Spectroscopy of the lightest nuclei in the Lanthanide region

C.M. Petrache[1], M. Fantuzi[1], M. Axiotis[2], D. Bazzacco[3], G. Benzoni[4], P.G. Bizzeti[5], N. Blasi[4], A. Bracco[4], M.A. Cardona[6], G. de Angelis[2], F. Della Vedova[2], M. De Poli[2], E.Farnea[3], A.Gadea[2], D. Hojman[6], T. Krll[3], S. Leoni[4], G. Lo Bianco[1], S. Lunardi[3], N. Marginean[2], T. Martinez[2], R. Menegazzo[3], D. Mengoni[1], D.R. Napoli[2], M. Nespolo[3], P. Pavan[3], C. Rossi Alvarez[3], A. Saltarelli[1], P. Spolaore[2], C.A. Ur[3], R. Venturelli[3]

[1] *Dipartimento di Fisica, Universit di Camerino and INFN, Sezione di Perugia, I-62032, Camerino, Italy*
[2] *INFN, Laboratori Nazionali di Legnaro, I-35020, Legnaro, Italy*
[3] *Dipartimento di Fisica, and INFN Sezione di Padova, Universit di Padova, I-35131 Padova, Italy*
[4] *Dipartimento di Fisica, and INFN Sezione di Milano, Universit di Milano, I-20133 Milano, Italy*
[5] *Dipartimento di Fisica, and INFN Sezione di Firenze, Universit di Firenze, I-50019 Firenze, Italy*
[6] *Departamento de Fsica, Comisin Nacional de Energa Atmica, Buenos Aires, Argentina*

One of the most exciting subjects in contemporary nuclear physics is the study of nuclei at the limits of stability with respect to particle emission. Recently, there has been an intensive experimental activity in measuring the proton decay and a large variety of proton emitters were observed in the region of heavy nuclei with $50 < Z < 82$. Very recently the proton radioactivity from ^{117}La [1], ^{121}Pr[2], ^{131}Eu and ^{141}Ho [3] has been identified. The proton decay rates deviates significantly from calculations assuming spherical configurations, thus indicating the onset of large deformations in the drip line nuclei below Z=69. However, a detailed study of the structure of these nuclei can only be performed by means of γ-ray spectroscopy using large detector arrays coupled with efficient light charged particles detectors, since the cross section for their population with the presently available stable beams are very low. The lightest nuclei in the lanthanide region for which spectroscopic information has been published are ^{123}La [4], ^{124}Ce [5], ^{125}Pr [6] and ^{128}Nd [7]. These data indicate a strong quadrupole deformation $\beta_2 \sim 0.35$. In order to establish the lowest single-particle excitations close to the point of the predicted [8] maximum deformation in this mass region (N,Z=64), we have studied the structure of the ^{122}La$_{65}$, ^{123}Ce$_{65}$ and ^{127}Nd$_{67}$ nuclei using the ^{40}Ca+^{92}Mo reaction, with a 200 MeV ^{40}Ca beam of 5 pnA intensity and the GASP+ISIS+neutron ring setup. The data of the present experiment were summed to the data of our previous experiment [9] performed at a beam energy of 190 MeV, getting therefore a total of 5.9x10^9 Compton-suppressed events. The events were sorted according to the number of charged particle and neutron detectors that fired in coincidence. For each charged particle and neutron combination E_γ - E_γ and E_γ - E_γ - E_γ matrices were produced off-line for further analysis. We report preliminary results on only one of the nuclei of interest populated in the reaction, ^{122}La. One of the observed bands has properties (aligned single-particle angular momentum, signature staggering, etc.) similar to the $\pi h_{11/2} \otimes \nu h_{11/2}$ bands observed in the neighboring odd-odd nuclei. In order to see how the level spacing in the two signature partners changes with decreasing neutron number, we plotted the systematics of the $\pi h_{11/2} \otimes \nu h_{11/2}$ bands in the sequence of the odd-odd lanthanum nuclei, and observe that there is a significant decrease of the level spacing between ^{124}La and ^{122}La, nuclei with N=67 and N=65, respectively. This could be related to the closeness to N=66, the neutron number for which maximum deformation is expected in this region. The data analysis is in progress, and we hope to identify new excited states also in the other nuclei at the limit of stability, ^{123}Ce and ^{127}Nd, that are also unknown from the spectroscopic point of view.

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