EPJ Web of Conferences 66, 03058 (2014)
DOI: 10.1051/epjconf/20146603058

Near barrier scattering of ^{8}He on ^{208}Pb

G. Marquínez-Durán[1,a], A.M. Sánchez-Benítez[2], I. Martel[1], L. Acosta[1,3], K. Rusek[4], M.A.G Álvarez[5,6], R. Berjillos[1], M.J.G. Borge[7], A. Chbihi[8], C. Cruz[7], M. Cubero[7,9], J.A. Dueñas[1], J.P. Fernández-García[5,6], B. Fernández-Martínez[5], J.L. Flores[10], J. Gómez-Camacho[5,6], N. Keeley[11], J.A. Labrador[5], M. Marqués[12], A.M. Moro[6], M. Mazzocco[13], A. Pakou[14], V.V. Parkar[15], N. Patronis[14], V. Pesudo[7], D. Pierrotsakou[16], R. Raabe[17], R. Silvestri[16], N. Soic[18], Ł. Standylo[11], I. Strojek[11], O. Tengblad[7], R. Wolski[19,20], and A.H. Ziad[5]

[1] *Departamento de Física Aplicada, Universidad de Huelva, 21071 Huelva, Spain*
[2] *GSI Helmholtzzentrum für Schwerionenforschung Gmb, Planckstr. 1, 64291 Darmstadt, Germany*
[3] *INFN Sezione di Catania. Via Santa Sofia 64 I-95123 Catania, Italy*
[4] *Heavy Ion Laboratory, University of Warsaw, 02-093 Warsaw, Poland*
[5] *Centro Nacional de Aceleradores, 41092, Sevilla*
[6] *Departamento de Física Atómica, Molecular y Nuclear, Universidad de Sevilla, 41080 Sevilla, Spain*
[7] *Instituto de Estructura de la Materia, CSIC, 28006 Madrid, Spain*
[8] *GANIL, CEA and IN2P3-CNRS, B.P. 5027, 14076 Caen cedex, France*
[9] *CICANUM, Universidad de Costa Rica UCR, Apartado 2060 San José, Costa Rica*
[10] *Departamento de Ingeniería Eléctrica, Universidad de Huelva, 21071 Huelva, Spain*
[11] *National Centre for Nuclear Research, A. Soltana 7, 05-400 Otwock, Poland*
[12] *Laboratoire de Physique Corpusculaire, 14050 Caen cedex, France*
[13] *Departimento di Fisica and INFN, Universita di Padova, 35131 Padova, Italy*
[14] *Department of Physics, University of Ioannina, 45110 Ioannina, Greece*
[15] *Bhabha Atomic Research Centre, Mumbai, India*
[16] *INFN - Sezione di Napoli, via Cintia, 80126 Napoli, Italy*
[17] *Instituut voor Kern-en Stralingsfysica, K.U. Leuven, Belgium*
[18] *Rudjer Boskovic Institute, Bijenicka 54, 10000 Zagreb. Croatia*
[19] *Institute of Nuclear Physics PAN, Kraków, Poland*
[20] *Flerov Laboratory of Nuclear Reactions, JINR, Dubna 141980, Russia*

Abstract. The exotic nucleus ^{8}He is investigated by means of the measurement of the angular distributions of the elastic channel and the ^{6}He and ^{4}He fragment yields produced in the collision with a ^{208}Pb target at two energies around the Coulomb barrier, 16 and 22 MeV. The experiment was performed at the GANIL-SPIRAL facility, with the aim of extracting information about the structure of ^{8}He and the relevant reaction mechanisms. In this contribution, details of the experimental setup and preliminary data on elastic cross sections are reported.

[a] e-mail: gloria.marquinez@dfa.uhu.es

1 Introduction

^{8}He has an extended valence neutron distribution, known as neutron skin. In particular, it is the lightest skin nucleus and it has the largest neutron-to-proton ratio among the nuclei stable against particle emission. The scattering of ^{8}He on gold and copper has been already investigated at GANIL [1, 2] but there is still a lack of experimental results needed to unveil the role of couplings between possible reaction channels and neutron-core correlations.

In comparison with the 2n-halo ^{6}He, ^{8}He has a more extended neutron layer whereas its binding energy is higher. Its binding energies for 1n (S_{1n}) and 2n (S_{2n}) systems are similar, unlike ^{6}He, where S_{2n} is appreciably less than S_{1n} and makes the two neutron transfer energetically favoured in collision processes [3–5]. These differences in geometry and binding energies should be reflected in the elastic and reactions cross sections in collisions at Coulomb barrier energies.

In this work, preliminary experimental results for the elastic channel of the ^{8}He+^{208}Pb system at the collision energies of 16 and 22 MeV are shown, together with data for the scattering of ^{6}He with the same target at the same energies [3, 4].

2 Experimental setup

The experiment was performed in the G21 line at the SPIRAL-GANIL facility, where high quality beams of ^{8}He are produced from the fragmentation of a ^{13}C beam at 75 MeV/nucleon on a dedicated target for the production of helium isotopes. Once produced and post-accelerated, the beam is driven through a set of collimators and beam diagnostics, towards the reaction chamber.

The detection system, GLORIA (GLObal ReactIon Array) [6], was recently developed at the University of Huelva for studying the structure and dynamics of exotic nuclei. It consists of twelve DSSSD detectors arranged in six particle telescopes allowing for measuring reaction fragments in a continuous angular range between 15^{o} and 165^{o}, with an overall solid angle of 26.1% of 4π. Each telescope is made of a 40 μ ΔE-detector of 50 mm x 50 mm, segmented in 16 strips on each side, and by a 1 mm E-detector of the same size and segmentation.

The target consisted of a self-supported foil of ^{208}Pb with a thickness of 1mg/cm^{2}. Its isotopic composition was the following: ^{208}Pb 98.43 %, ^{207}Pb 1.05 %, ^{206}Pb 0.51 %, ^{204}Pb 0.01 %. The target was tilted 60^{o} with respect to the beam axis, avoiding the shadowing of detectors and allowing for the detection of particles around 90^{o}.

3 Experimental results

Preliminary results for the scattering of ^{8}He on a ^{208}Pb target at 22 MeV are shown in figure 1 in red filled squares. For comparison, data relative to the ^{6}He+^{208}Pb system at the same energy is plotted in green [3] and blue [4] filled squares.

The elastic scattering of ^{8}He follows the trend of ^{6}He up to 70^{o}. At backward angles, the absorption becomes even stronger for ^{8}He than for ^{6}He. Two calculations are also presented in the figure. The results of an Optical Model (OM) calculation using parameters obtained from the ^{8}Li+^{108}Pb system [7] is shown with the doted-dashed line. The solid line represents a Coupled Reaction Channels (CRC) calculation, performed with FRESCO [8]. In this calculation, in the entrance and exit channles, the OM potential from the previous OM calculation was used and the coupling with the single neutron stripping channel was included. The overlap form factors, $\left\langle {}^{8}\text{He}|{}^{7}\text{He}+n\right\rangle$ and $\left\langle {}^{209}\text{Pb}|{}^{208}\text{Pb}+n\right\rangle$, were taken from [9, 10]. The comparison between both calculations reveals the importance of the coupling with the 1n stripping channel for ^{8}He, producing a reduction on the elastic cross section. It is also

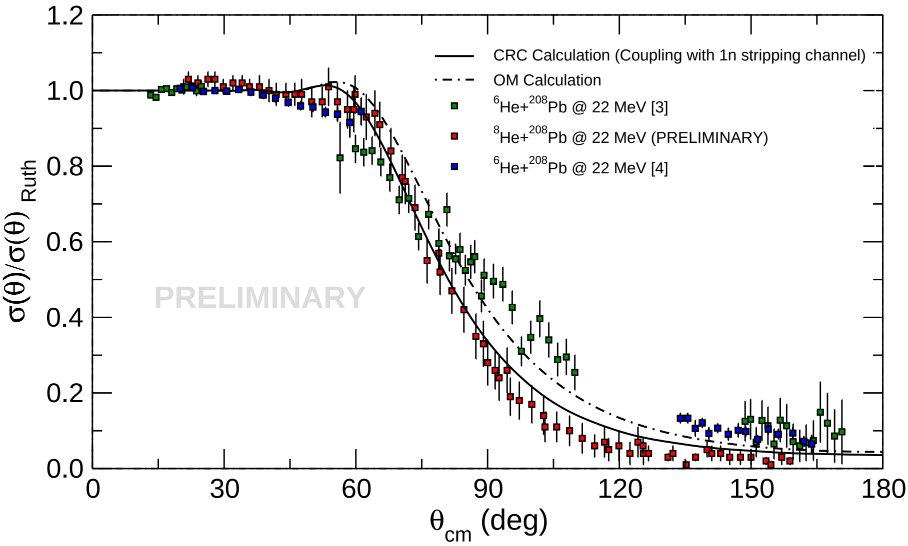

Figure 1. Angular distribution of the elastic cross section, normalized to the corresponding Rutherford cross section, for the systems $^{8}He+^{208}Pb$ and $^{6}He+^{208}Pb$ at 22 MeV. See text for details.

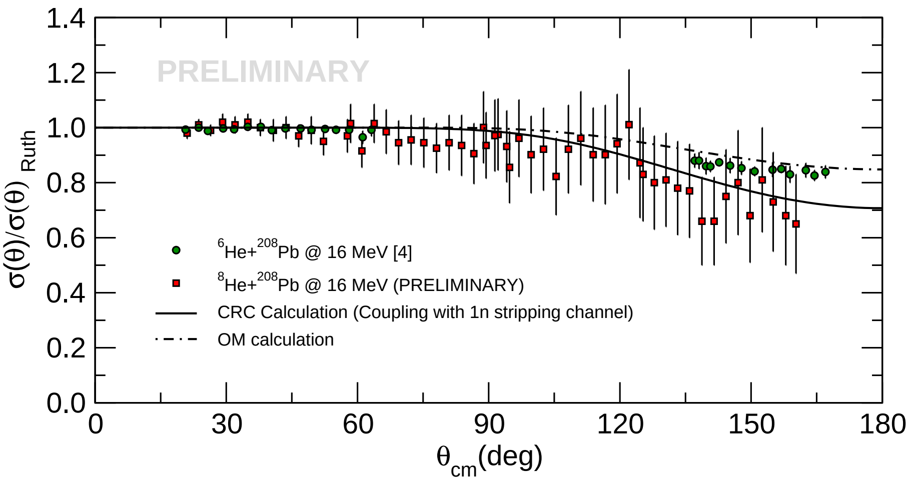

Figure 2. Angular distribution of the elastic cross section, normalized to the corresponding Rutherford cross section, for the systems $^{8}He+^{208}Pb$ and $^{6}He+^{208}Pb$ at 16 MeV. See text for details.

remarkable that the characteristic Coulomb-nuclear rainbow of the Fresnel type interference pattern of light stable nuclei at this energy regime does not appear.

In figure 2, preliminary results for the scattering of ^{8}He on a ^{208}Pb target at 16 MeV are shown in red filled squares. Also at this energy, available data for the $^{6}He+^{208}Pb$ system from [4] is plotted in green filled squares.

As found in the data at 22 MeV, at 16 MeV the absorption at backward angles, where the comparison is possible, is even greater than for ^{6}He. For the doted-dashed line, an OM calculation, the same entrance channel potential as at 22 MeV have been used. The solid line, a CRC calculation carried out in a similar way as for 22 MeV, includes the coupling to the 1n stripping channel. Also at this energy, this coupling produces the reduction on the elastic cross section, needed to reproduce the experimental data.

4 Summary and conclusions

The elastic scattering of ^{8}He+^{208}Pb has been measured at 16 and 22 MeV at SPIRAL-GANIL using GLORIA, a detector array developed at the University of Huelva. A strong effort has been made to properly assign the scattering angles and to calculate the solid angles subtended by each pixel of every telescope.

At 22 MeV, the angular distribution of the elastic channel follows the trend found for ^{6}He+^{208}Pb up to the grazing angle, where the absorption becomes greater. At 16 MeV, the absorption is also larger for ^{8}He. The analysis for both energies is still ongoing.

This work has been supported by the grant from the Spanish Research Council FPA-2010-22131-CO2-01, the grant from the Ministry of Science and Higher Education of Poland No. N202 033637, COPIGAL LEA, the grant EUI2009-04163432 (EUROGENESIS) from the European Science Foundation and the Grant VH-VI-417 from Helmholtz Association in Germany.

References

[1] A. Lemasson et al., Phys. Rev. **C82**, 044617 (2010)
[2] A. Lemasson et al., Phys. Lett. **B697**, 454 (2011)
[3] L. Acosta et al., Phys. Rev. **C84**, 044604 (2011)
[4] A.M. Sánchez-Benítez et al., Nucl. Phys. **A803**, 30 (2008)
[5] E.F. Aguilera et al., Phys. Rev. **C63**, 061603 (2001). Rapid communication.
[6] G. Marquínez-Durán et al., submitted to Nucl. Inst. and Meth. A
[7] J.J. Kolata et al., Phys. Rev. **C65**, 054616 (2002)
[8] I.J. Thompson, Comput. Phys. Rep. **7**, 167 (1988)
[9] N. Keeley et al., Phys. Lett. **B646**, 222 (2007)
[10] D.G. Kovar et al., Nucl. Phys. **A231**, 266 (1974)