# Excited States in N~20 Neon and Sodium Nuclei

E. Rodriguez-Vieitez[1,2], P. Fallon[1], D. Bazin[3], C. M. Campbell[3,4], R. M. Clark[1], J. M. Cook[3,4], M. Cromaz[1], M. A. Deleplanque[1], D.-C. Dinca[3,4], A. Gade[3,4], T. Glasmacher[3,4], I. Y. Lee[1], A. O. Macchiavelli[1], W. F. Mueller[3], S. G. Prussin[2], F. S. Stephens[1], M. Wiedeking[1], K. Yoneda[3,4]

[1]*Nuclear Science Division, Lawrence Berkeley National Laboratory, Berkeley, CA 94720, USA*
[2]*Department of Nuclear Engineering, University of California, Berkeley, CA 94720, USA*
[3]*National Superconducting Cyclotron Laboratory, Michigan State University, East Lansing, MI 48824, USA*
[4]*Department of Physics and Astronomy, Michigan State University, East Lansing, MI 48824, USA*

The existence of deformed (2p2h) intruder ground states in A~30 N~20 nuclei (the "island of inversion" [1]) provides (a) one of the most dramatic and clear manifestations of the breakdown of conventional shell structure in neutron-rich nuclei, and (b) a measure of the valence nucleon interactions away from beta stability. Its occurrence can be associated with a reduction in the N=20 shell gap from ~6 MeV in $^{40}$Ca to the ~3 MeV in $^{30}$Ne, $^{31}$Na, $^{32}$Mg. This variation in the N=20 gap as a function of Z has recently [2] been linked to the strong T=0 monopole interaction between valence $d_{3/2}$ neutrons and $d_{5/2}$ protons. Enhanced pairing effects have also been cited [3] as an important contributor to the observed collectivity in $^{32}$Mg, and presumably in other island-of-inversion nuclei. While the evidence for intruder ground states in nuclei such as $^{30}$Ne, $^{31}$Na, and $^{32}$Mg is well established, the questions remain; where does the transition from normal to deformed intruder ground states occur, and what is the nature of the observed collectivity? Information on excited states is needed to understand both these questions.

An experiment was carried out at the NSCL in Michigan State University to study the spectrum of excited states in N~20 neutron-rich nuclei. A 140 MeV/A $^{48}$Ca primary beam was used to produce a "cocktail" of secondary beams ($^{29}$Na/$^{30}$Mg/$^{32}$Al and $^{32}$Mg/$^{33}$Al/$^{35}$Si) which then underwent secondary knockout/fragmentation reactions to produce the neutron-rich isotopes of Na and Ne. The segmented germanium detector, SeGA, was used to measure the in-beam gamma-ray decays from excited states populated in the secondary reaction. In several cases it was possible to determine gamma-gamma coincidences and this was critical to establish the correct level scheme. In this talk I will focus on the Neon isotopes, $^{28\text{-}30}$Ne, and compare the observed levels with shell model calculations as a function of increasing neutron number. These data provide new information on the transition to the island of inversion. For example, in the case of $^{28}$Ne they may be used to constrain the amount of 2p2h-0p0h mixing in the ground and low-lying states, and hence provide a test of recent shell model calculations.

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