REVIEW

for the dissertation by Yeleusheva Badigul Maratovna
"Radiative capture reactions on light nuclei in stellar and interstellar plasma",
submitted for the degree of Doctor of Philosophy (PhD) of the educational program
8D05308 – "Nuclear physics"

The main goal of the research was to investigate the selected radiative capture reactions on light 1p-shell nuclei related to the special conditions of stellar and interstellar plasma occur at the initial stage of post BBN, homogeneous and inhomogeneous early Universe, solar and stellar CNO cycles.

Since the 1p-shell nuclei are very specific in their individual features – angular momentums and spin-isospin symmetry, dynamic and static characteristics, – each study of (N,γ) reaction turns to be a wise complicated problem both quantitative and qualitative. Reactions ^{8}Li$(n,\gamma_{0+1})^{9}$Li, ^{9}Be$(n, \gamma_{0+1+2+3+4+5})^{10}$Be, ^{13}B$(n, \gamma_{0+1})^{14}$B, and ^{15}N$(p,\gamma)^{16}$O investigated in present thesis are incorporated in treating of the declared goal in different planes. I will conclude, that Yeleusheva Badigul succeeded in solution of all scheduled tasks and overcame all challenges.

One of impressive illustration of mine statements is the considering of ^{8}Li$(n,\gamma_{0+1})^{9}$Li reaction. For the first time, a model-free criterion for evaluating the reliability of the calculated reaction rates is proposed due to the binding energy in the nucleon channels ^{6}Li$(n,\gamma)^{7}$Li , ^{7}Li$(n,\gamma)^{8}$Li, and ^{8}Li$(n,\gamma)^{9}$Li. The same criterion allows to estimate the range of the asymptotic normalizing coefficients (ANCs) providing correct long-range behavior of radial bound state functions.

Research of ^{9}Be$(n, \gamma_{0+1+2+3+4+5})^{10}$Be reaction is an example of an almost exhaustive study, since five bound states and five resonances are included in consideration. Excellent agreement with available experimental data is demonstrated, but also some predictions on the cross sections, ANC and reaction rates have been proposed.

A completely unique situation has developed around the reaction ^{13}B$(n,\gamma_{0+1})^{14}$B: there is practically no objective experimental data on the n + ^{13}B channel, no ANC, no thermal cross sections, or reliably measured total cross sections. This problem turned a real challenge. Finally, the substantiated and implemented calculations of the total cross sections of ^{13}B$(n,\gamma_{0+1})^{14}$B reaction are suggested as proposal for the future experiments which are extremely in demand, as the strong conclusion that the ^{13}B$(n,\gamma_{0+1})^{14}$B reaction in the Boron-Carbon-Nitrogen chains is not *the break-point* of the Boron sequence might be checked.

Reaction ^{15}N$(p,\gamma)^{16}$O is a key one in the CNO cycles occurs on the Sun and sun-like stars. The corresponding astrophysical *S*-factor is measured quite accurately within the different methods in different laboratories, which provide the cross-check of obtained data. Intensive study of this reaction performed applying indirect ANC method, *R*-matrix method, EFT model and others are matching of the experimental data in sense. The specific feature of ^{15}N$(p,\gamma)^{16}$O reaction is two overlapping $^{3}S_{1}$ resonances, that is why in present thesis the interference effect was considered within the MPCM approach. It was demonstrated that the model treating of this reaction allows to simulate the interference pattern based on the physical assumptions, but not on the fit of experimental data.

For the first time the re-estimation of the astrophysical S-factor for the $^{15}N(p,\gamma)^{16}O$ reaction in the framework of MPCM includes *magnetic non-resonance M1 transition* and its consequent input into $S(0)$ and low-temperature reaction rate. The simulation of considering the experimentally observed *cascade transitions* is suggested.

Comparative analyses of the reaction rates for $^{12}N(p,\gamma)^{13}O$, $^{13}N(p,\gamma)^{14}O$, $^{14}N(p,\gamma)^{15}O$, $^{15}N(p,\gamma)^{16}O$ reactions involved into different branches of the CNO cycle obtained in the framework of the same model, MPCM is implemented.

I would classify as quintessential the result of research formulated as regularity – *the higher the channel threshold, the higher the reaction rate*. This effect is conditioned and observed for $^{6,7,8}Li(n,\gamma)^{7,8,9}Li$, $^{10\text{-}13}B(n,\gamma)^{11\text{-}14}B$ and $^{12,13,15}N(p,\gamma)^{13,14,16}O$ reactions, and it seems very perspective to continue this research

All obtained results are new and perspective for the future applications and developments.

During the research Badigul Yeleusheva has established herself as a competent young scientist, able to independently solve the scientific problems assigned to her. This is confirmed by publications in high-ranking scientific journals, such as Frontiers in Astronomy and Space and Chinese Physics C, and presentations at international scientific conferences, including 25th European Conference on Few-Body Problems in Physics (EFB25), Mainz, Germany.

I believe that the results obtained in the work fully comply with the requirements for the results of the dissertation of Doctor of Philosophy, and the applicant Badigul Yeleusheva undoubtedly deserves the award of the degree of Doctor of Philosophy (PhD) of the educational program 8D05308 – "Nuclear physics".

Local scientific supervisor:
Doctor of Science, Professor N.A. Burkova

Қолын растаймын
Подпись заверяю

«Әл-Фараби атындағы Қазақ ұлттық университеті» коммерциялық емес акционерлік қоғамы
Некоммерческое акционерное общество «Казахский национальный университет имени аль-Фараби»
Non-profit joint-stock company «Al-Farabi Kazakh National University»
ӘЛ-ФАРАБИ УНИВЕРСИТЕТІ
БИН 990140001154