Search for two-proton radioactivity in ^{39}Ti*

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In this contribution we will report on a recent experiment focused on the study of the possible two-proton radioactivity branch of ^{39}Ti. This nucleus was already considered among the most promising candidates for direct two-proton decay in the 1990s [1-3] and recent calculations also highlighted it as a good candidate for two-proton radioactivity [4,5]. In addition, several β-delayed multi-particle emission branches are also energetically possible from the isobaric analog state of the daughter nucleus, the proton unbound ^{39}Sc. Previous studies of this nucleus were performed with setups based on silicon detectors, with limited sensitivity to such exotic branches.

For this study we exploited the separation capabilities of the LISE3 fragment separator [6] at GANIL and the sensitivity of the Optical Time Projection Chamber (OTPC) developed at the University of Warsaw [7]. This detector has proved its capabilities to identify two-proton radioactivity and β-delayed multi-particle emission (see for example Refs. [8-10]), thanks to the possibility of 3D reconstruction of the charge-particle tracks and to its transparency to β electrons. The experiment was carried out in March 2023, employing an upgraded version of the OTPC detector, with a new CCD camera for optical readout and after replacing part of the Gas Electron Multiplier (GEM) foils by thicker ones [10] in the amplification stage. The ^{39}Ti ions were produced by fragmentation of a ^{58}Ni primary beam at 74.5 MeV/nucleon impinging on a natural nickel target with a carbon stripper. The reaction products were identified in-flight by using the energy loss signal (ΔE) from a silicon detector mounted in front of the entrance window of the OTPC and the Time-of-Flight (ToF) signal obtained as the time difference between two gaseous detectors of LISE3.

First preliminary results of this experiment will be presented in this contribution. In particular, an experimental upper limit for two-proton radioactivity will be discussed in the context of recent model predictions, for which the energy window for this process is a critical parameter. This energy is directly related to the mass excess of ^{39}Ti. As will be shown, from our experiment we also aim at determining this mass excess value by means of the energies of the β-delayed two protons.

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