Particle Identification by Pulse-Shape Analysis with Neural Network

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Recent cluster-model calculations predict that α condensed states emerge in self-conjugate $N = 4n$ nuclei. In the α condensed states, all of the α clusters are condensed in the lowest energy orbit, and their matter density is as low as 1/4 to 1/5 of normal nuclear states. Thus, observation of the α condensed states is important for clarifying physical properties of low-density nuclear matter, for example, appearing on the surface of neutron stars.

The α condensed states are expected to decay by emitting multiple α particles. However, it is predicted that the emitted α particles have low energies about 1—3 MeV. It is difficult to identify such low-energy particles by conventional $E - \Delta E$ telescopes, because these particles cannot penetrate the ΔE detector. There is also a method to identify particles from a correlation between energy and time of flight. However, in order to improve mass resolution, it is necessary to increase distance between emission sources and detectors, thus solid angles of the detectors become smaller. In order to search for the α condensed states, it is essential to establish a new method to identify low energy α particles with covering large solid angles.

In the present study, we have attempted to identify particles by analyzing pulse shape output from Si detectors. This method has been somewhat successful mainly for high-energy heavy ions, but it has not been established for low-energy light ions.

In the conventional pulse-shape analysis, particle identification was performed by defining several parameters that characterize the pulse shape and comparing them between different particles. On the other hand, we tried to go beyond the limits of conventional methods by performing multi-dimensional analysis with a neural network which has developed significantly in recent years. We acquired pulse shapes for known particles and used them to train the neural network. We will report details of our study and performance of the particle identification method with the neural network.