Alpha decay study of ^{218}U; a search for sub-shell closure at Z=92

A.-P. Leppänen[1], J. Uusitalo[1], M. Leino[1], S. Eeckhaudt[1], T. Enqvist[1], K. Eskola[2], T. Grahn[1], F.P. Heßberger[3], P.T. Greenlees[1], P. Jones[1], R. Julin[1], S. Juutinen[1], H. Kettunen[1], P. Kuusiniemi[1], P. Nieminen[1], J. Pakarinen[1], J. Perkowski[1], P. Rahkila[1], C. Scholey[1] and G. Sletten[4]

[1] Department of Physics, University of Jyväskylä, P.O.Box 35, 40014 Jyväskylä, Finland.
[2] Department of Physics, University of Helsinki, Helsinki, Finland.
[3] GSI, Darmstadt, Germany.
[4] Department of Physics, University of Copenhagen, Copenhagen, Denmark.

The Uranium isotope ^{218}U is predicted to be a doubly magic nucleus in many recent theoretical calculations for super-heavy elements [1,2]. In addition to the magic neutron number N=126, there are predictions for a shell gap at Z=92 between the $h_{9/2}$ and $f_{7/2}$ proton orbitals. The Nilsson diagram for the deformed nuclei has been quite successful in explaining the single-particle levels and the semi-magic numbers when the heavy elements (Z≥98) have been studied. Since the Nilsson diagrams partly rely on the input of single-particle shell model energies also the magicity of Z=92 plays an important role. However, the standard mean field does not take into account octupole correlations which may distort the orbitals significantly. It is known that the octupole correlations play an important role in this part of the nuclear chart.

The existence of the two nearly-degenerate 8^+ states in the even N=126 nuclei disagrees with the idea of a substantial shell gap at Z=92. The two 8^+ states are based on configurations $(\pi h_{9/2})^2$ and $\pi h_{9/2} f_{7/2}$. In ^{216}Th the 8^+ state with the configuration $\pi h_{9/2} f_{7/2}$ becomes an yrast state with a relatively long half-life $T_{1/2}$=180 ms [3,4]. This state decays with a 5% α branch to the ground state of ^{212}Ra. The recent calculations predict two near degenerate 8^+ states in ^{218}U where the lower 8^+ has fallen below the 6^+ forming an yrast trap. This is considered to prove the near degeneracy of the $h_{9/2}$ and $f_{7/2}$ quasi-particle states which then disproves the existence of the Z=92 sub-shell closure [5].

The experimental studies of ^{218}U was done with the gas-filled recoil separator RITU and the K-130 cyclotron at JYFL. The fusion evaporation reaction of $^{182}W(^{40}Ar,xn)^{222-x}U^*$ at the excitation energy of E^*=45 MeV was employed to produce ^{217}U, ^{218}U and ^{219}U isotopes. The focal plane detector system (GREAT) was used to identify fusion recoils and emitted α particles and the triggerless Total Data Readout system was used as data acquisition. The separated fusion recoils were implanted into a Double-sided Silicon Strip Detector at the RITU focal plane. The α decay properties of the implanted recoils and the decay products were measured. The α decays of ^{218}U and ^{219}U were identified from correlated recoil-α-α decay chains and a candidate chain for the decay of ^{217}U. The ground state properties of ^{218}U were measured with improved statistics yielding a decay energy of E_α=8612 keV and a half-life of $T_{1/2}$=0.51 ms. A new α-decaying isomer was found in ^{218}U at the decay energy of E_α=10 678 keV and with a half-life of $T_{1/2}$=0.56 ms. The state was labeled as 8^+ according to the method of Rasmussen. The decay properties of ^{219}U was also measured with improved statistics, the measured decay energy was E_α=9774 keV and the measured half-life was $T_{1/2}$=0.08 ms.

The results of this study and interpretations will be discussed in more detail.

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