Particle unbound states of ^{115}Xe

P.Das[1,2], Ushasi.Datta[1,2],* S.Chakraborty[1,3], A.Rahman[1,4], M.J.G.Borge[5,6], O.Tengblad[5], J.Dey[1,2], B.K.Agrawal[1,2], A.N.Andreyev[7], A.Becerril[5], J.Cederkall[8], H.De Witte[9], L.M.Fraile[10], A.Gottberg[6,12], P.T.Greenless[13,14], M.Huyse[9], D.S.Judson[15], J.Konki[13,14], M.Kowalska[6], J.Kurcewicz[6], I.Lazarus[16], R.Lica[6], M.Lund[11], S.Mandal[17], M.Madurga[6], N.Marginean[18], R.Marginean[18], C.Mihai[18], I.Morroquin[5], E.Nacher[5], A.Negret[18], R.D.Page[15], S.Pascu[18], A.Perea[5], V.Pucknell[16], P.Rakhila[13], E.Rapisarda[6], F.Rotaru[18], J.Roy[1], T.Stora[6], C.O.Sotty[9], P.Van Duppen[9], V.Vedia[10], N.Warr[18], and R.Wadsworth[7]

[1] *Saha Institute of Nuclear Physics, Nuclear physics Division, Kolkata, India*
[2] *Homi Bhabha National Institute, Mumbai, India*
[3] *University of Engg. and Management, Kolkata, India*
[4] *Jalpaiguri Govt. Engg. College, Jalpaiguri, West Bengal, India*
[5] *Inst. de Estructura de la Materia, CSIC, Madrid, Spain*
[6] *ISOLDE, CERN, Geneva, Switzerland*
[7] *University of York, Department of Physics, York YO10 5DD, North Yorkshire, United Kingdom*
[8] *University of Lund, Sweden*
[9] *KU Leuven, Instituut voor Kern- en Stralingsfysica, Celestijnenlaan 200D, 3001 Leuven, Belgium*
[10] *Grupo de Fisica Nuclear, and IPARCOS, Facultad de CC. Fsicas, Universidad Complutense, CEI Moncloa, 28040 Madrid, Spain*
[11] *University of Jyvaskyla, Department of Physics, P.O. Box 35, FI-40014 University of Jyvaskyla, Finland*
[12] *Helsinki Institute of Physics, University of Helsinki, P.O. Box 64, FI-00014 Helsinki, Finland*
[13] *Department of Physics, Oliver Lodge Laboratory, University of Liverpool, Liverpool L69 7ZE, United Kingdom*
[14] *STFC Daresbury, Daresbury, Warrington WA4 4AD, United Kingdom*
[15] *Aarhus University, Aarhus, Denmark*
[16] *University of Delhi, Delhi, India*
[17] *University of Bucharest, Faculty of Physics, Atomistilor 405, Bucharest-Magurele, Romania and*
[18] *Institut fur Kernphysik, Universitat zu Koln, Zulpicher Strasse 77, D-50937 Koln, Germany*

Introduction

The first detailed study of exotic decay mode of the neutron-deficient, proton and alpha unbound nucleus, ^{115}Cs, close to upper mass limit of the rp-process nuclei, is reported here. The measurement was performed at the ISOLDE decay station (IDS), CERN by detecting delayed charged particles and gamma rays. The study of properties of nuclei near and beyond the drip lines provides unique information on n- n interactions [1] which is important for understanding the limits of existence of the nuclei. Many interesting properties have been observed in the nuclei around the drip line. The observation of the breakdown of traditional magic numbers in exotic nuclei [2] far from stability has been an important issue in nuclear structure physics. Other properties are appearance of new magic numbers, exotic decay[3], cluster structure etc. Due to large beta-decay energy (Q value) of this drip-line nucleus,it is source of many different decay channels.For ^{115}Cs: Q_{EC} = 8.96(10)MeV. In case of ^{115}Xe: S_p, S_{2p}, S_α are -3.15(15)MeV, -4.89(3)MeV and 2.506(14)MeV respectively.So many decay channels open:$\beta-\gamma$, $\beta-p$, $\beta-p-\gamma$, $\beta-2p$, $\beta-2p-\gamma$. Therefore beta-delayed particle emission take place.

Experimental Setup

This experiment was performed by ISOLDE facility at CERN, where secondary beam of ^{115}Cs was sent to the experimental hall and implanted on a $20\mu g/cm^2$carbon target. The IDS setup consisted of five DSSD (Double Sided Silicon Strip Detectors), four PAD detectors behind the DSSD(behind the lower DSSD there was no PAD) as shown in Fig 1. The solid angle coverage of DSSD1, DSSD2, DSSD4, DSSD5, DSSD6 are 7.3%, 8.8%, 8.8%, 14.8%, 6.1% of 4π respectively which is altogether nearly 45.8% of 4π. Four High-Purity Germanium(HPGe) clover detectors surround the chamber to provide high gamma-ray detec-

*Electronic address: ushasi.dattapramanik@saha.ac.in

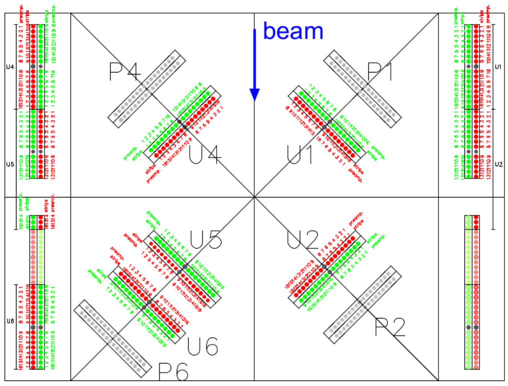

FIG. 1: Schematic diagram of the experimental (IS545) setup at the IDS, ISOLDE, CERN..

tion efficiency.

Data analysis and Spectrum

By adding the deposited energies of the delayed protons in the thin DSSD and in the corresponding PAD detectors, in coincidence mode, the delayed proton spectrum for higher energy has been obtained. On the other hand low energy protons (< 2.5 MeV) were fully stopped in the thin DSSD which has been obtained from the thin DSSD spectrum in anticoincidence mode with the corresponding PAD detector. That low energy spectrum has been added to the higher energy part. The delayed proton spectrum has been further converted into the reference frame of ^{115} Xe. For obtaining the proton unbound excited states of ^{115} Xe, the proton separation energy has been added with the spectrum. By fitting the peaks with the Gaussian shape with width as a variable parameter via χ^2 minimization, several proton unbound states of ^{115} Xe have been obtained. These states are with energies, 3.8 MeV (230), 4.8 MeV (703), 5.4 MeV (373), 6.1 MeV (536), 6.7 MeV (819),7.2 MeV (200), 7.6 MeV (230). The widths of the states are mentioned in keV within the first bracket.Considering the decay widths of the states, the obtained life time of those states are on the order of zeptoseconds. After efficiency correction, total number of delayed protons have been considered to be obtained delayed proton branch. According to our experimental data, the delayed proton branch is 0.2(06)%[4] which is more than previous reported value 0.07 %[5]. Fig 2 represents the angular distribution of high energy delayed protons, which are detected by DSSD4 and DSSD6. The lower and higher angular parts are coming from DSSD6 and DSSD4 respectively. The angle has taken with respect to the beam axis.

To obtain the decay half-life of ^{115} Cs, the time distributed proton spectrum was fitted with the function

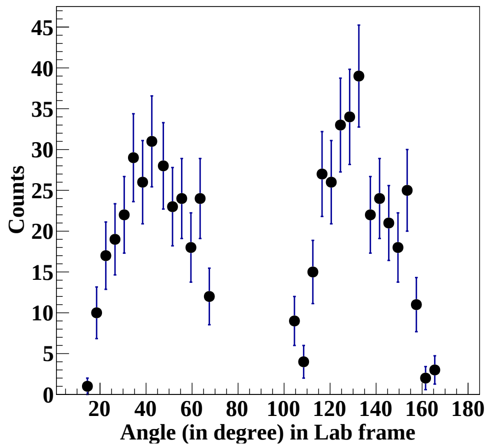

FIG. 2: Angular distribution of high energy protons from proton unbound states of ^{115} Xe .

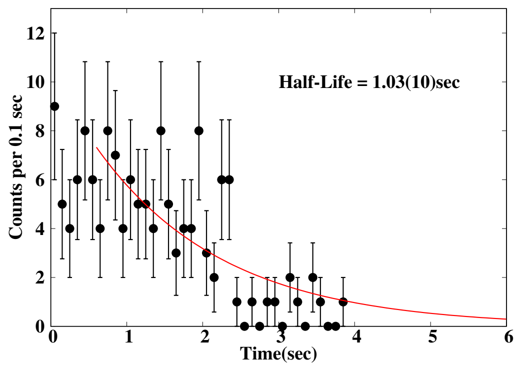

FIG. 3: The time distribution of delayed proton events obtained from ^{115}Cs of present experiment.

$N = N_0 e^{-\lambda t}$ as shown in Fig 3. The obtained half-life of ^{115} Cs is 1.03(10)sec[6]. Further data analysis is going on, we hope in future more interesting physics will come out.

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