

3 - 13 Progress on the CSRe Storage Ring Nuclear Physics Research: Mass and Half-life Measurements*

Yan Xinliang, Wang Meng, Zhang Yuhu and CSR mass measurement collaboration

Nuclear mass and half-life measurements are important research projects at the CSRe storage ring. The progress is summarized below. The data analyses are now finished for the 6th traditional IMS experiment with ^{112}Sn fragments (2016) and the 6th $B\rho$ -IMS experiment with ^{78}Kr fragments (2020).

1. Upgrading from the traditional isochronous mass spectroscopy (IMS) to the $B\rho$ -defined IMS

The $B\rho$ -IMS is the second generation isochronous mass spectrometry technique, its success is built on the precise velocity measurements of the stored ions using two time-of-flight (TOF) detector installed in the dipole-free straight section of the CSRe^[1]. The new $B\rho$ -IMS method also enables precision determination of the momentum compaction factor of the CSRe as a function of magnetic rigidity (or orbital length)^[2]. Due to the advantage of simultaneous velocity and revolution-time measurements of each stored ions, the new method can improve the mass resolving power of CSRe over the whole m/q -range without limiting the acceptance of the ring^[3]. Other technical progress includes tune measurement of the CSRe operated in the traditional isochronous mode^[4], study of systematic errors the IMS experiments^[5], development of a position-sensitive TOF detector^[6] and upgrade of the DC power supply with slow feedback control for the CSRe dipole magnets^[7].

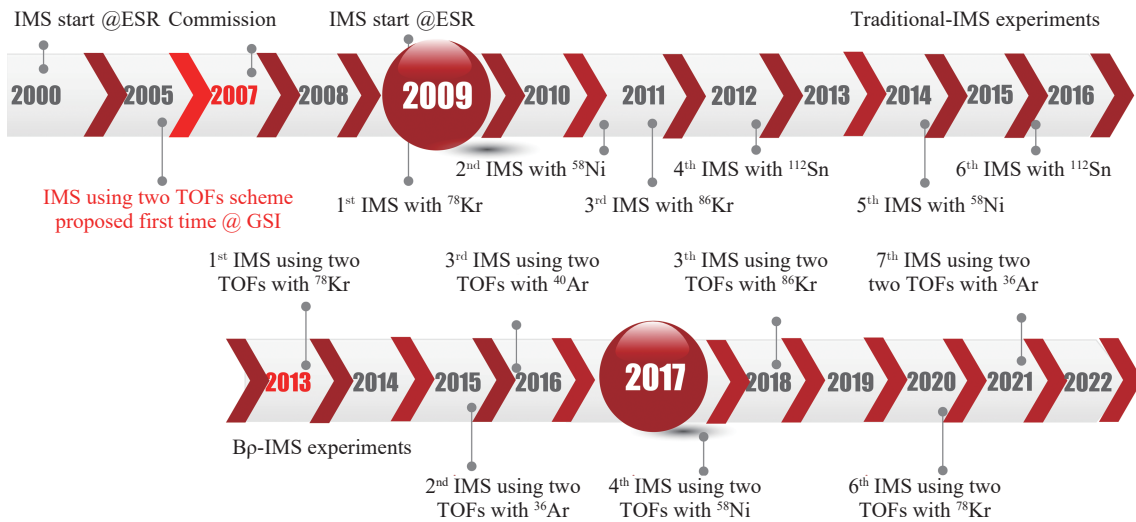


Fig. 1 (color online) Chronological record of the isochronous mass spectroscopy experiments conducted so far at CSRe.

2. Progress on the half-life measurements using Schottky mass spectroscopy

The Data-Acquisition system (DAQ) of the CSRe Schottky detector system has been upgraded over the past few years^[8]. Besides that, a new baseline estimation algorithm was derived from Bayesian method which enable precise determination of the storage half-life of the fully stripped ions stored in CSRe^[9]. A list of the half-life measurement experiments using the CSRe Schottky detector can be found in Table 1.

Table 1 Chronological record of the half-life ($T_{1/2}$) measurement experiments conducted so far at CSRe.

2010	2014	2017	2017	2018	2021
Schottky resonator installed	^{58}Ni projectile fragments, $T_{1/2}$ measurement ^[10]	New DAQ system installed	$^{58}\text{Ni}^{19+,28+}$, cooling experiment	^{86}Kr projectile fragments, $T_{1/2}$ measurement ^[8]	$^{36}\text{Ar}^{18+}$, $T_{1/2}$ measurement

3. Publications over the past year

The progress of the physics researches is summarised in the publications below.

(1) Mass measurements of ^{64}As and ^{66}Se show slow down of the rapid proton capture process at waiting point nucleus ^{64}Ge in X-ray bursts^[11]. The experimental data were collected in the year 2020 during the 6th $B\rho$ -IMS experiment with ^{78}Kr projectile fragments.

(2) Mass Measurement of upper fp -Shell $N = Z - 2$ and $N = Z - 1$ Nuclei and the importance of three-nucleon force along the $N = Z$ line^[12]. The results are derived from the same experimental data as mentioned above.

(3) Isochronous mass measurements of neutron-deficient nuclei from ^{112}Sn projectile fragmentation^[13]. The experimental data were collected in the year 2020 during the 6th traditional IMS experiment with ^{112}Sn projectile fragments.

(4) On the Masses of $A = 54$ Isospin Septet and the Isobaric Multiplet Mass Equation^[14].

References

- [1] X. Zhou, M. Zhang, M. Wang, et al., Phys. Rev. Accel. Beams, 24, 4(2021)042802,
- [2] M. Zhang, Y. H. Zhang, M. Wang, et al., Nucl. Instrum. Meth. A, 1027(2022)166329,
- [3] M Wang, M Zhang, X Zhou, et al., Phys. Rev. C, (2022)L051301,
- [4] X. Zhou T. Liao, C. Guo et al., Phys. Rev. Accel. Beams, (submitted)2023.
- [5] M. Zhang, Y. H. Zhang, M. Wang, et al., Nucl. Phys. Rev., 40. 2(2023)181.
- [6] H. Y. Jiao, IMP & HIRFL Annual Report, (2023)50.
- [7] Y. H. Li, X. J. Wang, H. J. Zhang, et al., Nucl. Instrum. Meth. A, 1049(2023)168108,
- [8] W. Qian, PhD Thesis, University of Chinese Academy of Sciences, Beijing, December, (2022).
- [9] W. Qian. X. L. Yan, X. C. Chen, et al., Nucl. Sci. Teth, 33, 11(2022)148,
- [10] X. L. Tu, X. C. Chen, J. T. Zhang, et al., Phys. Rev. C, 97, 1(2018)014321, January .
- [11] X. Zhou, M. Wang, Y.H. Zhang, et al., Nature Physics, (accepted)(2023).
- [12] M. Wang, Phys. Rev. Lett., (accepted)(2023).
- [13] Y. M. Xing, C. X. Yuan, M. Wang, et al. Phys. Rev. C, 107, 1(2023)014304,
- [14] H. F. Li, X. Xu, M. Wang, et al., Chinese Phys. C, 46, 6(2022)064001.

* Foundation item: CAS Young Scholar of Regional Development ([2023]15), CAS Project for Young Scientists in Basic Research (YSBR-002), National Key R&D Program of China (2018YFA0404401), Strategic Priority Research Program of Chinese Academy of Sciences (XDB34000000) and National Natural Science Foundation of China (12135017,12121005)