Resonances in low-energy nuclear processes and nuclear astrophysics and asymptotic normalization coefficients. A review

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This paper is continuation of the previous review [Mukhamedzhanov and Blokhintsev, Eur. Phys. J. A **58**, 29 (2022)] in which the asymptotic normalization coefficient (ANC) of a bound state was addressed. However, the ANC is important characteristics not only of bound states but also resonances. In this paper, the role of the ANCs in resonance processes is addressed. Among various topics considered here are Gamow-Siegert resonance wave functions for charged particles and their normalization, relationship between ANCs and resonance widths. Significant part is devoted to the R-matrix approach for resonance processes. The resonance wave functions, internal and external and their projections on the two-body channel are given. Important ingredients of the R-matrix method for resonance states are also discussed. Elastic resonance scatterings are analyzed and extended for subthreshold resonances. It is shown how the notion of the subthreshold resonance works in practical analysis. To this end, the ^{13}C(alpha, n)^{16}O reaction, which is considered to be the main neutron supply to build up heavy elements from iron-peak seed nuclei in AGB stars, is analyzed. Important part of the review is analysis of the relationship between resonance width and ANC of mirror resonance and bound states using the Pinkston-Satchler equation and the Wronskian method. Practical examples are given. Among important parts of the theoretical research is the theory of transfer reactions populating resonance states. Comparative analysis of prior and post-form DWBA amplitudes shows that the prior form is preferable over the post form due to faster convergence of the matrix element over the radius rnA between the transferred neutron and target . Calculations of the stripping to resonance reaction ^{16}O(d; p)^{17}O(d3/2) performed using the prior form of the CDCC method. A special attention is given to resonance astrophysical processes. Useful equations for internal and external radiative widths are given. Radiative capture through subthreshold resonance is considered. In particular, radiative capture reactions ^{11}C(p,gamma)^{12}N and ^{15}N(p,gamma)^{16}O and the role of the ANC is addressed in detail.

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