A new perspective on thermonuclear reactions

The mechanism of nucleosynthesis from light particles into heavier ones in the early universe has attracted a lot of attention in nuclear astrophysics [1-3]. With great efforts made both experimentally and theoretically, many data of thermonuclear reaction rates on stable targets are now available, and large data sets of nuclear astrophysics regarding the theoretical work on the binding energy, cross section and rate calculations are obtainable via different models. For example, the JINA REACLIB database, which is maintained by the JINA Collaboration, covers more than 8000 nuclides and over 80000 nuclear reactions, together with various parameters for calculating reaction rates, Q values and so on.

Recently, a research group from Fudan University, China, led by Prof. YuGang Ma performed a multilayer-directed nuclear reaction network analysis by combining the JINA REACLIB database with the substrate-product method in complex network science, in which nuclides act as nodes, reactions act as edges, and the number of reactions at each node acts as degrees. The nuclear reaction network is labeled by the edge respectively with the n-layer for neutrons, the p-layer for protons, the h-layer for ^4He , and the r-layer for the reminder. By investigating the properties of the four-layer nuclear reaction network, they found that the r-layer has a more complex topological structure in comparison with the other three layers, and that the degree-degree correlations are stronger for the np-, nh- and ph-layers that generally display almost linear behaviors, while those of the r-layer with the n-, p-, and h-layers seem weak. They also used the “mfinder” software to analyze the motif structure of the nuclear reaction network and identified the most frequent reaction patterns of interconnections occurring in different nuclides in the nuclear landscape [4].

The present work gives a new perspective on nuclear reactions by applying the construction of multilayer nuclear reaction networks, thus providing a big-data type study for the network of nuclear reactions, and shedding new light on this area of study.

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