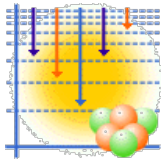
Argonne NATIONAL LABORATORY

Member of the US Nuclear Data Program

Configurations and Hindered Decays of K-Isomers in deformed nuclei with A>100

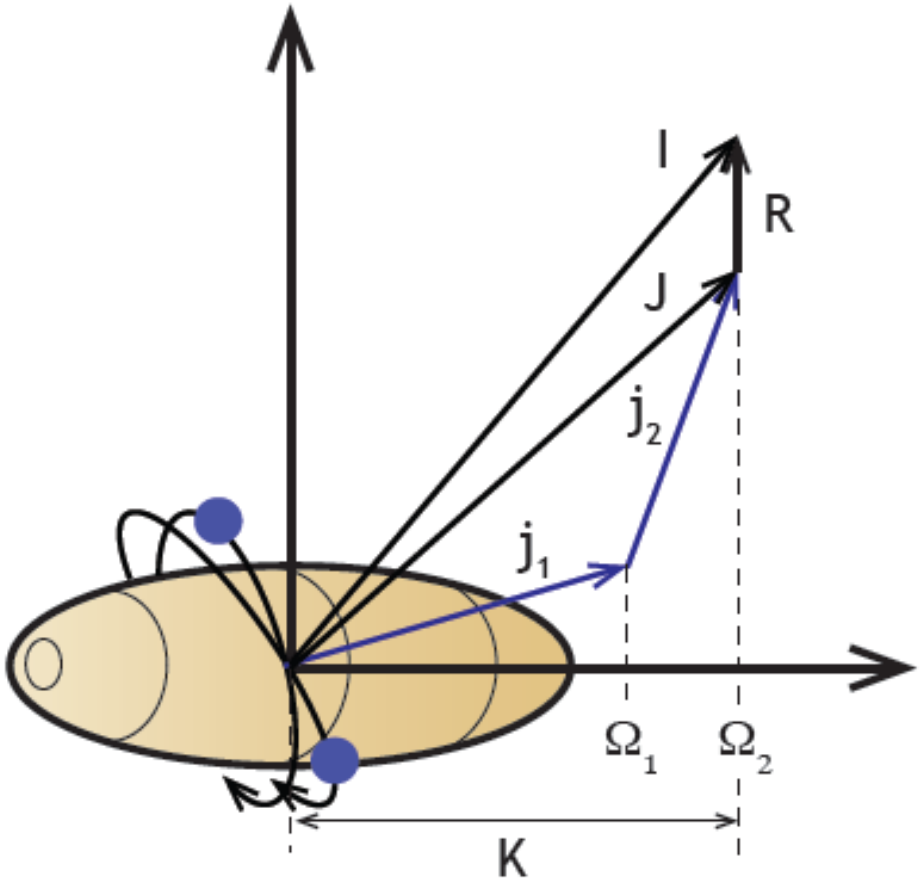
with G.D. Dracoulis & T. Kibedi (ANU)



project started several years ago (*NSDD 2007*) and evolved from a simple compilation of NS data to a comprehensive horizontal evaluation & associated database

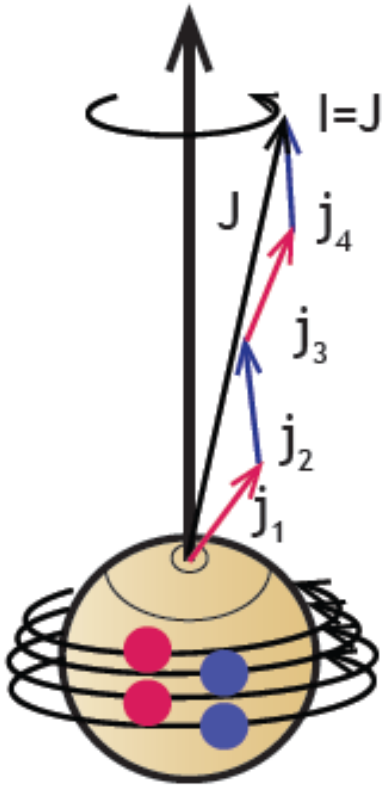
- ✓ implications for basic science & applications
- ✓ implications for (future) ensdf development
- ✓ implications to other ND activities that deal with deformed nuclei

angular momentum generation



$$I = \sum \Omega_i + R$$

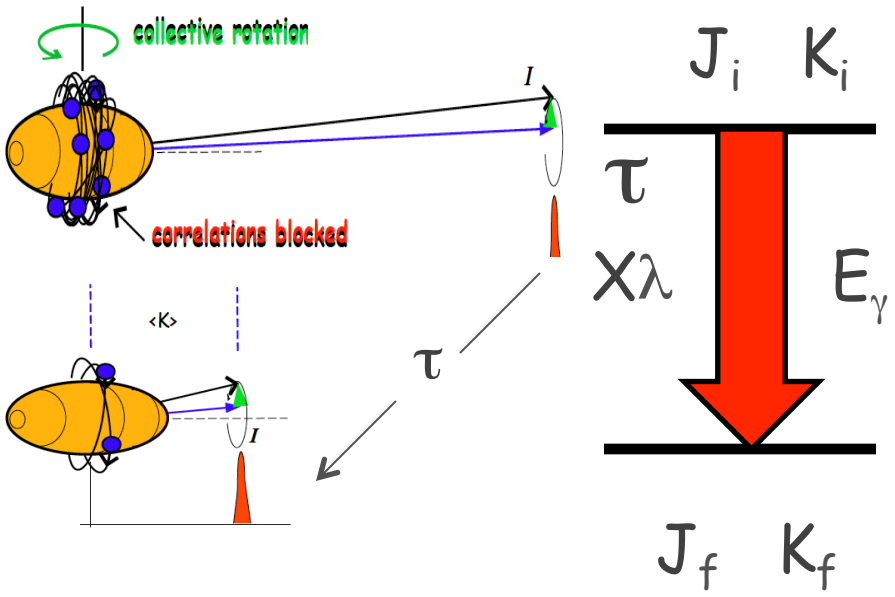
$$E_j = E_{int} + \frac{\hbar}{2\Im}[I(I+1) - K^2] + V_r$$



$$I = J = \sum j_i$$

$$E_j = \sum e_j + V_r$$

K hindered decays



- ✓ hindrance $F_w = \tau_\gamma / \tau_W$
- ✓ reduced hindrance $f_\nu = F_w^{1/\nu}$

- ✓ typically f_ν = 20 – 300, but many exceptions…
- ✓ rule of thumb 100 per ν - usually attributed to Lobner…

- ✓ transition of multipolarity λ can only change the K projection by at most λ.
- ✓ the shortfall is the degree of "forbiddenness" **ν = ΔK –λ.**

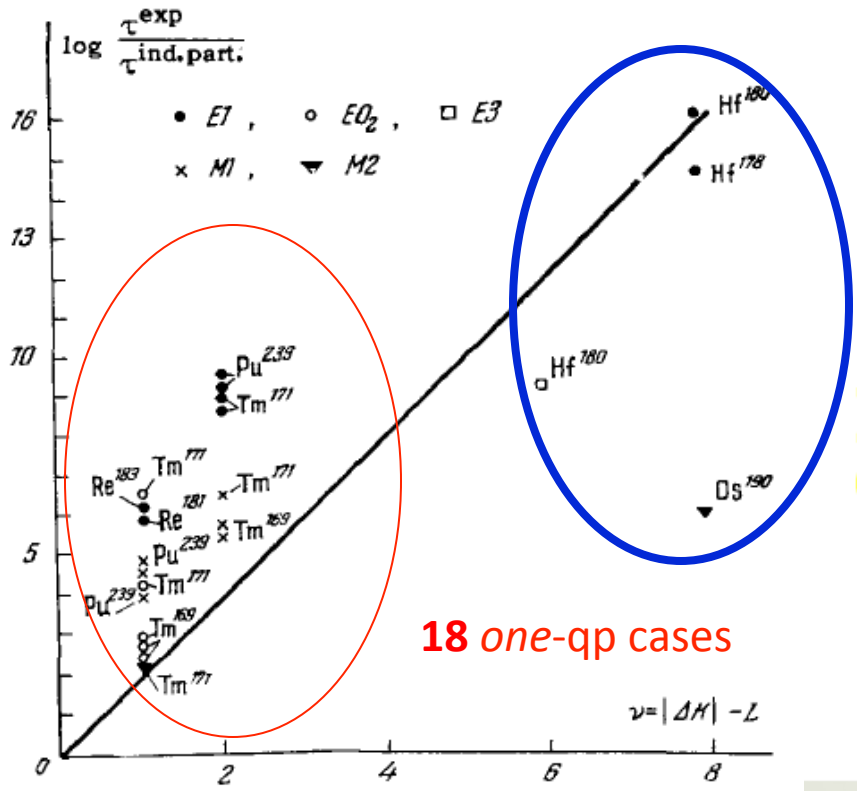
Rusinov's systematics

SOVIET PHYSICS USPEKHI VOLUME 4, NUMBER 2 SEPTEMBER-OCTOBER 1961

NUCLEAR ISOMERISM

L. I. RUSINOV*

Usp. Fiz. Nauk **73**, 615-630 (April, 1961)



only **4** *two*-qp cases

18 *one*-qp cases

small in all other instances. The experimental data on K-forbidden transitions show that increase of K forbiddenness by one degree represents the reduction of transition intensity by a factor of about 100. A sep-

$$\log F_W = 2(|\Delta K| - L)$$

Lobner's systematics

Volume 26B, number 6 PHYSICS LETTERS 19 February 1968

SYSTEMATICS OF ABSOLUTE TRANSITION PROBABILITIES OF K-FORBIDDEN GAMMA-RAY TRANSITIONS

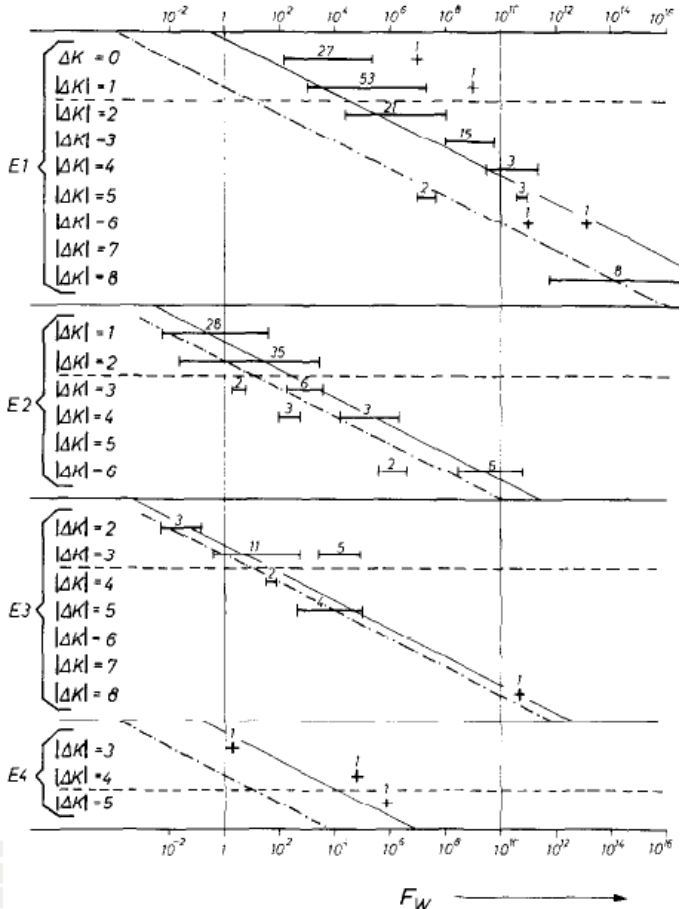
K. E. G. LÖBNER
Department of Physics, Technical University, Munich, Germany

250 cases- both *one*- and *two*- and higher mqp isomers

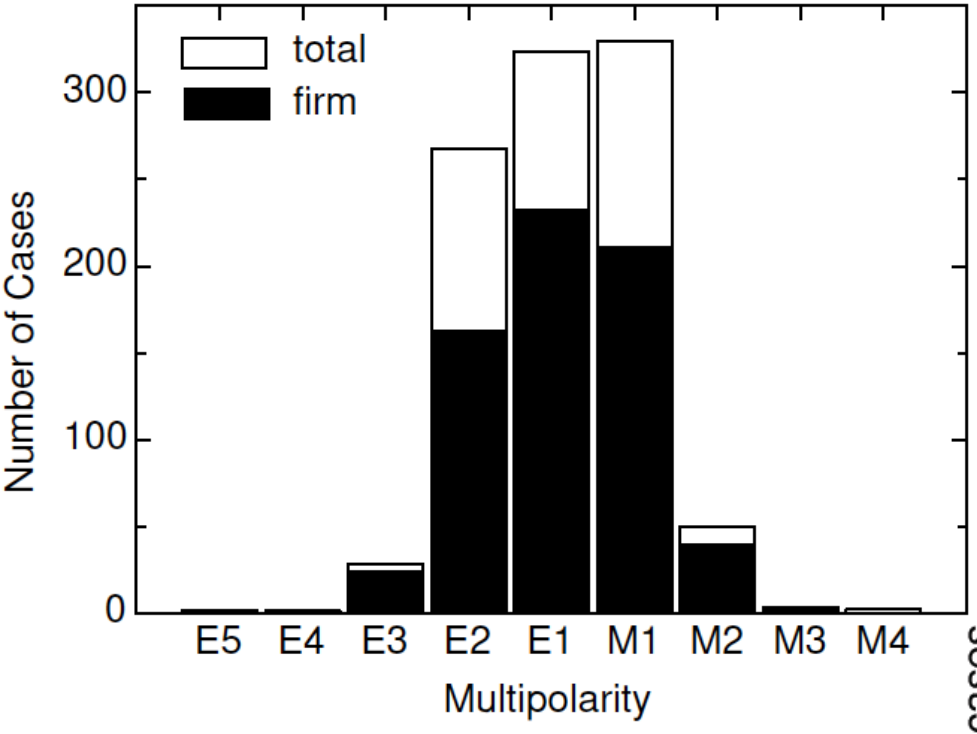
✓ sloping lines given in fig. 1 and fig. 2. It is found that the reduced transition probabilities decrease approximately by a factor of 100 per degree of K-forbiddenness in agreement with

✓ The frequently used "empirical rule" of Rusinov [1]: $\log F_W = 2(|\Delta K| - L)$ is in general not true, especially not for the E1 and E4 transi-

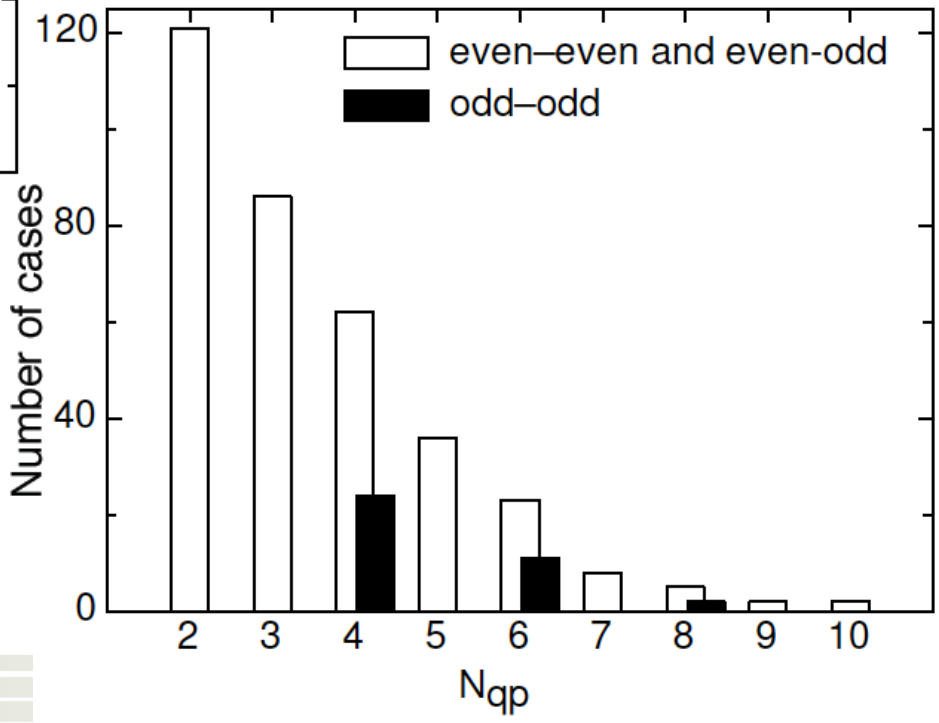
✓ It must be emphasized that the F_W values scatter considerably. Therefore, care should be taken if K values of levels are deduced from measured γ-ray transition probabilities.



New systematic studies

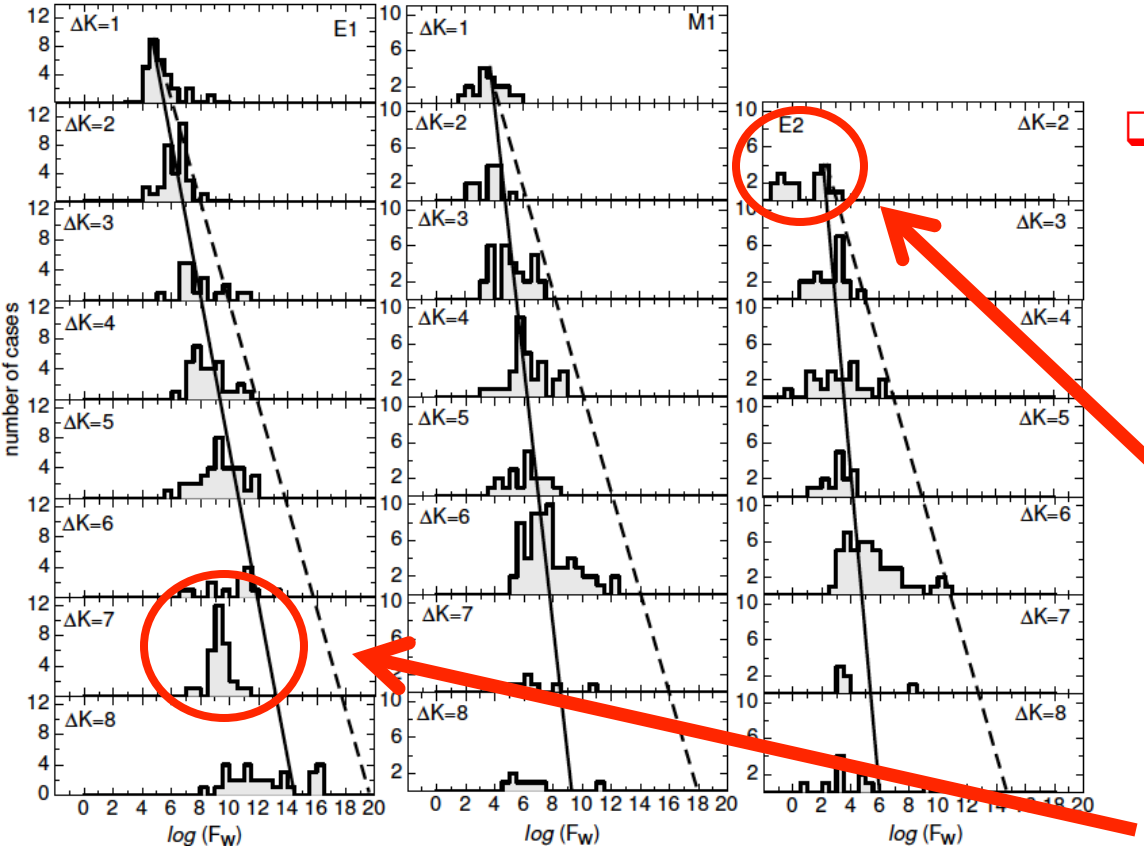


- ❑ examined **373** isomeric decays
- ❑ determined **1050** K-forbidden transitions
  - ✓ compare to **250** (Lobner)
  - ✓ compare to **22** (Rusinov)
- ❑ self-consistent fashion
  - ✓ ensdf files, Mult., ICC, etc.



- ✓ considered only mqp states
- ✓ established rotational bands (70% of cases)
- ✓ established configurations

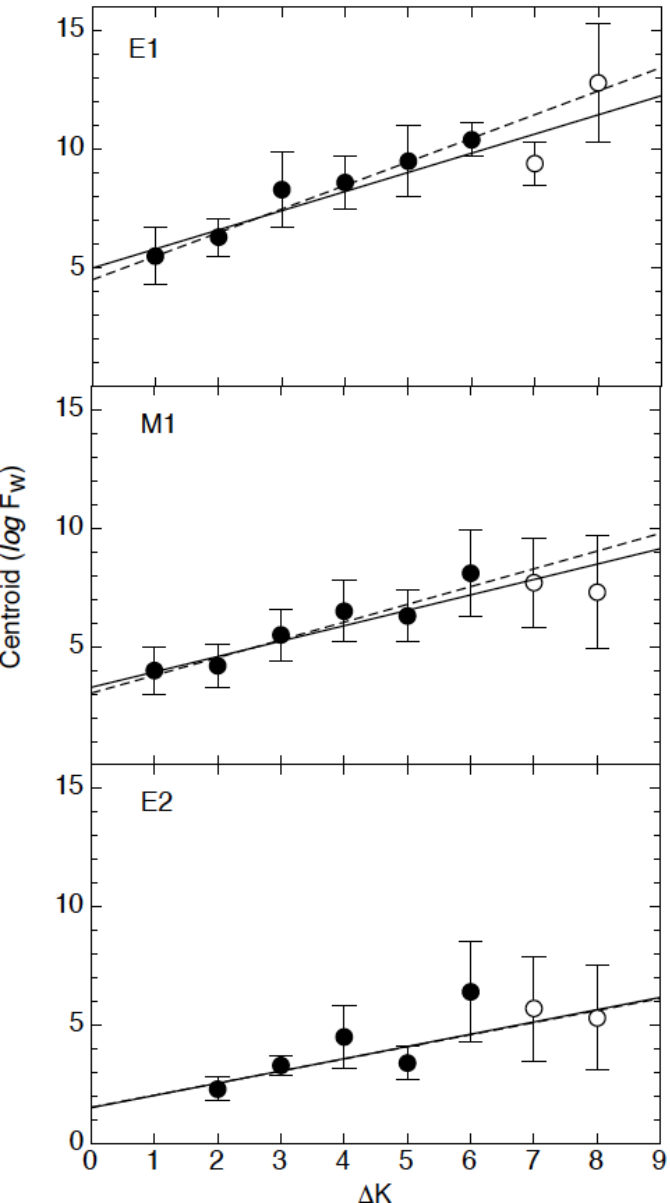
K-hindrance distributions



- distributions are not symmetrical – role of different mixing mechanisms
- centroids increase much more slowly than what would be expected from the rule of thumb, e.g. ~100 per degree of K-forbiddenness (dashed lines)
- ΔK=2 (allowed) E2 has two peaks
  - ✓ non-intrinsic states – transitions between rotational-aligned structures in transitional nuclei, e.g. $I^{\pi}=12^{+}$ state in ^{192}Os
- ΔK=7 E1 is strongly peaked, but at low value compared to the trend
  - ✓ multiple transitions from a single isomer, e.g. $K^{\pi}=7^{-}$ in ^{180}Os – five E1 transitions

✓ hindrance $F_w = \tau_\gamma / \tau_W$

K- hindrance classification



K forbidden

$$F = F_0 \times f_0^{\nu}$$

intrinsic

$\sigma\lambda$	F_0	f_0	χ^2
all points			
E1	$2.0^{+65}_{-15}\times10^5$	6.4^{+32}_{-21}	2.2
M1	$2.9^{+71}_{-6}\times10^3$	4.5^{+27}_{-17}	1.0
E2	$1.2^{+17}_{-7}\times10^2$	2.8^{+15}_{-10}	1.2
selected points: see Fig. 15			
E1	$1.0^{+37}_{-8}\times10^5$	12.5^{+124}_{-62}	0.3
M1	$1.7^{+55}_{-3}\times10^3$	6.7^{+65}_{-33}	0.3
E2	$1.2^{+17}_{-7}\times10^2$	3.2^{+28}_{-15}	0.9

- ✓ less than the ~100 per degree of K forbiddenness
- ✓ it is multipolarity dependent
- ✓ no need to divide by arbitrary factor of ~10^5 for E1

K-Isomers Evaluation - implications

- completed and accepted for publication in *ADNDT* – *a* short *Physical Review Letters* article is under preparation
- data are available in ENSDF format (will be continuously updated) - implications for ENSDF format development - *K* quantum number in deformed nuclei
- implications for nuclear reactions modeling at low excitation energies (NRF, astrophysics …), e.g. level densities, strength functions, RIPL, etc.
- new processing codes development – modification of ruler (a nightmare) & new python code (from scratch) … it is not that complicated …
- "Review of Nuclear Isomers in Heavy Nuclei" – invited article in the journal *Reports on Progress in Physics* – will also include the shell-model & seniority isomers - under preparation with P.M. Walker, U. Surrey, UK – will be submitted in July 2015