Resonances of 25,26F Atomic Nuclei

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Overview

- National Superconducting Cyclotron Laboratory (NSCL) at Michigan State University (MSU)
- Facility uses two particle accelerators called cyclotrons which produces many radioactive isotopes
- The isotopes are separated by a magnetic fragment separator
- The beam is then directed into a target where collisions cause reactions within the nucleus.

Isotope Separation

- Time-of-flight (ToF) is the time it takes the charged fragment to get from the target to the fragment detectors.
- The energy loss separates the elements and is proportional to $Z^2$ where $Z$ is the number of protons in the nucleus.
- Adjusting the ToF based on charged particle trajectories results in isotope separation.
- Nuclides generated from our secondary beam based on their adjusted ToF and energy loss is shown below.

Neutron Detection

- Neutron Time-of-Flight ($^{27}$F):
  - Neutron Time-of-Flight is the time it takes the neutron to get from the target to MONA and USA.
  - This is timed right before the liquid deuterium target to the MONA-LISA detectors.
  - First peak is an interaction with the detectors and Gamma-rays.

Simulation Overlay

- Edecay of $^{25}$F with simulation overlay:
  - The three simulation peaks are (red line) 375 MeV peak with a 2 MeV width, (pink line) 1.0 MeV peak with a 6 MeV width, and (blue line) 3.0 MeV peak with a 2.0 MeV width.
- Edecay of $^{26}$F with simulation overlay:
  - The three simulation peaks are (red line) 355 MeV peak with a 2 MeV width, (pink line) 1.45 MeV peak with a 6 MeV width, and (blue line) 3.5 MeV peak with a 2.0 MeV width.

Prior Results

- This figure (taken from Reference 1) shows the decay energy of $^{27}$F with resonances at 28 KeV (blue line) 350 KeV, and (dotted line) 1200 KeV.
- $^{27}$F unbound and bound states of $^{27}$F have been observed in prior experiments.$^{1,2,3}$
- The MONA Collaboration found a resonance produced from a nuclear-exchange reaction between a secondary beam of $^{27}$Ne and a target of $^{19}$Be.
- The state was difficult to determine due to the type of reaction in that experiment.
- The data presented in this poster looks different from this prior result possibly due to the different reactions or some additional background.

Interpretation

- The states above the Sn line have enough energy to emit a neutron and are still unstable and emit another neutron and ends at a stable $^{27}$F with two emitted neutrons.
- The three positive states (red lines) above the $S_n$ line have enough energy to emit a neutron and ends at a stable $^{27}$F with one emitted neutron.
- Theoretical calculations for the different ways $^{27}$Ne produces $^{27}$F or $^{29}$F.
- Green lines are for negative parity and red lines are for positive parity.
- An anomaly of how the state is mathematically represented with a positive parity being a cosine function and a negative parity is a sine function.
- Theory calculation using NuShellX

Outlook

- The difference between the prior results and our data will be explored.
- Publish a journal article on the unbound states of $^{25}$F and $^{26}$F.
- We plan to reconstruct a 3-body decay energy spectrum.

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