Neutron Halo and Antiproton-Nucleus Potential from Antiprotonic X-Rays

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Results of the PS203 experiment at the LEAR facility of CERN indicated that the periphery of some heavy nuclei is rich in neutrons [1]. Calculations using a simple asymptotic density model or the more complex Hartree-Fock approach are in quantitative agreement with the experimental results [2]. They clearly indicate the increase of the neutron to proton density ratio at large nuclear distances for neutron-rich nuclei. At the present status of theory however, a quantitative, parameter-free description of the experimental data is extremely difficult because the antiproton-nucleus optical potential is only poorly known.

Using the annihilation of stopped antiprotons is a new, simple method to study the nuclear periphery and the antiproton-nucleon potential. The Combined Analysis approach [3] could remove some of the model dependences, as an increased number of observables depending on the nuclear density and antiproton-nucleus potential is used. With this new method up to eight observables can be found for a nucleus. With the investigation of antiprotonic X rays width, shift and line splitting could be determined for several levels. The γ-ray analysis of the produced nuclei led to the so-called neutron halo factor.

During the first run of the PS209 collaboration at LEAR in June 1995 different isotopes of Ni, Te and Yb were investigated. One observation was an increased width of the penultimate level width, measured via the intensity balance of transitions populating and depopulating this level.

A large isotopic effect between ^{58}Ni, ^{60}Ni, ^{62}Ni and ^{64}Ni was observed. In ^{58}Ni the intensity of the n =6 to n = 5 transition is considerably larger than in ^{64}Ni (cf. Fig. 1). This clearly indicates a difference between the nuclear density at the periphery of the ^{58}Ni and ^{64}Ni nuclei and an extension of the neutron halo in ^{64}Ni. The relative yield of the n = 6 to n = 5 transition, obtained from the X-ray intensity balance of the level n = 6, is shown in Fig. 2 for the Ni isotopes. The yield is derived directly from the experimental data and not corrected for other effects like the admixture of other transitions or an E2 resonance.

A similar decrease of intensity was observed between ^{124}Te and ^{128}Te for the n = 8 to n = 7 transitions and between ^{172}Yb and ^{176}Yb for the n = 8 to n = 7 transitions. In ^{130}Te an additional strong E2 resonance effect diminishes the intensity of this transition.

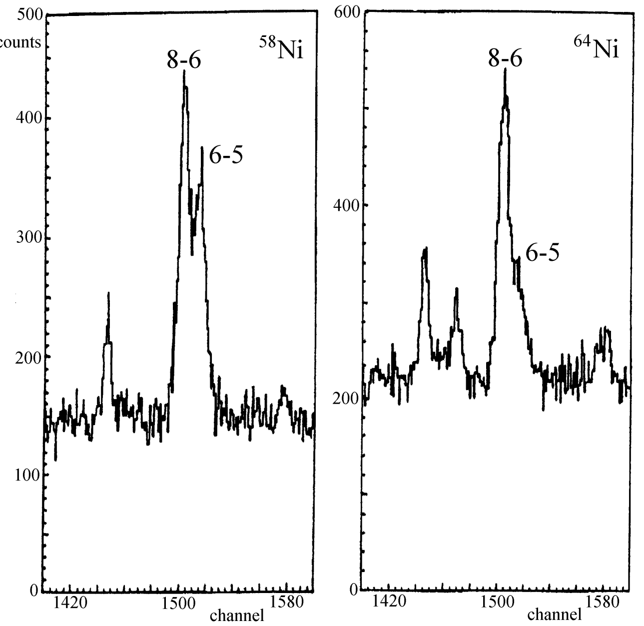

Fig. 1: The n = 8 → 6 (235 keV) and n = 6 → 5 transitions (237 keV) in ^{58}Ni and ^{64}Ni.

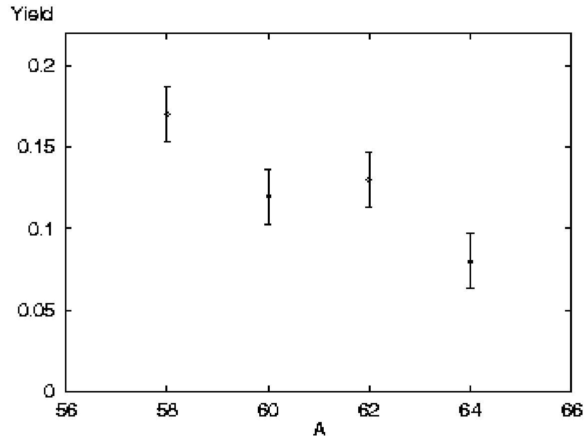

Fig. 2: Relative yield of the antiprotonic n = 6 → 5 transition in Ni isotopes as a function of the mass number A.

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