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The results of the ^{204}Tl and ^{205}Tl neutron capture cross section measurement at n_TOF (CERN) and their impact to the s-process-only ^{204}Pb and ^{205}Pb production

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Neutron capture cross sections are one of the key input parameters for an accurate description of the slow (*s*) process of stellar nucleosynthesis, which is responsible for the production of about half of the elemental solar abundances between Fe and Bi in AGB stars [1]. In this contribution we will present the results of the measurement of the capture cross section of the thallium isotopes ^{204}Tl and ^{205}Tl, performed at the n_TOF facility (CERN) between 2015 and 2018, and the implications that the new cross section data have for the production of the important *s*-process only lead isotopes ^{204}Pb and ^{205}Pb.

It is well-known that the *s*-process of elements heavier than Sr occurs in the Asymptotic Giant Branch (AGB) stage of low mass (1.5 to 3 solar masses) stars [1]. In the short, but intense, neutron irradiation taking place in the recurrent Thermal Pulse episodes, both thallium isotopes become unstable with very short half-lives, and thus they act as *branching points* of the *s*-process flow, i.e. nuclei in which capture reactions compete with the decay process. Consequently, the capture cross section of both isotopes strongly affects the *s*-process abundance of their daughter isotopes, which in the case of ^{204}Tl is ^{204}Pb. The s-only stable isotopes such as ^{204}Pb play a pivotal role in studying the *s*-process, because they can be used to benchmark state-of-the-art AGB models by comparing nucleosynthesis calculations with observed abundances of these nuclei. A new calculation of the stellar $^{204}\mathrm{Tl}(\mathrm{n},\gamma)$ cross section, based on the results of the first ever measurement of $^{204}\mathrm{Tl}(\mathrm{n},\gamma)$ conducted at n_TOF, and the consequences of this result for the ^{204}Pb production in AGB stars were all reported in a recent publication in Physical Review Letters [2]. With the new results, the uncertainty arising from the $^{204}\mathrm{Tl}(\mathrm{n},\gamma)$ cross-section on the *s*-process abundance of ^{204}Pb could be reduced from ∼30\% down to +8\%/ -6\%, and the *s*-process calculations are in agreement with the latest solar ^{204}Tl solar abundance of Pb reported by K. Lodders in 2021 [3]. Therefore, presently there is no need to invoke additional nucleosynthesis mechanisms or fractionation effects in order to explain the ^{204}Pb abundance observed in the solar system.

In the case of ^{205}Tl, the activation of its bound state beta decay to ^{205}Pb at stellar temperatures makes the ^{205}Pb abundance very sensitive to the cross section of the $^{205}\mathrm{Tl}(\mathrm{n},\gamma)$ reaction. Apart from being s-only, ^{205}Pb is radioactive with a long half-life of 17.2 Myr, and therefore it has potential to be used as a cosmochronometer of the *s* process. Recently, the results of the first ever measurement of the stellar decay of ^{205}Tl, conducted at GSI, were published by Leckenby et al. in Nature [4]. The new results allowed the authors to make the first accurate estimation of the *s*-process isolation time based on *s*-process calculations and the current ^{205}Pb meteoritic abundance. In this context, the latest results of the new measurement of the stellar $^{205}\mathrm{Tl}(\mathrm{n},\gamma)$ cross section that will be presented in this contribution will permit to further reduce the still relevant nuclear data uncertainty affecting the ^{205}Pb *s*-process stellar production.

[1] F. Käppeler, R. Gallino, S. Bisterzo, and W. Aoki, Rev. Mod. Phys. 83, 157 (2011).

[2] A. Casanovas-Hoste et al., Phys. Rev. Lett. 133, 052702 (2024).

[3] K. Lodders, Space Sci. Rev. 217, 44 (2021).

[4] G. Leckenby et al., Nature 635, 321 (2024).

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