Fission modes of neutron-rich nuclei in the r-process nucleosynthesis

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In the r-process study on nucleosynthesis, the following nuclear information is called for; (n,γ) and (γ,n) reaction rates, β-decay rates, various fission rates and fission fragments mass distribution (FFMD). There are mainly four kinds of fission processes which are important in the r-process; β-delayed fission, neutron induced fission, fission after β-delayed neutron emission and neutrino induced fission. Fission processes are indispensable to understand the whole picture of the r-process nucleosynthesis, because the fission process during and after the freeze-out of neutron density may affect strongly the element abundance patterns. For example, fission may affect the termination of the r-process, and also before the neutron freeze-out, the fission products from transuranium region may rejoin the r-process nucleosynthesis (so-called fission cycling). However, there are only a few groups which perform the network calculation taking into accounts of FFMD \cite{1, 2}. Furthermore, the theoretical estimation of FFMD has never been established. In the present paper, the attention is focused on the FFMD and the role of fission in the r-process nucleosynthesis.

We estimated FFMD by searching the local minimum of the potential energy surface (PES) between the saddle point and the scission point on about 2000 nuclides (Z>85). The PES is calculated by using the liquid drop model with the microscopic correction of the two-center shell model in three-dimensional parameter space which is composed of the distance of the center of two-harmonic oscillators, the deformation of the fragments and the mass asymmetric parameter. The details of determining FFMD are discussed. From the analysis of FFMD, we found the tendency that all neutron-rich nuclei, except that they are near Z~100 and N~164 (double magic), decay into asymmetric fragments via fission. In the present work, we also carried out the network-calculation on the r-process in consideration of FFMD. The comparison of the results of the network-calculation, with and without fission processes, is shown.

References
\cite{1} I. V. Panov et al., Nucl. Phys. A 747 (2005) 633-654  
\cite{2} A. Kelic and K. Schmidt, Proceedings of International Symposium on Nuclear Astrophysics (NIC-IX), Switzerland (2006), p. 63