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RELATIVISTIC COULOMB EXCITATION OF ^{54,56,58}Cr* **

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The first excited 2^+ states in ^{54,56,58}Cr have been populated by relativistic Coulomb excitation using the FRS-RISING setup at GSI. The Cr ions were produced by fragmentation of a ^{86}Kr beam on a primary Be target and separated by the FRS. The ion beams impinged on a thick secondary Au target at an energy of around $135A$ MeV. Gamma-rays were observed by the Ge cluster detectors of the RISING setup and stored in coincidence with particle and position signals from a set of tracking detectors. The steps of the analysis and spectra showing the $2^+ \to 0^+$ transitions are presented.

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1. Introduction

Very neutron rich nuclei may exhibit new shell structures due to the monopole part of the effective nuclear interaction and an apparent modification of the spin-orbit interaction. For nuclei in the $Z = 20$–28 region, theoretical and experimental results suggest a possible subshell closure at $N = 32$ or 34 [1–3]. Figure 1 shows an overview of calculated and known

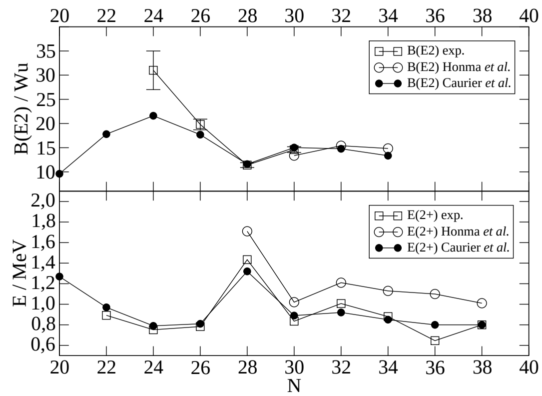


Fig. 1. Calculated and experimental values for $E(2^+)$ and $B(E2;2^+ \rightarrow 0^+)$ for Cr isotopes. The calculated values are from Honma *et al.* (open circles) [4] and Caurier *et al.* (filled circles) [5]. The open squares show experimental values from previous work [6].

experimental values in the Cr isotopes. Above the well-known shell closure at $N = 28$ the energies of the first excited 2^+ states show a maximum at $N = 32$. However, $B(E2)$ values which are a more crucial test of the nuclear wave function, are not known above $^{54}Cr_{30}$. In the present work, a report is given on a measurement of the $B(E2)$ values of the first 2^+ states in $^{56,58}Cr$ by relativistic Coulomb excitation.

2. Experiment

The experiment was performed using the RISING detector setup at GSI [7]. For the production of ^{54}Cr, ^{56}Cr and ^{58}Cr, ions of ^{86}Kr were accelerated to around $480A$ MeV and fragmented on a ^{9}Be target of $2.5\,g/cm^2$ thickness. The fragment separator FRS was used to select and identify the ions of interest out of the secondary beam before it hit the secondary target. Behind that target, the ions were stopped in the CATE detector array [8]. Tracking before the target was done with two multiwire detectors. They were placed before and after the MUSIC ionisation chamber [7] which is used to identify the charges of the incoming ions. The masses before the target were determined using the time of flight between two scintillators. The secondary target was a 7×7 cm^2 foil of ^{197}Au with 1 g/cm^2 thickness. Both, particle identification and tracking after the secondary target, were done with the calorimeter telescope CATE. The settings for the three runs for ^{54}Cr, ^{56}Cr and ^{58}Cr were chosen so that the beam energy after the secondary target was $100A$ MeV. The γ rays were detected using the Ge cluster detectors of RISING [7].

In the beam time of 22 h for ^{54}Cr an average intensity of 4×10^4 beam particles per spill was obtained. Around 45% of the beam particles were identified as ^{54}Cr before the target. The two other main beam components were ^{55}Mn and ^{53}V.

For ^{56}Cr in a beam time of 20 h the secondary beam intensity was around 2×10^4 particles per spill due to the lower production rate of this isotope. The main beam components were ^{56}Cr (35%), ^{57}Mn and ^{55}V.

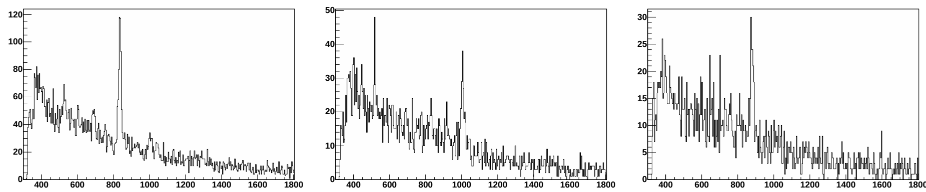
In the case of ^{58}Cr the production rate was still lower so that only 2–4 $\times 10^3$ particles per spill hit the secondary target during 55 h of beam time. The beam contained mainly the three nuclides ^{58}Cr (25%), ^{59}Mn and ^{57}V.

3. Analysis and results

In the analysis the incoming particles were identified using the detectors mentioned above. Particles with impact parameters above ≈ 50 fm (atomic background) or below ≈ 10 fm (nuclear reactions) were excluded by a scattering angle selection. It was required that in the Ge detector array exactly one γ ray with an energy above 500 keV was registered within a narrow time window.

The Doppler-shift correction of the γ-ray energies takes into account the angle between the outgoing particle and the Ge detector as determined from tracking, and the velocity calculated from the measured time of flight. Simulation results from the MOCADI software [9] were used to obtain the relation between time of flight and velocity after the target. The resulting γ-ray spectra are shown in Fig. 2.

The $B(E2)$ values for ^{56}Cr and ^{58}Cr can be determined in two alternative ways. Absolute values may be derived from the number of incoming and outgoing Cr ions on the Au target and from the intensities of the γ-ray lines in the spectra. Alternatively, the $B(E2)$ values for ^{56}Cr and ^{58}Cr may be determined relative to the known value for ^{54}Cr, $B(E2) = 14.6(6)$ W.u. [6], since the Coulomb excitation of the three isotopes was performed under comparable conditions. The analysis is in progress.



^{54}Cr, $E(2^+) = 835\,$keV ^{56}Cr, $E(2^+) = 1006\,$keV ^{58}Cr, $E(2^+) = 880\,$keV

Fig. 2. Doppler-corrected spectra showing the $2^+ \to 0^+$ transitions in ^{54,56,58}Cr with 4 keV per bin. The other peaks in the spectra are assumed to originate from neighbouring nuclei which cannot currently be separated due to up to now insufficient mass resolution after the target.

4. Summary

To measure $B(E2, 2^+ \to 0^+)$ values for ^{56,58}Cr and to obtain information on a possible subshell closure at $N = 32$, the first 2^+ states of ^{54,56,58}Cr were populated by relativistic Coulomb excitation in a ^{197}Au target using the FRS-RISING setup at GSI. In a preliminary analysis γ-ray spectra were produced that clearly show the $2^+ \to 0^+$ transitions in the three Cr isotopes under investigation.

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