Odd-Even Staggering in Fragment Yields from ^{78}Kr+Be Reactions *

B. Mei[1,2,3]*, H. S. Xu*[1]*, X. L. Tu*[1,2,4]*, Y. H. Zhang*[1]*, Yu. A. Litvinov*[1,2,4]*, K. -H. Schmidt*[2]*, M. Wang*[1]*, Z. Y. Sun*[1]*, X. H. Zhou*[1]*, Y. J. Yuan*[1]*, M. V. Ricciardi*[2]*, A. Kelić-Heil*[2]*, R. Reifarth*[3]*, K. Blaum*[4]*, R. S. Mao*[1]*, Z. G. Hu*[1]*, P. Shuai*[1,5]*, Y. D. Zang*[1]*, X. W. Ma*[1]*, X. Y. Zhang*[1]*, J. W. Xia*[1]*, G. Q. Xiao*[1]*, Z. Y. Guo*[1]*, J. C. Yang*[1]*, X. H. Zhang*[1]*, X. Xu*[1]*, X. L. Yan*[1,4]*, W. Zhang*[1]*, and W. L. Zhan*[1]

[1]IMP, Lanzhou; [2]GSI, Darmstadt; [3]University of Frankfurt; [4]MPIK, Heidelberg; [5]USTC, Hefei

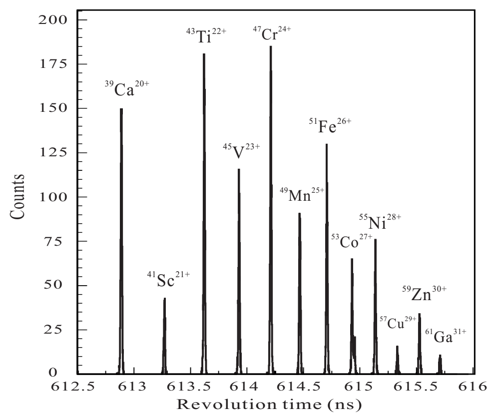

Figure 1: A part of the measured revolution time spectrum of the $T_z = -1/2$ nuclides produced in ^{78}Kr fragmentation reactions on Be target.

Nuclear fragmentation yields can provide unique information on nuclear structure properties, e.g. pairing, shell effects, and densities of excited levels. Odd-even staggering (OES) in the fragment yields, that is the enhancement in the yields of the even-Z nuclides compared with the neighbouring odd-Z nuclides, has been observed for different fragmentation reactions [1]. But an understanding of the origin of this OES is not yet reached. Our study allowed for the first time to quantitatively understand the origin of this OES.

OES in the fragment yields has been measured in the storage ring CSRe at the HIRFL-CSR facility in Lanzhou [2]. The fragments were produced in the ^{78}Kr+Be reactions at an energy of 482.9 AMeV. The $T_z = -1/2$ and $T_z = 1/2$ nuclides of interest were transmitted through RIBLL2 and injected into CSRe, which was tuned into an isochronous mode [3]. In this mode the revolution times of ions, which were measured using a dedicated time-of-flight detector [4], are used to measure their m/q values. Fig. 1 shows a part of the measured revolution-time spectrum of the $T_z = -1/2$ nuclides.

The momentum distributions and the transmission efficiencies for various fragments were estimated by using the LISE++ program [5]. The transmission efficiency varies almost smoothly with Z along a chain of nuclides with a constant T_z. The yields of $T_z = -1/2$ and $T_z = 1/2$ nuclei are presented in Fig. 2. The OES is very evident for the yields of the $T_z = -1/2$ nuclei, but small for the $T_z = 1/2$ nuclei. For the $T_z = -1/2$ nuclei, a sharp drop of the fragment yields near the closed shells $Z = 20$ and 28, where the strongest OES is shown, is observed for the first time. To our knowledge, no nuclear reaction model can reproduce the above OES over such a wide range of mass numbers, especially for the $T_z = -1/2$ nuclei.

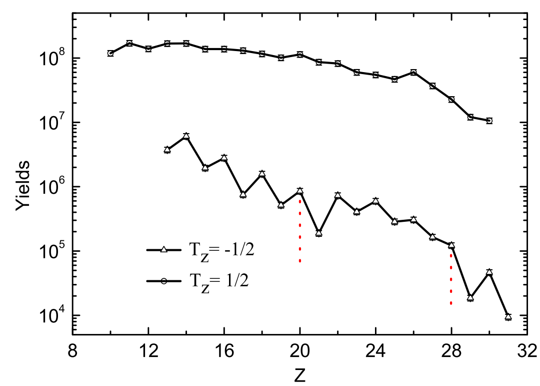

Figure 2: Fragment yields of $T_z = -1/2$ and $T_z = 1/2$ nuclei measured in this experiment. The closed shells $Z = 20$ and 28, where the strongest OES is reached for the $T_z = -1/2$ nuclei, are indicated.

The measured OES in the yields for the $T_z = -1/2$ and $T_z = 1/2$ mirror nuclei enabled us to compare the relative OES in fragment yields and the relative OES in PETE of mirror nuclei [6]. This comparison reveals unambiguously that the origin of the OES of fragment yields is mainly determined by the OES of the particle-emission threshold energies, where the impact of both pairing correlations and evident shell effects are clearly observed.

* Work supported in part by the BMBF WTZ grant (No. 01DO12012), by the Helmholtz-CAS Joint Research Group HCJRG-108, by the HGF Young Investigators Projects VH-NG-327, by the ESF through EuroGENESIS program, by the 973 Program of China (No. 2013CB834401), and by the NNSFC grants 10925526, 111035007, 10675147, 10805059, U1232208, 1135005, 11075103, 11205205.

References

[1] M. V. Ricciardi et al., Nucl. Phys. A733 (2005) 299.
[2] J. W. Xia et al., Nucl. Instr. Meth. A 488 (2002) 11.
[3] B. Franzke et al., Mass Spectrom. Rev. 27 (2008) 428.
[4] B. Mei et al., Nucl. Instr. Meth. A 624 (2010) 109.
[5] O. Tarasov et al., Nucl. Instr. Meth. B 266 (2008) 4657.
[6] B. Mei et al., submitted.

doi:10.15120/GR-2014-1-PNI-AP-08