Abstract

The 'Lund-York-Cologne-Calorimeter' (LYCCA) is the first operational NUSTAR (Nuclear structure astrophysics and reactions) device for the HiSpec (High resolution in flight spectroscopy, starting in 2017) experiment at FAIR (Facility for anti proton and ion research). LYCCA is a high efficient detector array for identification and tracking of exotic nuclei and the design, testing and commissioning of LYCCA was the main part of this work. The first part of this thesis discusses tests performed with α-sources, a proton beam at the Cologne FN-Tandem accelerator and heavy ion beams at the GSI facility. The successful operation of LYCCA achieved resolutions of $\frac{\Delta Z}{Z} = 0.6(1)$ (for $Z = 36$) and $\frac{\Delta A}{A} = 1.1(1)$ (for $A = 104$) FWHM for in-beam measurements with relativistic heavy ions.

A relativistic beam Coulomb excitation experiment using a radioactive beam was recently performed at GSI employing LYCCA, with the aim of measuring the reduced transition strengths ($B(E2)$ values) of the first two excited states in ^{33}Ar. The radioactive ion beam was produced by impinging a primary ^{36}Ar beam on a primary ^{9}Be target. At the central position of the γ-array (consisting of 15 EUROBALL Cluster high-purity germanium detectors and eight HECTOR BaF_2 scintillators) the secondary ^{33}Ar beam hit a ^{197}Au target with an energy of approximately 145 MeV/u. LYCCA was used to track the outgoing ions and to reject all nuclear reaction channels.

For the two lowest energetic excited states of ^{33}Ar (excitation energies: $\left(\frac{3}{2}\right)^+_1 : 1359$ keV and $\left(\frac{5}{2}\right)^+_1 : 1798$ keV) the reduced transition strengths have been determined:

$$B\left(E2; \left(\tfrac{3}{2}\right)^+_1 \rightarrow \left(\tfrac{1}{2}\right)^+_{g.s.}\right) = 6.39(1.49)\,\text{W.U.}$$

$$B\left(E2; \left(\tfrac{5}{2}\right)^+_1 \rightarrow \left(\tfrac{1}{2}\right)^+_{g.s.}\right) = 5.80(1.62)\,\text{W.U.}$$

These are the first transition strength values for proton-rich $T_z = -\frac{3}{2}$ sd shell nuclei. The new experimental data is used to test effective interactions for shell model calculations, describing excitation energies of sd shell mirror pairs. Shell model calculations based on a modified USD interaction employing full sd model space, yields the transition strengths 4.790 W.U. ($\left(\frac{3}{2}\right)^+_1 \rightarrow \left(\frac{1}{2}\right)^+_{g.s.}$) and 6.225 W.U. ($\left(\frac{5}{2}\right)^+_1 \rightarrow \left(\frac{1}{2}\right)^+_{g.s.}$) for the two new experimental results in ^{33}Ar.