# $^{19}$F spectroscopy and implications for astrophysics

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In astrophysics, $^{19}$F plays a major role because of the diverse reactions where it is involved and of its abundance. This may be used as a probe of stellar nucleosynthesis, since production and destruction rates are very sensitive to the stellar interior physical conditions, especially in the case of asymptotic giant branch (AGB) stars and the s-process. In these stars, $^{19}$F is produced by the $^{14}\mathrm{N}(\alpha,\gamma)^{18}\mathrm{F}(\beta^+)^{18}\mathrm{O}(p,\alpha)^{15}\mathrm{N}(\alpha,\gamma)^{19}\mathrm{F}$ reaction chain, so the study of $^{15}\mathrm{N}+\alpha$ elastic scattering provides valuable clues about its synthesis, as the spectroscopic information can be used to constrain the resonance strengths and energies intervening in the calculation of the reaction rate.

$^{19}$F spectroscopy through $^{15}\mathrm{N}+\alpha$ elastic scattering is also important in the context of AGB stars, making it possible to constrain the cross section of the $^{18}\mathrm{O}(p,\alpha)^{15}\mathrm{N}$ reaction and influencing the abundances of $^{18}$O, $^{19}$F and $^{15}$N. Finally, in explosive scenarios such as classical novae, the $^{15}\mathrm{N}+\alpha$ elastic scattering is important as it allows us to shed light on the spectroscopy of $^{19}$F mirror nucleus $^{19}$Ne, entering explosive nucleosynthesis through $^{18}\mathrm{F}+p$ capture reactions.

In this work [1], we report on the most extensive measurement and analysis of the $^{15}\mathrm{N}+\alpha$ elastic scattering, making it possible to span $^{19}$F excitation energies over a wide interval, from $\sim 5$ to $\sim 10$ MeV, as well as a broad angular range, to pin down unknown spin parities of observed states. The measurement was carried out through the thick target inverse kinematics method, and the experimental spectra fitted using the R-matrix approach. This analysis allowed us to suggest new spin parity assignments and to identify $^{19}$F states featuring $\alpha-$cluster structures also in the energy regions of astrophysical interest.

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[1] M. La Cognata et al., Physical Review C **99**, 034301 (2019).