Proton Emission Studies at GSI in the 80s

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The location of the borderline of nuclear stability could be estimated since nuclear models allowed for calculating the binding energies of nuclei over a wide range of elements and isotopes. It was expected that a new type of radioactivity, the spontaneous emission of protons, will determine the limit to nuclear existence for neutron-deficient nuclei. The process itself presents a unique opportunity to obtain spectroscopic information on unbound nuclei beyond the proton drip-line. The limiting character and the simplicity of the decay process made search experiments for proton radioactivity an attractive aim in nuclear physics.

Up to the year 1965 the phenomenon of radioactive emission of one or two protons was subject of a number of theoretical papers reviewed by Goldansky [1]. In 1970 the first case of radioactive proton emission was observed [2]. It could be assigned to an isomeric state in ^{53}Co, a nucleus that is proton bound in its ground-state.

Spallation reactions at ISOLDE as well as fusion reactions at the GSI on-line mass separator were used to search for neutron deficient isotopes, specifically for ^{113}Cs which was expected to be a proton emitter. However, ^{113}Cs could not be found. Possible evidence for ground-state proton emitters observed in experiments at Dubna was reported by Karnaukhov et al. at the 1970 Leysin conference.

At SHIP we investigated fusion reactions based on the neutron deficient isotope ^{58}Ni as projectile and various neutron deficient isotopes of elements from molybdenum to tin as targets. Several new neutron-deficient α emitters were synthesized, and the proton drip-line was approached. The α emitters were identified by applying a position and time correlation method, after the nuclei had been implanted into position-sensitive silicon detectors.

A first report on the observation of a proton radioactivity from the ground-state was presented in 1981 at the Helsingør conference. The activity could be assigned to the ground-state decay of ^{151}Lu [3]. This isotope was produced with a cross-section of 70 μb in the reaction ^{58}Ni + ^{96}Ru $\rightarrow$ ^{154}Hf*. Within a time range of three years three more proton emitters have been observed at SHIP and at the GSI on-line mass separator in the region of nuclei near ^{151}Lu [4,5]. Proton decay of the short lived isotopes ^{113}Cs and ^{109}I, first observed by Faestermann et al. [6] and Gillitzer et al. [7], could be confirmed in experiments at SHIP.

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