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Dissertation Award in Nuclear Physics[1]

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A main goal in nuclear physics is to understand which nuclei exist; i.e., whether a specific number of protons and neutrons combine to form a bound state. The boundary point at which an element can no longer hold additional neutrons, the neutron drip line, is greatly effected by the underlying single particle shell structure. In recent years, the single particle orbitals for neutron rich nuclei have been found to change in energy relative to their isotopic neighbors near the valley of stability. One of the outcomes of this evolution is the appearance of new magic numbers, and their effect on the location of the neutron drip line is largely unknown. With recent advancements in radioactive beams and experimental equipment, it is now possible to probe exotic nuclei at and beyond the drip line. From these investigations an interesting phenomenon has been observed, whereby the $Z = 8$ oxygen isotopes abruptly end at $N = 16$ ^{24}O, while the $Z = 9$ fluorine isotopes extend out to at least $N = 22$ ^{31}F. Such a large jump in the drip line poses a theoretical challenge. A hypothesis has been proposed suggesting that a new magic number appears at $N = 16$ for $Z = 8$ causes the sudden end to the oxygen drip line. Neutron unbound states in ^{24}O and ^{25}O were experimentally investigated to shed light on the single particle structure at the oxygen drip line. From observation of the ground state resonance of ^{25}O and two excited states in ^{24}O, the $N = 16$ shell gap was determined to be nearly 5 MeV and the energy of the first excited state in ^{24}O was found to be 4.7(1) MeV. This new data strongly supports a new magic number $N = 16$ at the oxygen drip line, making ^{24}O a doubly magic nucleus. A theoretical investigation of the data revealed that a consistent picture for the oxygen-fluorine region had yet to exist.

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