



Canadian Association  
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Association canadienne  
des physiciens et physiciennes

Contribution ID: 3149

Type: Oral (Non-Student) / Orale (non-étudiant(e))

## Study of cross-shell excitations near the 'island of inversion' using fusion-evaporation and Doppler shift methods

Thursday 9 June 2022 09:30 (15 minutes)

The 'island of inversion' centred on  $^{32}\text{Mg}$  is characterized by ground state configurations with an inverted ordering of  $sd$  and  $pf$  (intruder) neutron orbitals due to nuclear deformation and nucleon-nucleon interactions. For neutron rich  $sd$  shell nuclei outside of the 'island of inversion', similar configurations incorporating the neutron  $pf$  shell occur in levels with high excitation energy and spin. Several recent studies have used fusion-evaporation reactions to preferentially populate and study these intruder states, including a recent experiment at the ISAC-II facility at TRIUMF in which the nuclides  $^{25}\text{Na}$  and  $^{28}\text{Mg}$  were produced following  $^{12}\text{C} + ^{18}\text{O}$  fusion [1, 2].

In this experiment, fusion-evaporation exit channels were separated via time coincident identification of charged particles and gamma rays. Gamma-ray spectroscopy utilized the TIGRESS array at ISAC-II. Charged particles were detected and identified using a recently completed CsI(Tl) 'ball' scintillator array, developed at Simon Fraser University and commissioned at TRIUMF [3]. Lifetime measurements of excited states populated in the channels of interest were performed using Doppler shift methods.

Six new excited states in  $^{25}\text{Na}$  and  $^{28}\text{Mg}$  were identified, including candidates for the  $I^\pi = 5_1^+, 6_1^+$  levels in  $^{28}\text{Mg}$ . Evidence for negative parity states was also observed, including a candidate for the  $I_\pi = 13/2_1^-$  level in  $^{25}\text{Na}$  and an unusually long-lived state in  $^{28}\text{Mg}$  thought to decay by an M2 transition ( $I^\pi = (0, 4)^-$ ). The energies of these levels are consistent with predicted intruder states arising from single neutron excitation to the  $pf$  shell, using the SDPF-MU and FSU shell model interactions. This data and its interpretation with respect to the 'island of inversion' will be discussed, along with future plans to extend this work towards  $N = 20$  by studying  $^{32}\text{Si}$  and other nearby nuclides populated following  $^{12}\text{C} + ^{22}\text{Ne}$  fusion.

[1] J. Williams et al., PRC 100 014322 (2019).

[2] J. Williams et al., PRC 102 064302 (2020).

[3] J. Williams et al., NIM A 939 1-9 (2019).

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**Session Classification:** R1-4 Precision Nuclear Processes and Beyond (DNP) | Processus nucléaires de précision et au delà (DPN)

**Track Classification:** Technical Sessions / Sessions techniques: Nuclear Physics / Physique nucléaire (DNP-DPN)