European Nuclear Physics Conference 2025



Contribution ID: 366

Type: Invited Presentation

Helium burning and nuclear clustering: recent studies and constraints from direct reactions

Understanding stellar nucleosynthesis remains a forefront challenge in physics and relies on detailed knowledge of helium burning, whose pivotal triple- α and ${}^{12}C(\alpha,\gamma){}^{16}O$ reactions set the carbon–oxygen balance in stars. This talk will present recently published precision data on the triple- α reaction and a new direct measurement of ${}^{12}C(\alpha,\gamma){}^{16}O$ performed at iThemba LABS. Finally, it will introduce a framework for analysing direct-reaction data that treats sub-threshold states and resonances in a manner consistent with R-matrix scattering analyses. This enables more stringent tests of nuclear clustering and yields parameters that are more model-independent and comparable across different studies. These parameters may ultimately support improved constraints on astrophysical reaction rates.

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Session Classification: Parallel session

Track Classification: Nuclear Astrophysics