Shape evolution in even-even Mo isotopes studied via Coulomb excitation

K. Wrzosek-Lipska[1,2], M. Zielińska[1], K. Hadyńska-Klęk[1,2], Y. Hatsukawa[3], J. Iwanicki[1], J. Katakura[3], M. Kisieliński[1,4], M. Koizumi[3], A. Kordyasz[1], M. Kowalczyk[1,2], J. Kownacki[1,4], H. Kusakari[5], S. Lalkovski[6], M. Matsuda[3], T. Morikawa[7], P. Napiorkowski[1], A. Osa[3], M. Oshima[3], L. Pieńkowski[1], D. Piętak[1,8], L. Próchniak[9], T. Shizuma[3], J. Srebrny[1], M. Sugawara[5], Y. Toh[3], K. Zając[9]

1. Heavy Ion Laboratory, Warsaw University, Warsaw, Poland
2. Institute of Experimental Physics, University of Warsaw, Warsaw, Poland
3. Japan Atomic Energy Agency, Tokai, Ibaraki, Japan
4. Sołtan Institute for Nuclear Studies, Świerk, Poland
5. Chiba University, Inage-ku,Chiba, Japan
6. Department of Physics, University of Sophia, Bulgaria
7. Kyushu University, Hakozaki, Fukuoka, Japan
8. Warsaw University of Technology, Institute of Radioelectronics, Warsaw, Poland
9. Institute of Physics, M. Curie-Skłodowska University, Lublin, Poland

The competition of single-particle and collective modes, characteristic for transitional (A~100) nuclei, results in a variety of phenomena, making this region of nuclear chart an ideal testing ground for modern nuclear structure theories. For the Sr and Zr isotopes, a dramatic change of the ground state structure is observed at N=58,60 [1]. This effect is less pronounced in the Mo, Ru and Pd isotopes, but still the rapidity of shape change results in shape coexistence in these nuclei.

Shell model calculations [2] can well describe the properties of light Mo isotopes with neutron number close to 50. From the 2^+ level energy systematics for the most neutron rich Mo isotopes, one can observe that with the increasing neutron number the influence of the collective motion on the electromagnetic structure becomes stronger. In the ^{96,98,100}Mo isotopes both single-particle and collective excitations compete resulting in unusual features of these nuclei.

The ^{98}Mo isotope is one of the four even-even stable nuclei with $Z > 20$ that have a first excited state of spin and parity 0^+. In the neighbouring Mo isotopes the 0^+ excited states move higher in energy, but still they lie close to the first 2^+ state. Observation of such low-lying 0^+ excited states can be the first indication of the shape coexistence phenomenon.

Multiple Coulomb excitation is one of the most important experimental methods to study nuclear shapes. The Coulomb excitation technique can bring information on static quadrupole moments (in both ground and excited states) as well as relative signs of transitional matrix elements, which are essential to determine the nuclear shape in a given state in a model independent way using the Quadrupole Sum Rules method [3,4].

Quadrupole deformation parameters – the overall deformation parameter as well as triaxiality - were deduced from the Coulomb excitation experiments for the ground and the first excited 0^+ states in ^{96,98,100}Mo. The results obtained for ^{98}Mo [5] indicate shape coexistence of the 0^+ state - while the overall quadrupole deformation of both states is comparable, the shape changes from triaxial (the ground 0^+ state) to the prolate one (the first excited 0^+ state). The results received for the case of ^{96}Mo [6] show that the ground state is deformed, while the excited one is almost spherical. The most recent results, which will be presented here for the first time, concern the last stable molybdenum isotope. In ^{100}Mo a rich set of twenty E2 and M1 reduced matrix elements, including three quadrupole moments, was determined. The extracted shape parameters of the 0^+ states of this nucleus support the prediction of current mean field theories concerning the shape evolution of neutron rich Mo isotopes [7].

The experimental results on shape evolution in even-even stable Mo isotopes will be presented and compared to the theoretical predictions based on the generalized Bohr Hamiltoniam approach [8].

References:

[1] J. L. Wood *et al., Nucl. Phys.* **A651**, 323 (1999).
[2] P. Singh, R. G. Pillay, J. A. Sheikh, H. G. Devare, *Phys. Rev.* **C45** 2161 (1992).
[3] D. Cline, *Annu. Rev. Nucl. Part. Sci.* **36**, 683 (1986).
[4] K. Kumar *et al., The Electromagnetic Interaction in Nuclear Physics,* Morth Holland, 1974.
[5] M. Zielińska *et al., Nucl. Phys.* **A712**, 3 (2002).
[6] K. Wrzosek *et al., Acta Phys. Pol.* **B39**, 513 (2008).
[7] J. Skalski, S. Mizutori, W. Nazarewicz, *Nucl. Phys.* **A617**, 282 (1997).
[8] L. Próchniak, G. Rohoziński, *J. Phys. G: Nucl. Part. Phys.* **36** 123101 (2009).