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Experimental study of ^{6}He Coulomb breakup as an indirect measurement of ^{4}He$(2n,\gamma)^{6}$He reaction rate for the astrophysical r-process

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Compact binary mergers as Binary Neutron Star Mergers (BNSM) have attracted a lot of attention in recent years as the most likely site for r-process (rapid neutron capture) nucleosynthesis [1] and for the emission of gravitational waves [2]. Recently there has been reported experimental evidence of r-process nucleosynthesis in a BNSM identified as the origin of the gravitational-wave source GW170817 [3]. The nuclear reactions that describe the evolution of such systems involve thousands of nuclides following a complex network of capture and decay processes. Here, the main parameter determining the feasibility of the astrophysical environment to produce heavy elements by the r-process is the neutron-to-seed ratio (existing nuclei in the onset of the r-process, like ^{12}C). In this context, the three-body capture reaction ^{4}He$(2n,\gamma)^{6}$He are expected to be important in producing ^{12}C, thus playing a relevant role [4].
As part of a possible path to synthesize ^{12}C, a low mass seed nucleus of the r process, the collaboration has proposed the measurement of the ^{4}He$(2n,\gamma)^{6}$He reaction rate at the TriSol facility of the NSL laboratory at the University of Notre Dame [6,7]. The experimental approach adopted consists of measuring the Coulomb breakup channel in collisions of the system ^{6}He+^{208}Pb, that is, the ^{6}He$(\gamma,2n)^{4}$He reverse reaction, applying the theoretical framework described in [7], which was developed by members of the collaboration.
The experiment was performed in June 2013. The energy of the ^{6}He beam was 19.3 MeV. The detection system was composed of six silicon telescopes available at NSL placed at forward angles (11 $^{\circ}$ < θ_{lab}< 25 $^{\circ}$). A 1.7 mg/cm^{2} thick self supported enriched target of ^{208}Pb, made by the collaboration at the target laboratory in the University of Lisbon-LIP, was used. More details about the experimental setup and preliminary results of the undergoing data analysis of the experiment will be presented in this talk.

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[1] Astrophys. J. 807, 115 (2015)
[2] Phys. Rev. Lett. 116, 061102 (2016)
[3] Nature 551, 67–70 (2017)
[4] Phys. Rev. C 74, 015802 (2006)
[5] NIM A 1047 (2023) 167784
[6] NIM B 541 (2023) 216-220
[7] Phys. Rev. C 93 (2016) 041602(R).

Primary authors: Mr SANCHEZ BENITEZ, Angel Miguel (Centro de Estudios Avanzados en Física, Matemáticas y Computación (CEAFMC), Department of Integrated Sciences, University of Huelva, Spain); Mr FERNÁNDEZ GARCÍA, Juan Pablo (Departamento de FAMN, University of Seville, Spain); Mr ACOSTA SÁNCHEZ, Luis Armando ((1) Instituto de Física, UNAM, Mexico; (2) Instituto de Estructura de la Materia, CSIC, Madrid, Spain;); Mr O'MALLEY, Patrick (Dept. of Physics and Astronomy, University of Notre Dame, United States); COLLABORATION, for the experiment

Presenter: Mr SANCHEZ BENITEZ, Angel Miguel (Centro de Estudios Avanzados en Física, Matemáticas y Computación (CEAFMC), Department of Integrated Sciences, University of Huelva, Spain)

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