Behavior of Nuclei at Ultra-High Spin

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The visualization of nuclei in a two-dimensional (Z,N) Chart Of The Isotopes sense influences our conception of studies of the limits to be investigated. The sorts of questions that derive from this conception are:

(1) what is the highest Z element that can be produced;
(2) where is the neutron drip line;
(3) where is the proton dripline;
(4) what is the isospin dependence of nuclear forces.

When we include the dimension of angular momentum in our picture, other questions immediately come to mind. Such questions include:

(1) what are the limits of angular momentum that can be deposited in a nucleus;
(2) how is nuclear structure modified at ultra-high spin;
(3) what is the relation between excitation energy and angular momentum along the Yrast line;
(4) how does this relation depend on Z and N in a gross sense and how is it influenced by nuclear structure.

<u>A RIA facility will allow us to address most of these questions.</u>

The spectra of rotational bands associated with superdeformed shapes are very regular and have strong transition matrix elements. These features constitute an excellent marker for nuclear structure effects, and might be used as a probe to learn about nuclear structure at ultra-high spin. The well known superdeformed minimum associated with N=86, (Z:X = 1.85:1), has been identified and studied in nuclei near Dy. For ^{152}Dy (Z=66), we calculate a fission barrier of 10 MeV at I=70 hbar. For ^{136}Sn (Z=50), this fission barrier for the superdeformed shape is increased substantially and has a value of roughly 17 MeV at I=70 hbar. At I=80 hbar, this barrier is still roughly 12 MeV for ^{136}Sn. Producing the N=86 isotones for Z values from 66 to 50 (neutron rich) will increase our understanding of nuclei at ultra-high spin substantially.

There are already some hints that our understanding of nuclear structure at high spin is incomplete. There has been no experimental verification of the hyperdeformed shapes predicted in many calculations to be Yrast at very high spins in several nuclides. The production of neutron rich nuclides at the RIA will provide an opportunity to acquire an understanding of nuclear structure at the highest spins.