Contribution ID: **81** Type: **Oral**

Extending the Hoyle-state paradigm to ^{12}C+^{12}C fusion

Carbon burning is a key step in the evolution of massive stars, Type 1a supernovae and superbursts in x-ray binary systems. Determining the ^{12}C+^{12}C fusion cross section at energies relevant to these different astrophysical scenarios by extrapolation of direct measurements is challenging due to resonances at and below the Coulomb barrier.

A study of the ^{24}Mg(α,α′)^{24}Mg reaction has recently identified several 0^+ states in ^{24}Mg, close to the ^{12}C+^{12}C threshold, which predominantly decay by ^{20}Ne(g.s)+α. These states were not observed in ^{20}Ne(α, α_0)^{20}Ne resonance scattering suggesting that they may have a dominant ^{12}C+^{12}C cluster structure. Given the very low angular momentum associated with sub-barrier fusion, these states may play a decisive role in ^{12}C+^{12}C fusion in analogy to the Hoyle state in helium burning. This demonstrates how nuclear structure is important to various aspects of nuclear astrophysics. Estimates of updated ^{12}C+^{12}C fusion reaction rates are presented based on contributions from these near-threshold 0^+ states.

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Session Classification: Poster Session

Track Classification: Poster Presentations