improved approximations of cross sections and rates of thermonuclear reactions

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***Introduction.*** For simulations of the controlled fusion (CF) problems, one needs to know the dependences of the reaction rates  on temperature. The most important reactions are , , , , however, numerous other reactions are taken into account [1]. The reaction rates are obtained from experimentally measured dependences of the reaction cross sections  on energy. Many experimental works are published [2]; however most of them possess low accuracy.

***Set of reactions.*** We consider reactions which satisfy 2 conditions. Firstly, the reaction must be significant compared with the  and  reactions in the actual energy range ( keV). We account for the reactions for which the cross sections are at least 1% of the mentioned reference reactions. Secondly, cross section data must be known for low enough energies from which extrapolation to zero energy is possible according to the Gamow law. Such extrapolation implies that the S-factor (equal to the cross section divided by the quasi-classical Coulomb barrier penetrability) is extended to the lower energies as a constant.

From more than 50 reactions outlined in [1], only one reaction  turns out to satisfy the mentioned conditions. Note that in astrophysical problems (e.g., supernovas explosions), the achievable temperatures are sufficiently higher than in the CF set-ups. In such problems, the significant reactions should be chosen from softer conditions providing larger reaction set.

***Cross section.*** For the S-factor of the selected reaction, we construct approximation via the proposed earlier regularized double period method [3]. In the method, approximation of a non-periodic function is constructed from specific over-determined Fourier series. Also, penalty is introduced for large values of the second derivative of the approximation curve. This allows to damp non-physical oscillations of the latter. For this method, a procedure is proposed providing the confidence belt of the approximation curve. For the considered reaction, the accuracy of the approximation is ~0.1% for energy range 2 keV – 5 MeV.

***Reaction rates.*** To obtain the reactivity, we multiply the S-factor by the Gamow factor and the Maxwellian distribution and perform integration numerically. The confidence belt of the calculated reactivity is ~1%.

References

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