

# 4He + 4He elastic and inelastic scattering: probing the mysterious properties of the second 0+ state of 4He

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The  $^4\text{He}$  nucleus is one of the simplest nuclear systems. No bound excited states are present in its level scheme however, a pronounced resonance with the same spin and parity ( $0^+$ ) as the ground state exists with a centroid slightly above the proton emission energy threshold. The results from several available studies show discrepancies on the determination of the  $^4\text{He}(0_2^+)$  resonance energy, width and line shape. Furthermore, recent results focusing on the first excited resonant state of  $^4\text{He}$  nucleus, reveal a puzzling situation potentially calling for missing physics in our best known nuclear forces and, consequently, in our understanding of the nuclear phenomenology. Into this context, we performed new measurements of the  $^4\text{He}$  resonance by  $^4\text{He} + ^4\text{He}$  scattering at the MAGNEX facility of INFN – Laboratori Nazionali del Sud, featuring data of unprecedented sensitivity and state-of-art analyses of the spectral line shape and the scattering cross sections. Our experimental data on the line shape of the  $^4\text{He}(0_2^+)$  and on elastic and inelastic differential cross section angular distributions allow for a new insight on the relevant role of the interference between the resonance and the underlying non-resonant continuum. Our data can be reasonably described within the known physics of nuclear interactions and resonance properties, indicating no hint for new physics from  $^4\text{He}$  resonance properties.

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