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Lifetime measurements of $2^+_2$ and $3^+_1$ states in $^{20}$O
The role of 3N forces

- Shell model calculations failed to reproduce the oxygen dripline.
- When adding the 3N forces, the dripline changes from the $0d_{3/2}$ orbital ($N=20$, $^{28}$O) to the $1s_{1/2}$ ($N=16$, $^{24}$O).
- Additional information on the relative position of the orbitals is needed.

Non-yrast states in $^{20}\text{O}$

- The non-yrast states are sensitive to the position of the $0d_{3/2}$ orbital.
- The gap between the orbitals influences the lifetime of the $2^+_2$ and $3^+_1$ states of $^{20}\text{O}$.
The experiment

- $^{19}\text{O}(d,p)^{20}\text{O}$ reaction
- Beam $^{19}\text{O}$ 8 MeV/A i: $4 \times 10^5$ pps.
- Target CD$_2$ 0.3 mg/cm$^2$ + nat Au 20 mg/cm$^2$.
- AGATA array + MUGAST + VAMOS.
Event-by-event Doppler correction

The velocity vector and excitation energy of the $^{20}$O recoil was reconstructed from the information on the proton.

The event-by-event Doppler correction improved the resolution of 25% with respect to the one using the average $\beta=12.6\%$.
The experiment

By gating on the excitation energy spectrum, it was possible to reconstruct the level scheme of the $^{20}$O nucleus.
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\[0^+ + \text{g.s.} \quad 2^+ \quad 4^+ \quad 2^+ \quad 3^+ \quad (2^+) \quad (2^+)\]

\[3^+ \quad (2^+) \quad 1154 \quad 3551 \quad 3954 \quad 3329 \quad 4071 \quad 1674 \quad 1897 \quad 2307 \]**

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Lifetime measurements of 2+2 and 3+1 states in 20O - I. Zanon
The experiment

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Lifetime measurement of the $2^{+}_2$ and $3^{+}_1$

The lifetime measurement is extracted by comparing the lineshape of the transition to Monte Carlo simulations performed with Geant4.

Realistic parameters like angular distributions and resolutions of HPGe detectors are added to the simulation.

The experimental and simulated spectra are compared using the least-$\chi^2$ test.
Lifetime measurement of the $2^+_{2}$ and $3^+_{1}$

- The lifetime of the $2^+_{2}$ resulted to be $63^{+29}_{-16}$ fs.
- The lifetime of the $3^+_{1}$ resulted to be $55^{+16}_{-19}$ fs.
- Systematic errors are still being evaluated.
Influence of the feeder

Without the gate on the direct population of the $2^+_2$, the lifetime of the state results to be about 40% longer.
Theoretical calculations

The new experimental value of the $2^+_2$ confirms the influence of 3N forces in this region.

The discrepancy of this new measurement leaves open questions.
Conclusions

• Challenging experiment with state-of-the art particle detection and $\gamma$-ray tracking;

• Strong control on the population of the states using of (d,p) reaction to populate the $^{20}$O nucleus;

• Lifetime measurement of the $2^+_2$ and $3^+_1$ states;

• Evidence of the role of 3N forces in the ab-initio calculations.
Thanks to the collaboration


On behalf of the AGATA, VAMOS and MUGAST collaborations