The neutron capture cross section measurement of the thallium isotopes ^{203}Tl, ^{204}Tl and ^{205}Tl at the n_TOF facility at CERN

A. Casanovas[a], C. Domingo-Pardo[b], C. Guerrero[c], A. Tarifeño-Saldivia[a], J. Lerendegui-Marco[c], F. Calviño[a], J. L. Taín[b], and the n_TOF Collaboration[d]

[a]*Universitat Politècnica de Catalunya, Spain*
[b]*Instituto de Física Corpuscular, CSIC-Universidad de Valencia, Spain*
[c]*Universidad de Sevilla, Spain*
[d]*European Organization for Nuclear Research (CERN), Switzerland*

About half of the elemental abundances between Fe and Bi are produced by the so-called s (slow) process of neutron capture reactions in AGB stars [1]. Of particular importance are some nuclides produced during the s-process which are radioactive, with half-lives from years to Gy, so its decay process competes with the neutron capture chain: these nuclides are known as branching points. The measurement of the neutron capture cross section of these elements is crucial to determine the local abundance pattern around the branching point, which yields information of the s-process stellar environment, such as temperature, neutron density or pressure. ^{204}Tl ($T_{1/2} = 2.78\ y$) is a very interesting branching point. In the recurrent He-flashes of AGB stars, ^{204}Tl can either β-decay to the s-only nuclide ^{204}Pb or capture another neutron, thus producing ^{205}Tl, which in some stellar environments can decay to ^{205}Pb [2]. On the other hand, neutron capture on ^{204}Pb also yields ^{205}Pb ($T_{1/2} = 1.5 \times 10^7\ y$). Therefore, the value of the capture cross sections of ^{204}Tl, and also of ^{205}Tl, are necessary to determine precisely the primordial ^{205}Pb/^{204}Pb abundances ratio, which could allow one to estimate the time span since the last s-process events that contributed to the elemental composition of the Solar System.
In the year 2015, the cross section of the ^{204}Tl(n,γ) reaction was measured for the first time ever employing four C_6D_6 scintillation detectors in the neutron time-of-flight facility n_TOF at CERN [3]. The sample was a ^{203}Tl oxide pellet enriched to 4% in ^{204}Tl. The ^{204}Tl total mass was 9 mg, with a total activity of 160 GBq. Due to the amount of ^{203}Tl in the sample an ancillary measurement of the ^{203}Tl(n,γ) was also necessary in order to improve the accuracy of this reaction cross section. Concerning the ^{205}Tl(n,γ) reaction, its cross section will be measured this year also at n_TOF.
In this talk we will cover the different aspects of these capture cross section measurements, from the experimental methods to the extraction of the cross section and other important capture reaction parameters, to finally conclude with the application of the results on s-process nucleosynthesis.

References

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