Decay modes of ^{39}Ti: search for two-proton radioactivity*

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For very exotic even-Z neutron-deficient nuclei the simultaneous emission of two protons provides extremely valuable insights on the nuclear structure of neutron-deficient nuclei beyond the drip line. The long-lived ground state two-proton radioactivity has only been observed in a few isotopes: ^{45}Fe [1,2], ^{48}Ni [3], ^{54}Zn [4,5] and ^{67}Kr [6]. A better understanding of this exotic process requires the discovery of new cases. Theoretical predictions are essential to identify potential candidates, but they suffer from the lack of experimental data to tune and constrain the models.

In this contribution we discuss an experiment focused on the study of the possible two-proton radioactivity branch of ^{39}Ti, considered a promising candidate for direct two-proton decay (for a recent theoretical discussion of this case see [7]). The experiment was carried out at GANIL, where ^{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 with the LISE3 fragment separator [8] and implanted inside the Optical Time Projection Chamber (OTPC) developed at the University of Warsaw [9]. This detector has been widely used to study two-proton radioactivity cases [3,10,11].

We will present the results of this experiment. In particular, theoretical predictions of the two-proton branching ratio will be compared with our experimental upper limit for direct observation of two-proton radioactivity. The study of the β-delayed two-proton branch populating ^{37}K allows us to determine the mass excess of ^{39}Ti by means of the isobaric multiplet mass equation (IMME). This mass excess is employed to evaluate the energy window for two-proton radioactivity in ^{39}Ti, a critical input parameter for theoretical models. We will also discuss the branching ratios associated with other exotic decay modes such a β-delayed alpha-proton emission.

[1] M. Pfützner *et al.*, Eur. Phys. J. A **14** (2002), 279.
[2] J. Giovinazzo *et al.*, Phys. Rev. Lett. **89** (2002), 102501.
[3] M. Pomorski *et al.*, Phys. Rev. C **83** (2011), R061303.
[4] B. Blank *et al.*, Phys. Rev. Lett. **94** (2005), 232501.
[5] P. Ascher *et al.*, Phys. Rev. Lett. **107** (2011), 102502.
[6] T. Goigoux *et al.*, Phys. Rev. Lett. **117** (2016), 162501.
[7] B. Huang *et al.*, Phys. Lett. B **861** (2025), 139257.
[8] R. Anne and A. C. Mueller, Nucl. Instrum. Methods B **70** (1992), 276.
[9] K. Miernik *et al.*, Nuclear Inst. Methods A **581** (2007), 194.
[10] K. Miernik *et al.*, Phys. Rev. Lett. **99** (2007), 19250.
[11] A. Kubiela *et al.*, Phys. Rev. C **104** (2021), 064610.

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