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Alpha clustering in Ti isotopes: ^{40,44,48}Ca + α resonant scattering

Sam Bailey[1,a], Martin Freer[1,b], Tzany Kokalova[1,c], Carl Wheldon[1], Robin Smith[1], Joseph Walshe[1], Lovro Prepolec[2], Neven Soić[2], Vedrana Tokić[2], Miguel Marqués[3], Lynda Achouri[3], Franck Delaunay[3], Marian Parlog[3], Quentin Deshayes[3], Beatriz Fernández-Dominguez[4], and Bertrand Jacquot[5]

[1] *School of Physics and Astronomy, University of Birmingham, Birmingham, B15 2TT, UK*
[2] *Institut Ruder Bošković, Bijenička cesta 54, 10000 Zagreb, Croatia*
[3] *Laboratoire de Physique Corpusculaire de Caen, 6 bd Maréchal Juin, 14050 Caen Cedex, France*
[4] *Universidade de Santiago de Compostela, Praza do Obradoiro, 15782 Santiago de Compostela, Spain*
[5] *Grand Accélérateur National d'Ions Lourds, Bd Henri Becquerel, BP 55027 - 14076 Caen Cedex 05, France*

Abstract. Measurements were made of the ^{4}He(^{40,44,48}Ca,α) resonant scattering reactions at 180° and up to $E_{c.m.}$ ~11.5 MeV, using the Thick Target Inverse Kinematics technique. These measurements are discussed, with a focus on assessing their usefulness for investigating α-clustering in medium mass ^{44,48,52}Ti nuclei.

1 Introduction

Clustering in nuclei allows the techniques of few-body physics to be applied to the many body nuclear problem, yet identifying nuclei which exhibit cluster structures is far from trivial. Alpha-clustering has been shown to play an important role in the structure of many α-conjugate and neutron rich light nuclei [1]. However, it is equally apparent that mean field approaches to nuclear structure describe the properties of heavy nuclei very well, suggesting that clusters do not contribute significantly to their structure. This leads to the question of to what extent does α-clustering persist into medium and heavy mass nuclei.

The core+Xn+α molecular cluster structure is an essential component in the structure of ^{20,21,22}Ne [2, 3]. Here ^{16}O acts as a core, and any additional neutrons act as valence particles providing additional binding to the α + ^{16}O cluster structure. This structure is thought to be exceptionally pronounced due to the inert nature of the doubly magic ^{16}O core. It has been hypothesized that ^{44}Ti may exhibit a similar cluster structure to ^{20}Ne, due to its doubly magic ^{40}Ca core. If confirmed this would provide evidence for α-clustering in medium mass nuclei.

In the present work ^{44,48,52}Ti are investigated, allowing the interaction of valence neutrons with the ^{40}Ca+α structure to be examined and compared with ^{20}Ne. Additionally since ^{48}Ca is also a doubly magic nucleus, this allows the evolution of this cluster structure across an entire shell to be explored.

[a] e-mail: s.c.bailey@pgr.bham.ac.uk
[b] e-mail: m.freer@bham.ac.uk
[c] e-mail: t.kokalova@bham.ac.uk

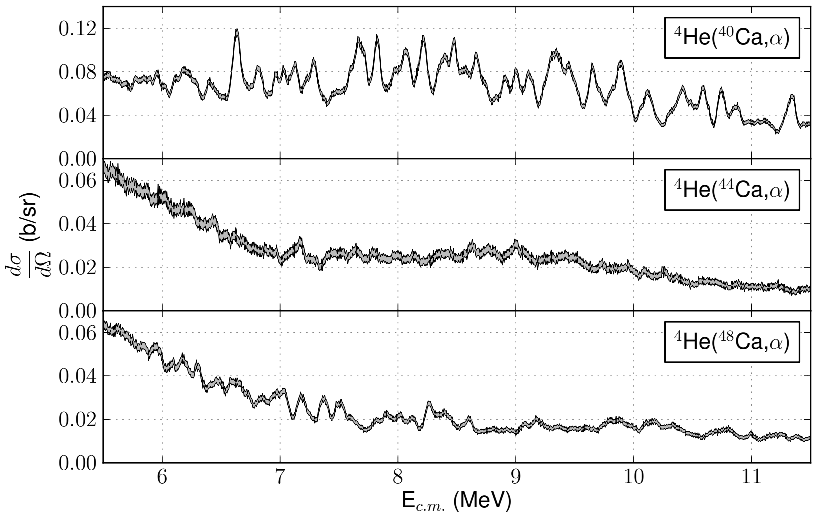

Figure 1. Measured spectra. All measurements taken at a scattering angle of 180° and normalized to the Rutherford scattering cross section at low $E_{c.m.}$. Grey region represents a 90% confidence interval.

2 Experimental Work

Measurements were made of the ^{4}He(^{40,44,48}Ca,α) resonant scattering reactions, at a scattering angle of 180° using the Thick Target Inverse Kinematics technique [4]. The experiment was performed at GANIL, France using ^{40,44,48}Ca beams incident on a thick ^{4}He gas target, with beam energies of 180, 207 and 234 MeV respectively. The scattered α-particles were measured using Double Sided Silicon Strip Detectors, which were placed at the end of the reaction chamber at 0° to the beam line, corresponding to a scattering angle of 180° in inverse kinematics. The beam loses energy as it traverses the gas, tracing out the continuous excitation spectra shown in Figure 1.

The resonant structure of these spectra is dependent entirely on the properties of the states in the compound nuclei: ^{44,48,52}Ti. This dependence is expressed using R-Matrix theory [5], which formulates explicitly the differential cross-section in terms of the energies, spins, parities and reduced widths of the compound nuclear states. The analysis will focus on developing techniques based on R-Matrix theory to probe the structure of ^{44,48,52}Ti, using these measurements of resonant structure. Since the states in these measurements are being populated through the α+^{40,44,48}Ca channels it is expected the α-clustered states will be preferentially populated, providing an excellent insight into the degree of α-clustering in ^{44,48,52}Ti.

References

[1] W. von Oertzen, M. Freer, and Yoshiko Kanada-En'yo, Physics Reports **432**, 43–113 (2006)

[2] W. von Oertzen, Eur. Phys. J. **A11**, 403 (2001)

[3] G. V. Rogachev et al., Phys. Rev. C **64**, 051320 (2001)

[4] K. P. Artemov et al., Sov. J. Nucl. Phys. **52**, 408–411 (1990)

[5] A. M. Lane and R. G. Thomas, Rev. Mod. Phys. **30**, 257 (1958)