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**Imaginary time approach for reaction rate of triple-alpha process**

KAZUHIRO YABANA, Center for Computational Sciences, University of Tsukuba, TAKAHIKO AKAHORI, Graduate School of Pure and Applied Sciences, University of Tsukuba, YASURO FUNAKI, RIKEN Nishina Center — We propose a new theoretical approach for the radiative capture reaction rate, which we call the imaginary-time theory. In the theory, inverse temperature is identified with the temperature. Since reaction rates can be calculated without solving any scattering problem in the theory, it is ideally suited for the triple-alpha process in which scattering problem of three charged particles has caused difficulties. Using the imaginary-time theory, we obtain the triple-alpha reaction rate in the quantum three-body model treating alpha particles as structureless point particles. The calculated rate is almost identical to the standard NACRE rate. We have also found that the reaction mechanism of the triple-alpha process changes at exactly the same temperatures as those in empirical theories. We may show that it is possible to derive an analytical formula close to that of the NACRE rate, if we introduce some assumptions in the three-body model. We demonstrate that, if we introduce a coupled-channel expansion with a truncation, reaction rate is substantially overestimated. This finding may help to explain the very different reaction rates obtained so far using different theoretical approaches.

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