Shape evolution in light n-rich nuclei

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The light n-rich isotopes between the N=20 and N=28 shell closures provide an interesting testing ground for the shell model where drastic shape changes and co-existence of deformed and spherical structures are expected. One example is ^{32}Mg with a prolate deformation of the 2^+ state of $\beta \approx 0.5$ [1]. Recent theoretical work [2] predicts an even stronger deformation for ^{34}Mg and reduced deformation for ^{36}Mg. The aim of this experiment is to study the level structure of nuclei in this mass region and, in particular, to determine for the first time lifetimes of excited states. B(E2)-values obtained from the lifetimes will be a measure of the deformation of the nuclei in their excited states. Excitation of the nuclear states will be achieved by nucleon removal reactions. Such an experiment employing the VEGA set-up has been accepted by the GSI-EA (S244). To take advantage of the superior efficiency, however, it is suggested to perform it with RISING.

Beam cocktails of excited nuclei with A/Z ratios between 2.5 and 3.0 can be well produced either by primary fragmentation [3] of a ^{48}Ca beam or by secondary fragmentation [4] of e.g. a ^{38}Si beam derived from fragmentation of the primary ^{48}Ca beam. The advantage of a two step process is that the isotopes to be studied have 3 to 6 orders of magnitude higher relative abundance in the cocktail compared to the production in one step. Thus detector load and background from unwanted channels is strongly reduced. The number of useful intermediate beams is of course limited since they have to be produced with a yield of 10^3 to 10^5 ions/s to be efficient.

To determine lifetimes the target will be composed of a stack of three 0.3 g/cm^2 ^{197}Au foils, separated by 0.7 mm and 2.1 mm from each other. This arrangement results in specific γ-line shapes for lifetimes between about 0.1 ps and 20 ps covering the range expected for the nuclei of interest.

With two settings the whole range of Mg nuclei with A=28..36 will be reachable in the experiment. The first one employs a ^{48}Ca beam directly with an intensity of 10^5/s... 10^6/s (depending on the rate capability of the tracking). In the second setting a ^{38}Si beam with an intensity of $\approx 10^3$/s is expected for a primary intensity of 10^9/s ^{48}Ca. Beside the Mg isotopes the neighbouring isotopic chains are present in the fragmentation cocktail with similar intensities. Therefore the whole region of the nuclidic chart will be investigated with the two settings.

Using RISING a γ-detection efficiency of about 3% (at 1.3 MeV) can be achieved. Thus to obtain a minimum of 100 counts in the 2^+ γ-line 3 shifts of beam time are required for the direct fragmentation setting and 9 shifts for the secondary fragmentation setting.

[1] T. Motobayashi et al., Phys. Lett. B346 (1995) 9.

[2] H. Lenske, private communication, Univ. Giessen.

[3] M. Belleguic, Ph.D. thesis, Univ. Lyon, 2000.

[4] S. Wan et al., Eur. Phys. J. A6 (1999) 167.