A New Setup for Transfer Reactions at REX-ISOLDE ◇

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1. Introduction

The "island of inversion" is a region on the neutron-rich side of the nuclear chart around ^{32}Mg, where intruder states from the fp-shell favour deformed ground states instead of spherical ones formed by the normal sd-states. Recent studies of $B(E2)$-values at "safe" and intermediate beam energies have shown that indeed ^{30}Mg is outside the "island of inversion" while ^{32}Mg lies inside [1, and references therein]. The measurement of the magnetic moment of the ground state of ^{31}Mg, which may be directly on the shore of the "island of inversion", has established the spin-parity assignment of $1/2^+$ [2]. This was not predicted by theory and could only recently be reproduced by adjusting the monopole part of the interaction for the fp-shell [3].

We aim to extend the study of single particle configurations around the "island of inversion" also to excited states populated by neutron transfer reactions in inverse kinematics [4]. Nucleon transfer reactions are a well established tool for the investigation of the single particle structure of nuclei. Relative spectroscopic factors extracted from transfer cross sections are a measure for the occupation numbers of single particle configurations (particles or holes). These can be directly compared to results from shell model calculations. The transferred orbital momentum leading to the spin assignment of a state is determined from the angular distribution of the particles.

As a first experiment we want to study the d(^{30}Mg, ^{31}Mg)p reaction using a deuterated PE target.

2. Setup & Simulation

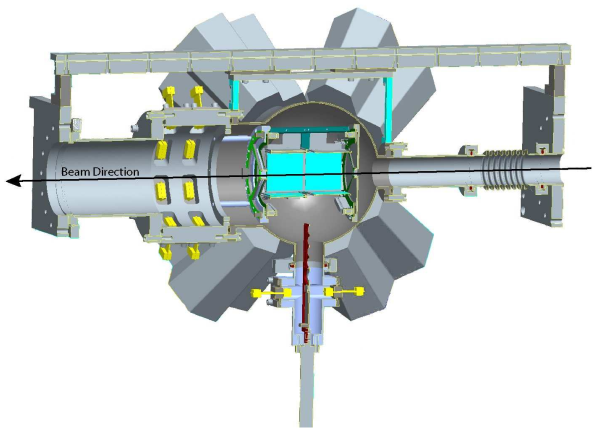

Fig. 1: Schematical drawing of the setup

Figure 1 shows a technical drawing of the setup. The silicon array consists of two annular DSSSD detectors (CD detectors) for forward and backward angles and a quadratic barrel of position sensitive strip detectors (16 strips perpendicular to the beam with ≈ 0.5 mm position resolution) around 90°.

The particle identification for different masses and Q-values requires the use of thin ΔE detectors and thick E_{rest} detectors. This allows that the protons for a large range of energies pass through the ΔE detector and are stopped in the E_{rest} detector. The inverse kinematics combined with small Q-values translates for backward angles an excitation energy difference of 1 MeV into a difference in kinematic energy of the protons of a few hundred keV. This compression effect, combined with the energy spread due to the target thickness (≈ 0.5 mg/cm^2), limits the achievable energy resolution and makes it necessary to detect the γ-rays in coincidence for the identification of the populated levels.

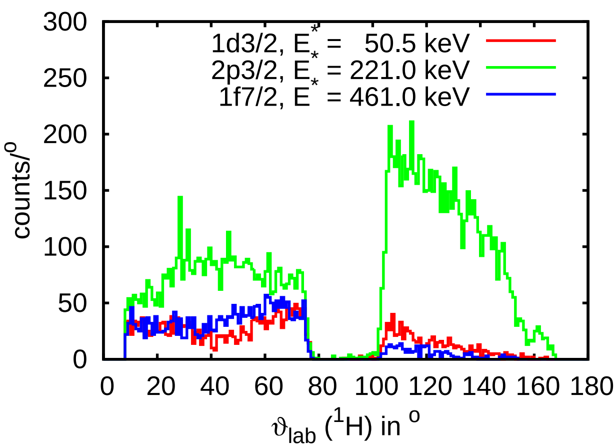

Fig. 2: Simulated angular distributions using GEANT4 for the first three states of ^{31}Mg in the laboratory system.

In a previous experiment performed with only a forward CD at REX-ISOLDE with MINIBALL only an angular range from 15° − 55° was covered [5]. Here it was not possible to determine the transferred orbital momentum unambiguously. The new setup will cover an extended angular range of $\vartheta_{lab.} \approx 8° - 75°$ and $105° - 172°$ and, as can be seen in figure 2, the ambiguities can be resolved for the excited states.

With this new setup an angular resolution of $3° - 5°$ and an energy resolution of 60 keV (backward CD) to 2 MeV (forward CD) for protons emitted in the transfer reaction d(^{30}Mg, ^{31}Mg)p at 3 MeV/u can be achieved. The energy resolution for both CD detectors is mainly limited by the energy losses in the target, whereas for the barrel it is dominated by the beam spot size (≈ 5 mm). The efficiency of the setup to detect a particle is ≈ 62 %.

References

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◇ supported by BMBF 06MT190 and 06MT238