PROBING THE CLUSTERING EFFECTS IN NUCLEAR EXCITATIONS

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Clustering is of fundamental importance in structure studies at all levels, from celestial bodies to elementary particles， and appears as intriguing phenomenon in many systems, including nuclide. The stable nuclide is basically described according to the independent particle model, in which the nucleons are moving almost freely in a mean field, although clustering phenomenon may appear in some special cases. But for nuclei far from the β-stability line cluster or molecular structures seem enhanced due most likely to the low-binding energy, size expansion and coupling to the continuum states. This change of the structure degree of freedom would cause dramatic evolution of the nuclear properties and their theoretical descriptions, which may have large impact on the nuclear technique applications and the understanding of the r-process in nuclear astrophysics.

So far the cluster structure has been experimentally identified in several states in stable nuclei, but its observation in unstable nuclei is still very scarce and often under disputing. A clear finding of a cluster state in a nucleus is very challenging, since it requires experimental determination of the excitation energy and spin systematics associated with a rotational band, the cluster decay partial width and the characteristic transition strength. The latter has recently been emphasized in case of monopole transition between states with relatively small energy separation.

An inelastic excitation and decay experiment for neutron-rich ^{12}Be at 29 MeV/nucleon was performed by our experimental nuclear physics group at the HIRFL-RIBLL facility in Lanzhou [1]. Thanks to the application of a specially designed 0-degree telescope, a remarkably large peak around 10.3 MeV, just above the cluster separation threshold, is identified. Based on the angular correlation analysis, the spin-parity of this state is determined to be 0^+, being the band head of the proposed molecular rational band. Furthermore according to the DWBA analysis, an enhanced monopole matrix element of 7.0 +/- 1.0 fm2 in the ^{4}He + ^{8}He decay channel is extracted, corresponding to the typical property of the transition among cluster states. In addition this resonant state possesses a large cluster-decay branching ratio, resulting in a large dimensionless reduced width of 0.53 +/- 0.10. These results reveal a typical cluster state in ^{12}Be, in agreement with the GTCM prediction. In particular the observation of the enhanced monopole strength in an unstable nucleus has opened new possibilities for probing exotic structure at the vicinity of the neutron drip-line. Detection around 0-degrees with the silicon-strip telescope is essential in observing the resonance close to the cluster decay threshold. It would be desirable to further apply this method in subsequent similar studies.

We report also the latest experimental results for excitations of the cluster degree of freedom in the neutron rich nucleus ^{20}O.

REFERENCES

[1] Z.H. Yang, Y.L. Ye, Z.H. Li, et al., Phys. Rev. Lett. 112(2014)162501.