Towards Two-Neutron Transfer around the Island of Inversion

W. Schwerdtfeger, B. Bruyneel [a], T. Faestermann, R. Gernhäuser, D. Habs, Th. Kröll, R. Krücken, M. Lauer [b], R. Lutter, H.J. Maier, T. Morgan, M. Münch, O. Niedermaier [b], P. Reiter [a], O. Schaile, H. Scheit [b], P.G. Thirolf, W. von Oertzen [c], N. Warr [a], D. Weisshaar [a], and H. Wolter

[a] Institut für Kernphysik, Köln [b] Max-Planck-Institut, Heidelberg [c] Hahn-Meitner-Institut, Berlin

The shape coexistence in the singly-magic nucleus ^{32}Mg can be studied via two-neutron transfer reactions. While ^{30}Mg (N=18) has a spherical 0^+ ground state, the ground state of ^{32}Mg (N=20) is highly deformed ($\beta = 0.5$) and the spherical 0^+ state is predicted at $E^* = 1.55$ MeV [1]. Since nucleon transfer predominantly proceeds between states of similar deformation, two-neutron transfer from ^{30}Mg to ^{32}Mg offers the possibility to study the shape coexistence for the first time. It is planned to perform this experiment using the radioactive beam at REX-ISOLDE in conjunction with the MINIBALL γ-ray spectrometer [2].

In order to study the feasibility of this reaction a preparatory experiment with a stable ^{26}Mg beam was performed at the IKP Cologne using the MINIBALL γ spectrometer. The one-neutron transfer cross section was measured using the ^{9}Be(^{26}Mg,^{27}Mg)^{8}Be reaction (E=57 MeV) in order to allow for a comparison with DWBA calculations and extrapolations for the two-neutron cross section in the final reaction ^{10}Be(^{30}Mg,^{32}Mg)^{8}Be. A thin self-supporting metallic ^{9}Be target (62μg/cm^2) was used. A clear trigger signal for one-neutron transfer is obtained, since the reaction product ^{8}Be is unstable and instantly decays into two α particles. Due to the reaction kinematics for the one-neutron transfer (Q = 4.778MeV, $\theta_{graz} = 80.3°$) a double sided silicon strip detector (16 × 16 channels) was placed perpendicular to the beam in order to detect the two α particles (angular region: $\theta = 90° \pm 20°$, $\phi = 90° \pm 20°$). The DSSSD was covered by a 1.5μm Mylar foil against scattered particles. Eight MINIBALL triple cluster detectors were used (four in forward direction ($\theta = 45°$) and four in the backward hemisphere ($\theta = 135°$)). As trigger condition for the DAQ system one signal in the DSSSD was used, resulting in an accepted event rate of ∼ 800/s at a beam current of ∼ 5nA. For the one-neutron transfer data were collected for 59 hours. For further details on the experimental setup see [3].

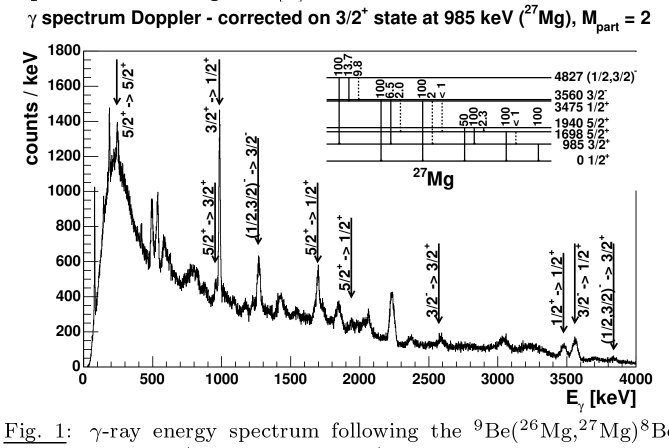

Fig. 1: γ-ray energy spectrum following the ^{9}Be(^{26}Mg,^{27}Mg)^{8}Be transfer reaction (E_{beam} = 57 MeV) after Doppler-correction for transfer to the first excited state of ^{27}Mg. Only particle-gamma coincidences were used ($M_{part} = 2$).

During the data analysis events were selected by a particle-γ coincidence condition together with a requirement of a particle multiplicity $M_{part} = 2$. For the Doppler-correction of the γ-ray energy spectra an average value, derived from kinematic calculations was used.

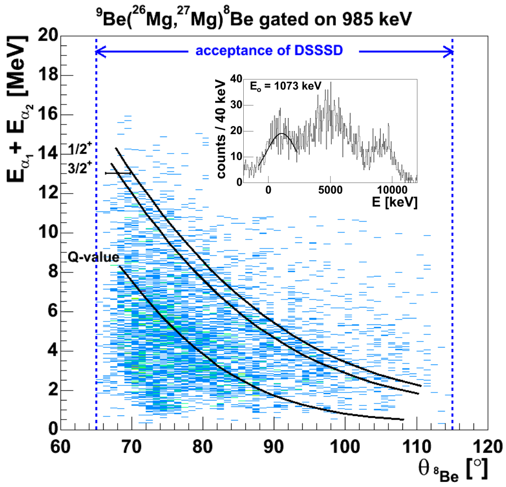

Fig. 2: Energy-angle correlation for the one-neutron transfer to ^{27}Mg gated on the first excited state ($3/2^+$) at 985 keV in coincidence with two detected particles in the DSSSD. The solid lines correspond to the kinematic expectations for different states in ^{27}Mg as indicated. The projection along the Q-value is shown as an insert.

Fig.1 shows the Doppler-corrected γ-ray energy spectrum for the one-neutron transfer reaction ^{9}Be(^{26}Mg,^{27}Mg)^{8}Be leading to the first excited state in ^{27}Mg. The transitions from several excited states in ^{27}Mg are clearly visible. The kinematical energy-angle correlation allows to identify the relevant ^{8}Be decay products from the respective transfer channels. In Fig.2 the correlation between the ^{8}Be energy (determined from the sum of the two registered particles in the DSSSD minus Q = 92 keV from the ^{8}Be decay) and the reconstructed direction of the ^{8}Be reaction products is displayed for events gated on the 985 keV transition in ^{27}Mg. The solid lines represent kinematic expectations for the ground state and for the first excited state.

DWBA calculations using FRESCO [4] were performed. The optical model parameters were taken from the reaction ^{28}Si(^{9}Be,^{8}Be)^{29}Si [5]. The spectroscopic factors originated from a ^{26}Mg(d,p)^{27}Mg measurement with a similar Q-value (4.211 MeV) [6]. The calculated transfer cross section to the ^{27}Mg $3/2^+$ state is $\sigma^{theo} = \int\int \frac{d\sigma^{theo}}{d\Omega} d\theta d\phi = 0.44$ mb, while the measured is $\frac{d\sigma^{exp}}{d\Omega} = 0.04$ mb. The discrepancy is subject to further examinations. From the present state of knowledge it can be concluded that the two-neutron transfer cross section is too low for a successful experiment at REX-ISOLDE (three orders of magnitude are missing).

References

[1] D. Guillemaud-Mueller *et al.*, Eur. Phys. J. **A13** (2002) 63
[2] J. Eberth *et al.*,Prog. Part. Nucl. Phys. **46** (2001) 389
[3] W. Schwerdtfeger *et al.*, Annual report 2003, p. 5
[4] I.J. Thompson *et al.*, Comp. Phys. Rep. **7** (1987) 167
[5] D.P. Stahel *et al.*, Phys. Rev. **C16 4** (1977) 1456
[6] P.M. Endt *et al.*, Nucl. Phys. **A310** (1978) 193