EXOTIC NUCLEI : RELATIVISTIC MEAN FIELD APPROACH

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In recent years highly neutron rich (deficient) nuclei far away from the stability line are being produced in various research laboratories. The study of these so called Exotic Nuclei reveal several interesting features e.g. large deformations, abrupt changes in rms radii, shape co-existence etc. The 28-50 nuclear range is of particular interest because here both neutron rich as well as neutron deficient nuclei can be produced and the nucleus N=Z show large deformations. For example ^{80}Zr till todate is the known highly deformed N=Z nucleus ($\beta \simeq 0.5$).

Here we analyse these Exotic Nuclei in the 28-50 region using the Relativistic Mean Field (RMF) Theory. The RMF equations are solved self consistently by expanding separately the Dirac spinors and the meson fields for Sigma (σ), Omega (ω), Rho (ρ) mesons in terms of Harmonic Oscillator (HO) basis (for details see ref.1).

The masses and the coupling constants of the respective meson fields with the Dirac nucleon spinor fields are taken from the earlier work and correspond to the highly successful parameter set NL1. The explicit values of these parameters are:

Masses(MeV):			The coupling constants:
Nucleon:	$m_N = 938.0$		$g_\sigma = 10.14$
Mesons :Sigma	$m_\sigma = 492.5$		$g_w = 13.29$
Omega	$m_w = 795.36$		$g_\rho = 4.98$
Rho	$m_\rho = 763.0$	Photon	$\alpha^p = 1/137$

In addition Sigma (σ) meson is considered to move in nonlinear potential with cubic and quartic terms having coupling constants $g_2 = -12.17$ and $g_3 = -36.27$ respectively.

The pairing is taken into account in the constant gap approximation. The required gap parameters Δn (Δp) for neutrons (protons) are obtained either from the observed odd-even mass differences where available or from the empirical relation $12/\sqrt{N(Z)}$.

Some of the representative results arranged in the table show the following features:

1. The results are in good agreement with the experiment where ever available .
2. Slightly deformed (near spherical; β=very small) solutions in general appear slightly lower in energy ($\Delta E \simeq$ 1.5Mev) as compared to the corresponding spherical (β=0.)solutions .
3. The deformed and spherical solutions appear very close to each other for ^{74}Sr, ^{76}Sr, ^{76}Zr, ^{78}Zr and ^{80}Zr with energy differences ΔE -1.7, -1.6, 0.01, 0.01 and 1.6 Mev, respectively. Thus indicating a possible shape co-existence very near to the ground state for these systems .
4. The charge (proton rms) radius decrease with the decrease with the addition of neutrons from ^{74}Sr to ^{76}Sr .

Nucleus		Δn	Δn	E/A	r_c	r_{rms}	β
^{74}Sr	(Sph)	2.0	1.95	-8.20	4.34	4.15	0.
	(Def)	2.0	1.95	-8.23	4.31	4.17	.432
^{76}Sr	(Sph)	1.95	1.95	-8.37	4.31	4.17	0.
	(Def)	1.95	1.95	-8.39	4.24	4.12	.008
	(Def)	1.95	1.95	-8.40	4.32	4.20	.467
^{76}Zr	(Sph)	2.0	1.9	-8.02	4.41	4.20	0.
	(Def)	2.0	1.9	-8.04	4.31	4.14	.001
	(Def)	2.0	1.9	-8.02	4.38	4.22	.433
^{78}Zr	(Sph)	1.95	1.9	-8.22	4.40	4.22	0.
	(Def)	1.95	1.9	-8.24	4.31	4.17	.0001
	(Def)	1.95	1.9	-8.22	4.39	4.25	.466
^{80}Zr	(Sph)	1.9	1.9	-8.38	4.37	4.23	0.
	(Def)	1.9	1.9	-8.40	4.31	4.12	.0004
	(Def)	1.9	1.9	-8.36	4.38	4.21	.466

References :

1. Y.K. Gambhir et.al.; Ann Phys. 198, 132(1990) and references quoted therein .