Drastic Increase of the Nuclear Deformation in Bromine between A = 79 and 77 ◇

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It is well known that the nuclear shape may change drastically between two nuclei which differ only by one or two nucleons. As N changes for a given Z or vice versa strong competition can occur between the different forces which separately drive the nucleus towards prolate, oblate, triaxial and spherical shapes. The phenomenon of shape coexistence exists in many regions of the nuclear chart. One of these is the region just below the $Z = 40$ shell closure. In the isotopic chains of $_{38}$Sr, $_{37}$Rb, and $_{36}$Kr the nuclear shape changes from nearly spherical around $N = 50$ (^{88}Sr$_{50}$, ^{87}Rb$_{50}$, ^{86}Kr$_{50}$) to strong prolate deformation ($\beta_2 \sim 0.4$) at $N \sim 40$ and $N \sim 60$. For the light isotopes of Sr, Rb, and Kr the deformation develops gradually from $N \sim 46$ to $N \sim 40$. In this context the nuclear shapes of $_{35}$Br would be interesting. For Br, however, direct information on the neutron-number dependence of the nuclear deformation – as normally obtained from laser spectroscopy measurements of mean square radii and nuclear electric quadrupole moments – is not available. Concerning the ground-state properties of neutron-deficient Br isotopes, only the magnetic moments are known experimentally from nuclear orientation (NO) and nuclear magnetic resonance on oriented nuclei (NMR-ON) measurements. From such measurements the conclusion was drawn that the ground-state deformation increases gradually from $\beta_2 = 0.20$, $\gamma = 0$ in ^{81}Br to $\beta_2 = 0.33$, $\gamma = 0$ in ^{75}Br, and that the Br nuclides can be better described as hole in the more deformed Kr nuclides rather than a particle beyond the Se cores [1]. Such a gradual increase of the deformation with decreasing N was actually in agreement with the change of the deformation of $_{36}$Kr, $_{37}$Rb, and $_{38}$Sr. For Bromine, however, the overall deformation may be influenced considerably by the single-particle properties of the valence proton. If this valence proton occupies a strongly downsloping Nilsson orbit, it may drive the nucleus towards a large deformation. Such a situation is actually realized: The odd-A Br nuclei $^{75-87}$Br all have ground state spin $3/2^-$. Within the Nilsson scheme, the 35$^{\text{th}}$ proton is expected, depending on the nuclear deformation, to occupy the $I^\pi[Nn_z\Lambda] = 3/2^-[301]$ or the $3/2^-[312]$ orbital. From the experimental magnetic moments of ^{77}Br and ^{79}Br it was concluded that the transition between these orbitals occurs between $A = 79$ and 77 and that the deformation increases moderately from $\beta_2 \sim 0.22$ to ~ 0.28 ... 0.30 between ^{79}Br and ^{77}Br. As the magnetic moment is not very sensitive on the nuclear deformation, this conclusion contained unpredictable uncertainties.

The electric quadrupole moment, however, is much more sensitive on the nuclear deformation. The quadrupole moment of ^{79}Br is known to be $Q = +0.331(4)$ b, which is consistent with a deformation of $\beta_2 \sim 0.22$. Thus the shape

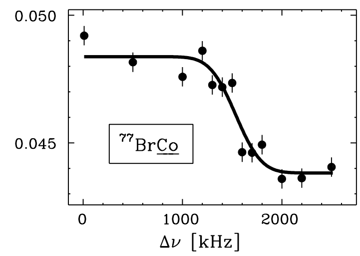

Fig. 1: MAPON spectrum of ^{77}Br in hcp-Co. The solid line is the result of a *least-squares* fit, taking into account a Gaussian distribution for the quadrupole subresonance resonance separation. The MAPON signal is given by the integral of this distribution, i.e. an error function.

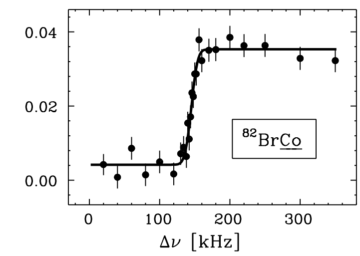

Fig. 2: MAPON spectrum of ^{82}Br in hcp-Co. The different sign of the MAPON signal in comparison to ^{77}Br is due to the fact that the γ anisotropy of ^{77}Br is positive, whereas it is negative for ^{82}Br.

change between $A = 79$ and 77 can be determined via an experimental value for the quadrupole moment of ^{77}Br. Therefore we measured the quadrupole interaction of ^{77}Br and ^{82}Br in hcp-Co, from which, taking into account the known quadrupole moment of ^{82}Br, the quadrupole moment of ^{77}Br and hence the nuclear deformation of ^{77}Br could be determined.

We applied the technique of modulated adiabatice fast passage on oriented nuclei (MAPON). Spectra are shown in Figs. 1 and 2. As final result we obtain

$$Q(^{77}\mathrm{Br}) = +0.530(22)\ \mathrm{b},$$
$$\beta_2 = +0.354(15).$$

Our β_2 is considerably larger than the values deduced from the magnetic-moment measurements and the theoretical calculations. Thus the deformation-driving effect of the downsloping $\pi 3/2^-[312]$ orbital has been strongly underestimated until now.

A full description of this work is given in Ref. [2].

References

[1] A.G. Griffiths *et al.*, Phys.Rev.C **46** (1992) 2228

[2] G. Seewald *et al.*, Phys.Rev.Lett **80** (1998) 5289

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