Coulomb excitation of $^{112, 114, 116}$Sn and $^{120, 122}$Te

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Abstract

It is proposed to measure the B(E2, $0^+ \rightarrow 2^+$) values of the first excited states of the stable $^{112, 114, 116}$Sn and ^{120,122}Te with projectile Coulomb excitation at energies of 3.6 MeV/u on a 1mg/cm^2 ^{60}Ni target. The gamma-rays from the deexcitation will be measured with two Super-Clover and two Cluster Ge-detectors. Information of the scattering angle, needed for a good Doppler-shift correction, and impact parameter selection will be extracted from an annular position sensitive parallel plate avalanche counter (PPAC). The experimental results are of great interest for the comparison with sophisticated shell model calculations.

1 Physics motivation

The B(E2) values of shell model calculations for the even tin isotopes $^{102-130}$Sn show a parabola-like trend, as can be seen in figure 1, which resembles the typical behaviour of a one-body even tensor operator across a shell in the seniority scheme[1]. Thus, for a seniority changing transition, the B(E2) values increase at first, then flatten, peak at midshell and fall off thereafter.

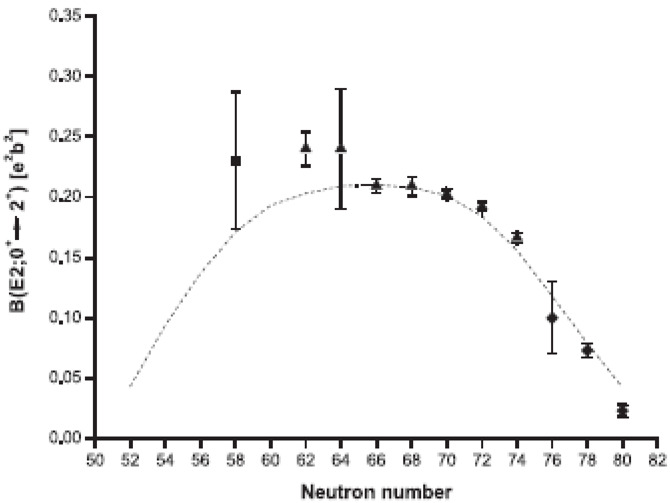

Figure 1: Comparison of experimental B(E2) values of Sn isotopes with the theoretical predictions (dotted curve). Picture taken from [2]

Existing experimental data show an almost perfect agreement with this plot for tin isotopes heavier than A = 114[3][4], hence only if at least half of the major shell N = 50 - 82 is filled. In the case of lighter stable tin isotopes, which have a natural abundance of less than 1% , the publications for ^{112}Sn[5][6][7] and ^{114}Sn[8][9][10] yield higher B(E2) values than expected, but so far big experimental errors prohibit further theoretical interpretations. One main reason for these errors is that these experiments either have used enriched targets, then the uncertainty stems from the impurity of the target, or used the recoil distance Doppler-shift (RDDS) method which is error prone for lifetimes lower than 1ps.

The B(E2) value obtained for the unstable ^{108}Sn[2] in a RISING experiment is based on a relative B(E2) measurement to ^{112}Sn. Since the present error in ^{112}Sn is significant, a more precise measurement of ^{112}Sn would also decrease the error of ^{108}Sn.

In the case of the Te isotopes, one expects a similar behaviour of the B(E2) values than in the Sn case. The evolution of the B(E2) values, shown in figure 2, shows however an indication for a lower B(E2) value in ^{120}Te[11], which has two neutrons more than the midshell ^{118}Te.

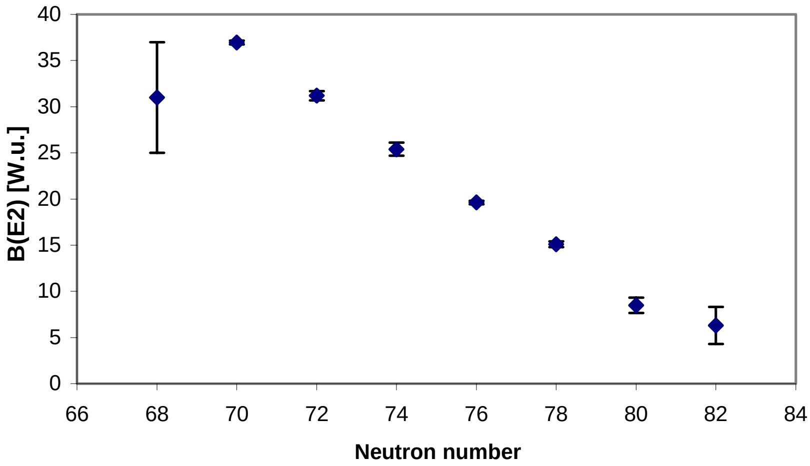

Figure 2: Comparison of experimental B(E2) values of Te isotopes

The aim of this experiment is hence to study the detailed structure of very rare stable ^{112,114}Sn and ^{120}Te isotopes with an error of less than 3% (FWHM) for the B(E2) values, while ^{116}Sn and ^{122}Te serve as calibration points.

2 Experimental details

The proposed Coulomb excitation experiment will be performed with an isotopic pure Sn or Te UNILAC beam in the X7 area. Since it is planned to make a double relative B(E2) measurement, which means the normalized intensity ratios of projectile excitation to the ^{60}Ni target excitation will be compared with the calibration runs, good statistics are needed in all projectile and target excitation cases. Therefore, we aim for peak integrals of 10^4 counts per $2^+ \rightarrow 0^+$ transition.

The gamma decays will be measured with two Super-Clover and two Cluster Ge-detectors. We intend to have a resolution of better than 1%. Assuming an intrinsic resolution of these detectors of 0.3% and a β of 0.088, the distance of the Ge-detectors to the target will be put to 20 cm, which results in a photo peak efficiency of 3% at 1.3 MeV.

The scattering angle determination of the heavy ions will be made with a position sensitive annular parallel plate avalanche counter (PPAC), which covers scattering angles of θ_{lab} = 12 – 45° and φ_{lab} = 0 – 360°. Because the projectile as well as the target nucleus will be detected in the PPAC, they can be discerned by a relative time of flight measurement.

Including the setup of the electronics and the calibration runs we ask for 21 shifts of beam time.

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