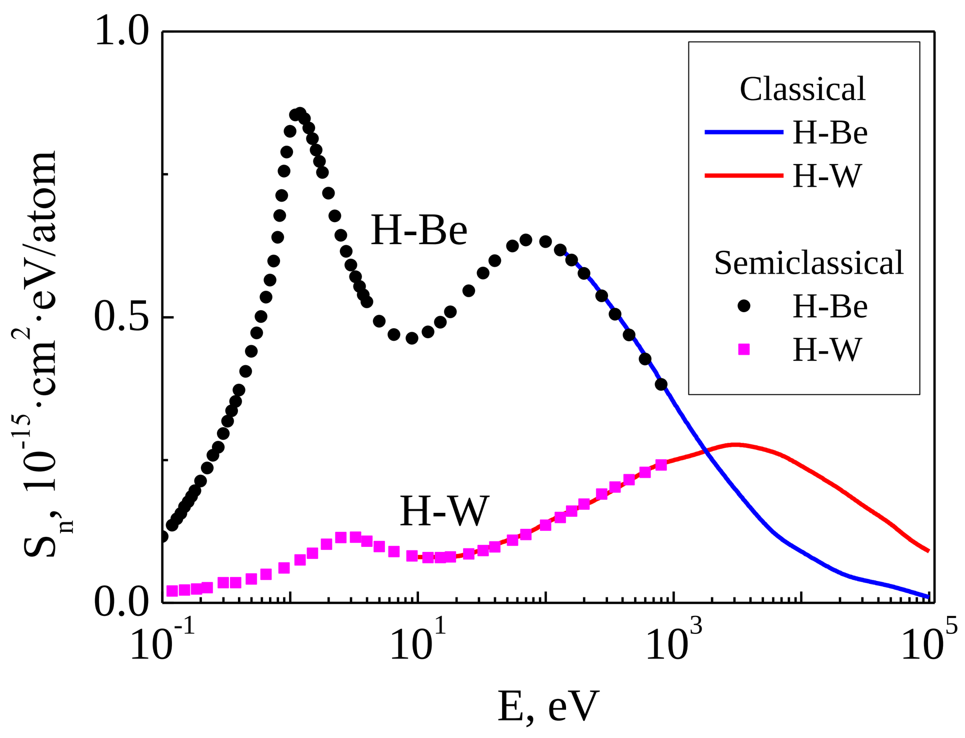

Fig. 3. The nuclear stopping cross section dependence on the incident particle energy for the H-Be and H-W system. Lines - "classic" and DFT potential, points - "quasi-classic" and DFT potential.

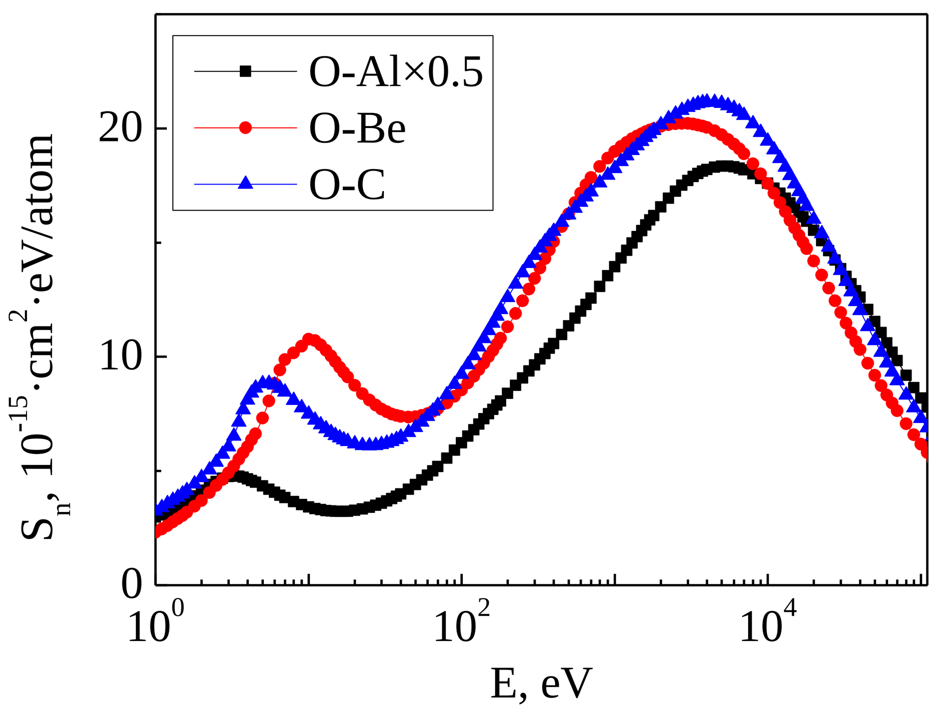

Fig. 4. Dependence of the nuclear stopping cross section on the collision energy for various systems with oxygen.

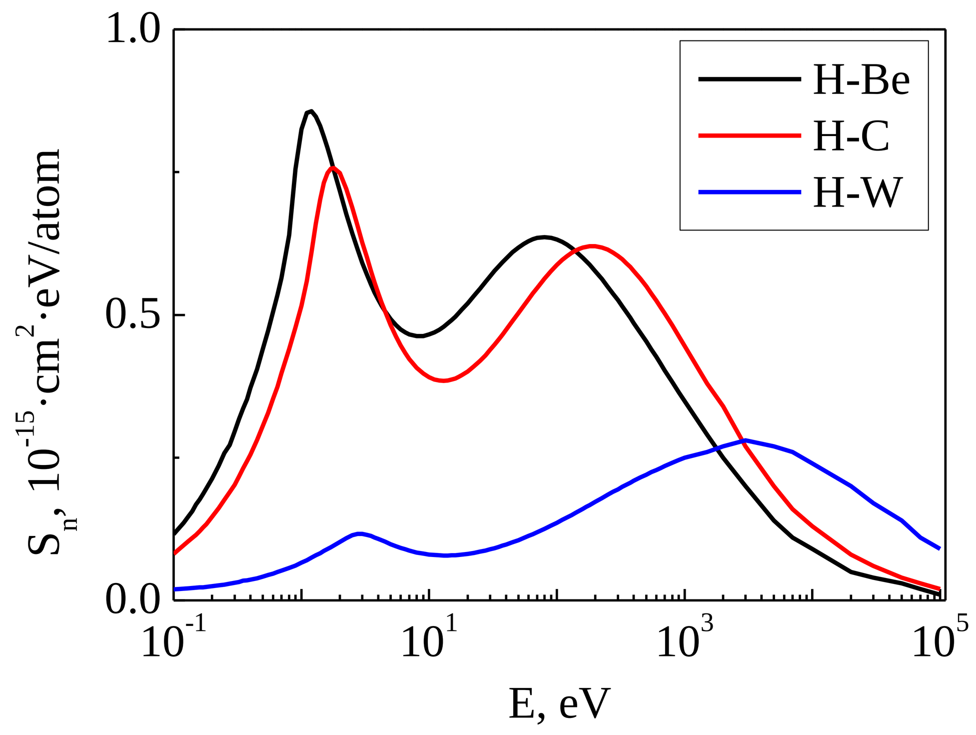

Fig. 5. Nuclear stopping for H-Be, H-C, H-W systems.

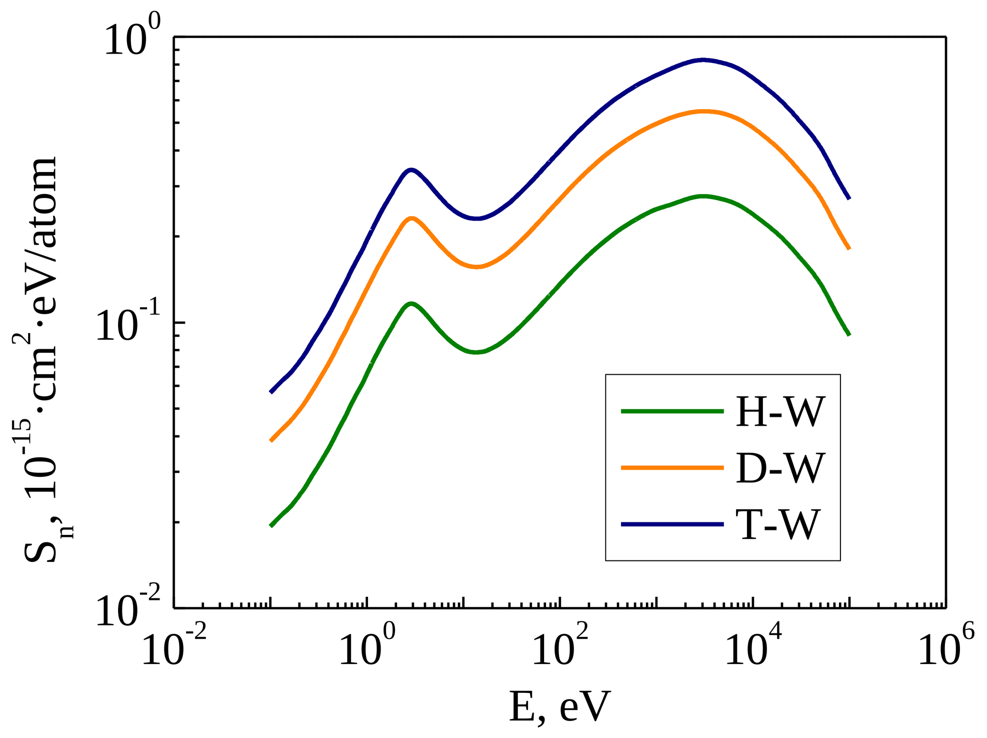

Fig. 6. Nuclear stopping for H-W, D-W, T-W systems.

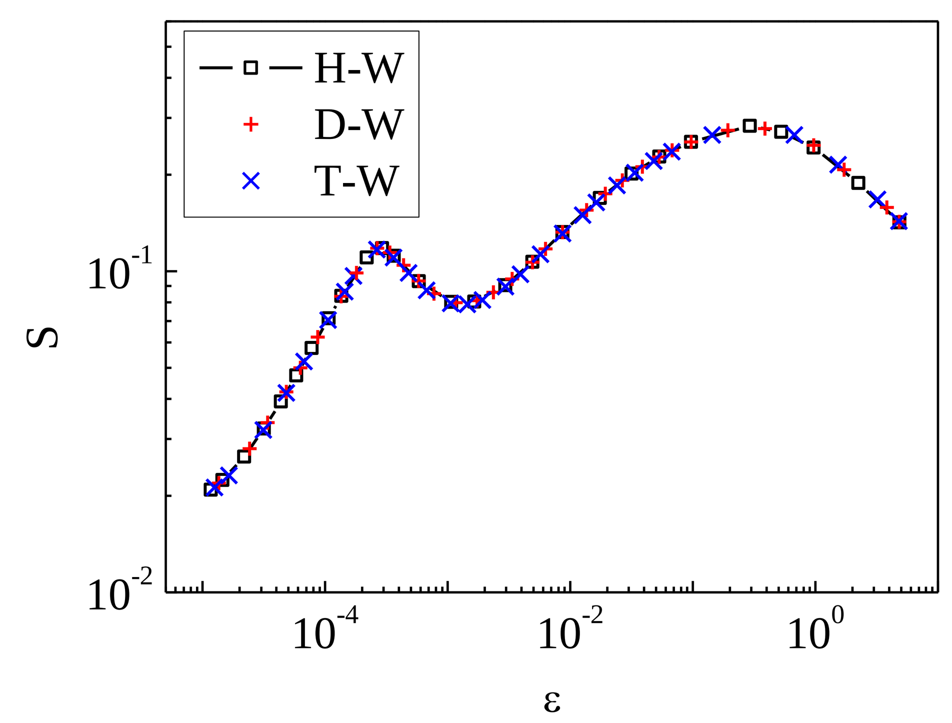

Fig. 7. Nuclear stopping data for the same systems in universal coordinates.

CONCLUSIONS

Calculations of the nuclear stopping cross sections for the H-Be, H-C, H-W systems have been performed, which are of interest for calculating processes in the near-wall region of a tokamak-reactor, as well as for some systems with oxygen (O-C, O-Be, O-Al). It is found that an additional peak appears in the dependence of the nuclear stopping cross section on the collision energy, associated with scattering by an attractive well in the potential.

It seems important that the results obtained in the semiclassical approximation practically coincide with the data obtained by the methods of classical mechanics. This greatly simplifies calculations for other systems.

It was found that the nuclear stopping cross sections for various hydrogen isotopes are recalculated by simple renormalization.

It should be noted that the calculations of the nuclear stopping in this work were performed for scattering at a potential corresponding to the ground state of the system. When considering particle collisions, one should take into account the multichannel scattering, i.e. the possibility of simultaneous scattering by a set of terms corresponding to both the ground and excited states of the system. For energies above 100 eV, this difference is insignificant, while at lower energies the influence of attraction has a weaker effect on the potentials describing scattering by excited states. Accordingly, the influence of the additional peak will be less pronounced. We plan to take into account corrections related to multichannel scattering in the future. The main difficulty here is associated with obtaining reliable data on the potentials for excited states.