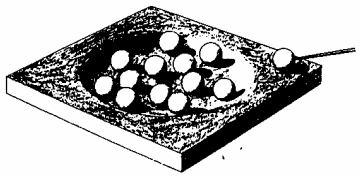
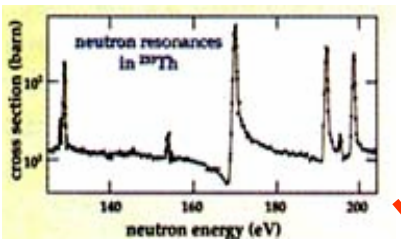
Nuclear Structure at Finite Temperature

- Statistical properties of CN and Shell model states
- The transition between order and chaos
- The damped rotation

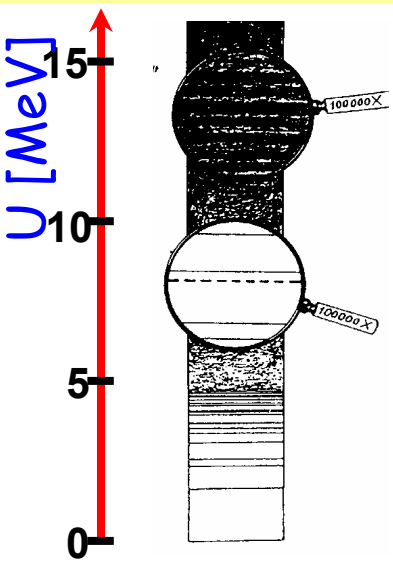
Nuclear Structure at Finite Temperature

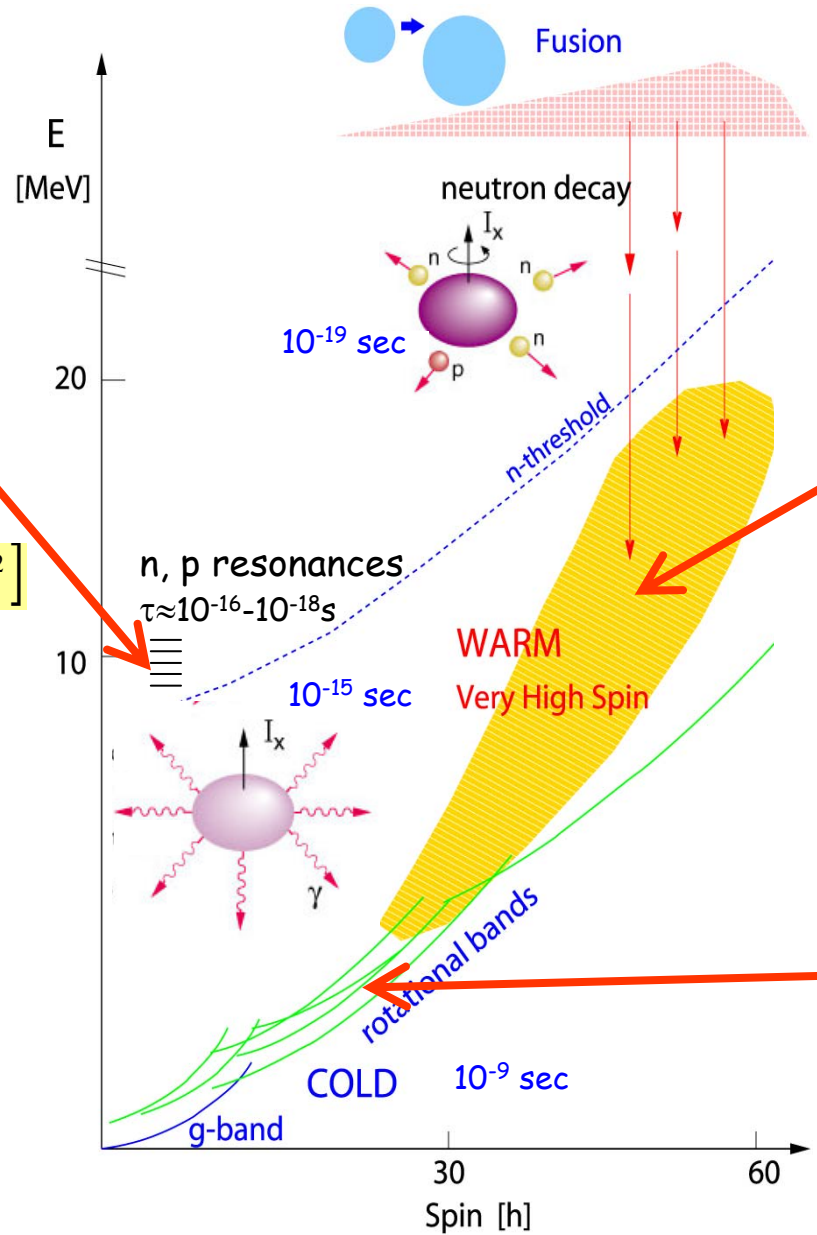
Bohr's compound states





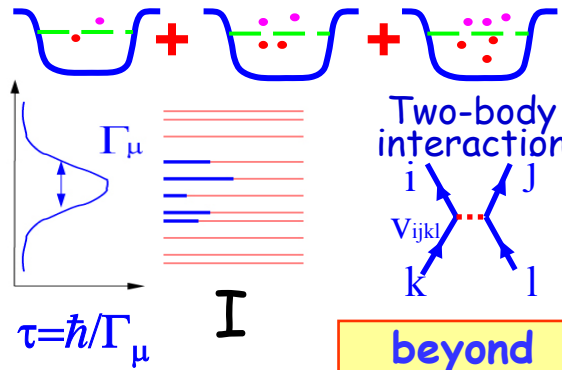
$$\rho(E) = \rho(0)\exp\left[2(aE)^{1/2}\right]$$





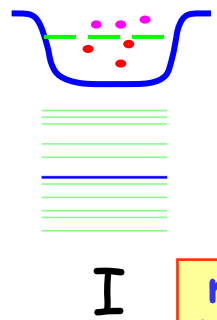
compound states

$$|\alpha\rangle = \sum_{\mu} X^{\alpha}_{\mu} |\mu\rangle$$



beyond mean-field

np-nh states

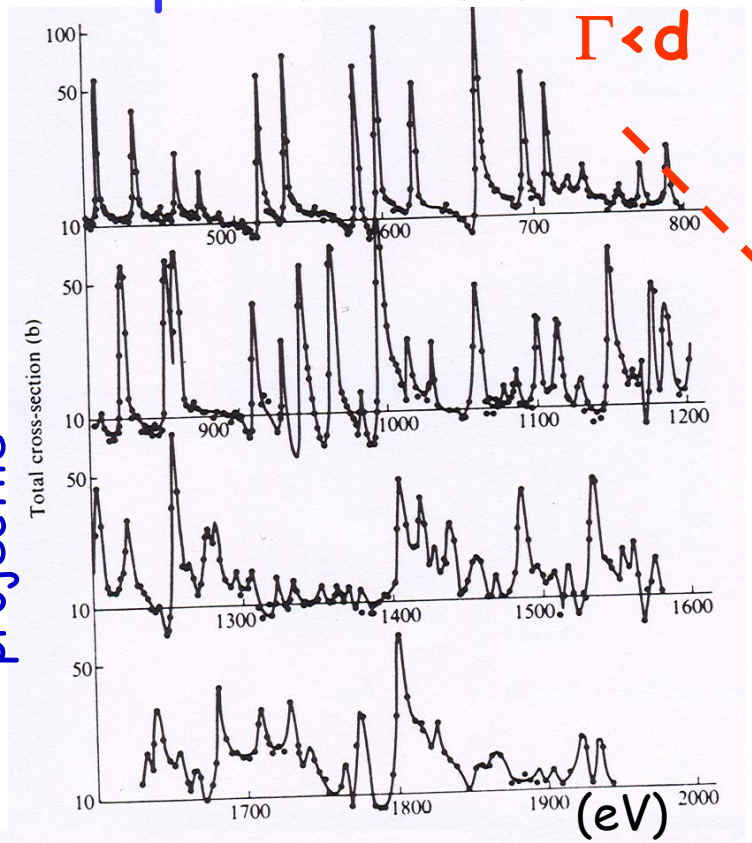


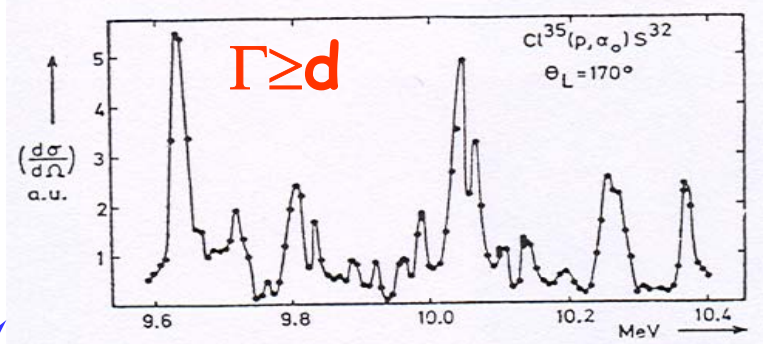
mean-field (shell model)

Statistical Properties of CN states

$E_{projectile}$

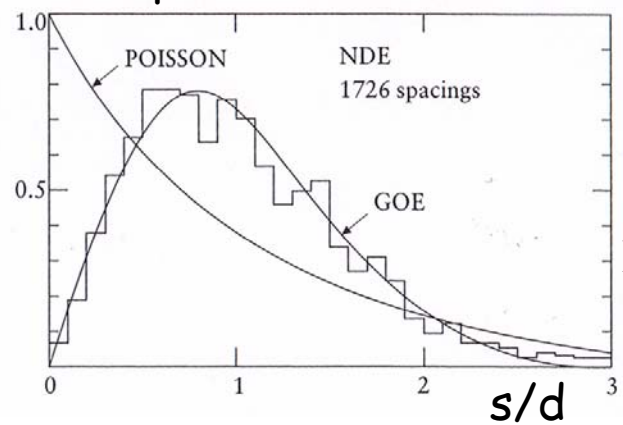
p or n resonances





NON overlapping resonances:
isolated resonances
behaving stocastically
(chaotic system)

Level spacing distribution
of p and n resonances



$J^{\pi}=1/2^{+}$
$U \approx 8\text{-}10$MeV
$d \approx 10$ eV
$\Gamma \approx 1$ eV

strongly overlapping resonances:
Ericson fluctuations
(chaotic system)

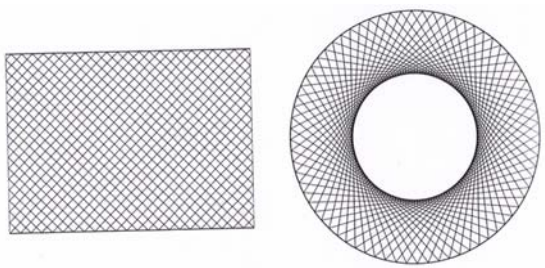
→ The CN is CHAOTIC

Order and Chaos in classical & quantum mechanics

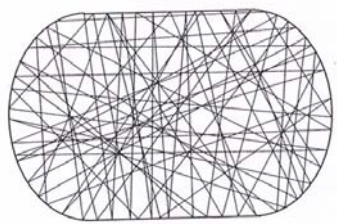
Order and **Chaos** are concepts well defined in classical mechanics, namely for systems governed by Hamilton's equations

ORDERED Systems	CHAOTIC Systems
▪ integrable	▪ NON-integrable
▪ regular, periodic orbits	▪ irregular, NON-periodic orbits
▪ predictable	▪ NON-predictable

example: point-particle moving freely in 2-dimensions and reflected elastically from boudaries



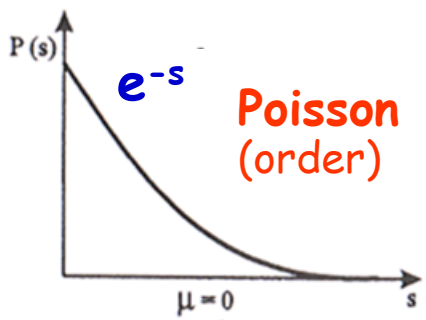
rectangle circle

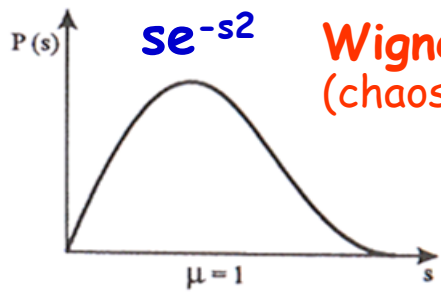


Stadium or Sinai biliard

Quantum counterparts: Schrödinger equations in 2-dimensions for a free particle with wave-function becoming 0 at the surfaces of the boundaries

Level spacing distributions

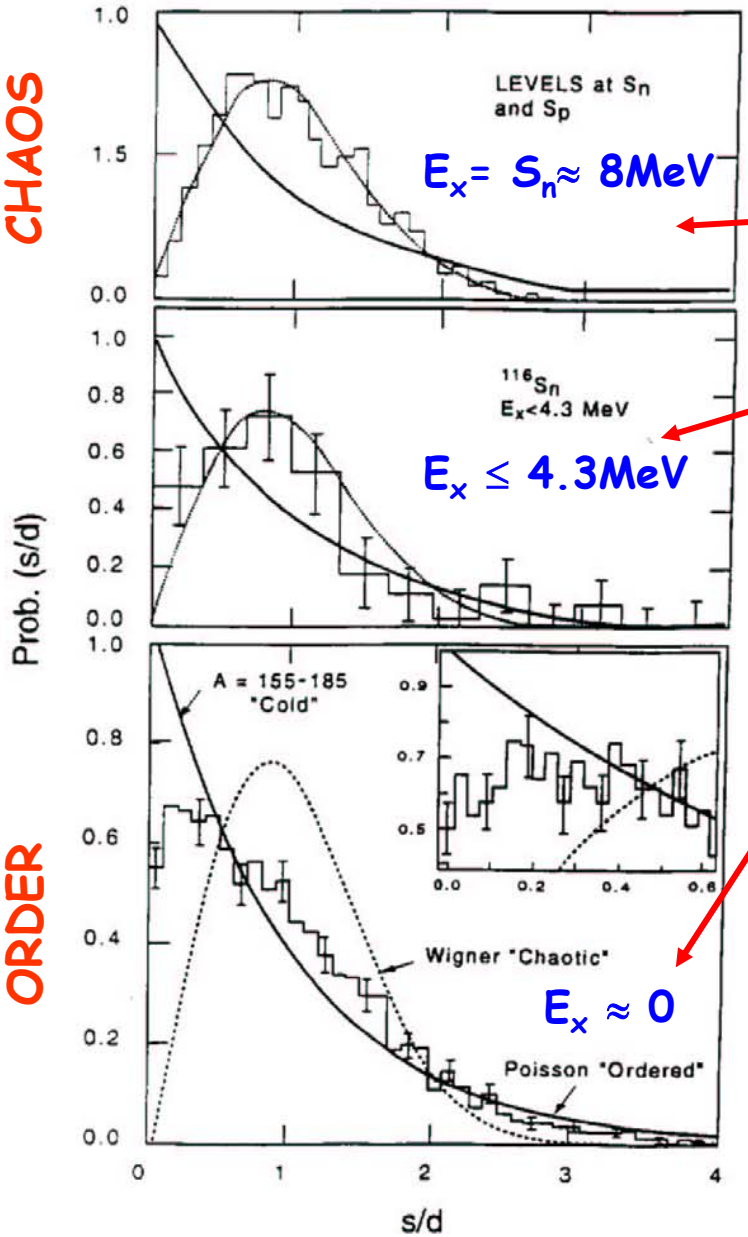


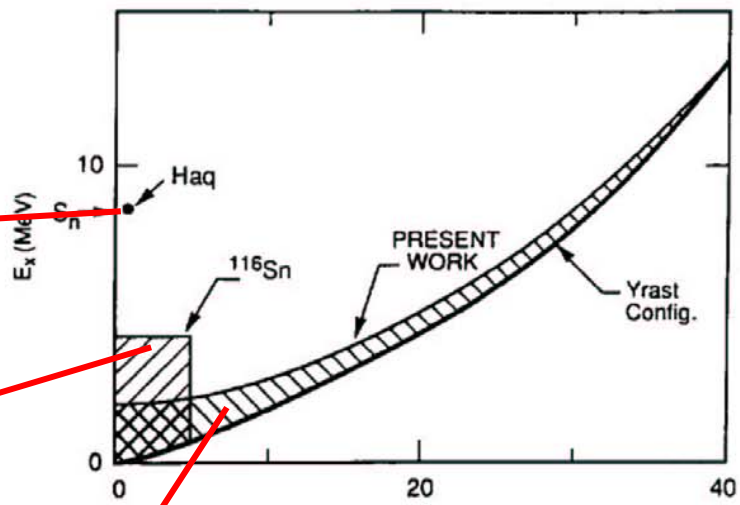


Level spacing distributions

CHAOS

ORDER





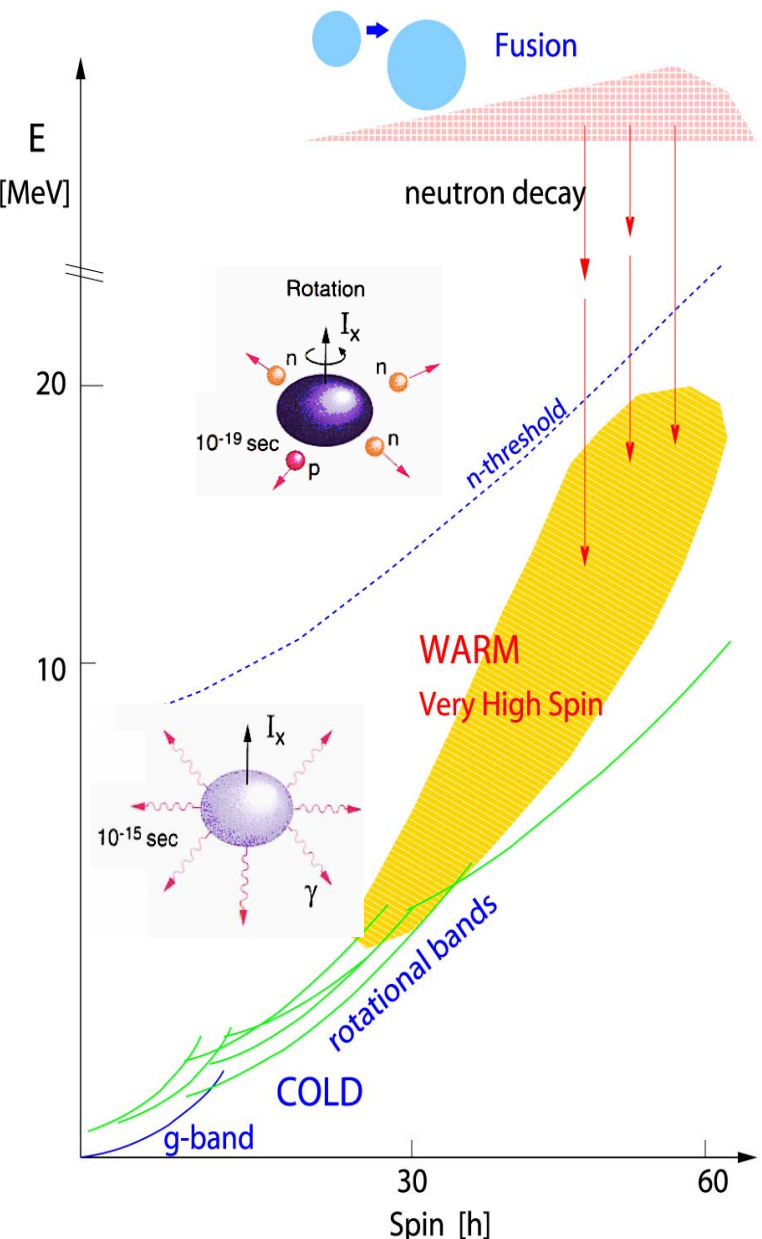
T=0 order:

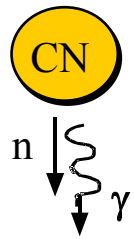
shell model states (mean field)

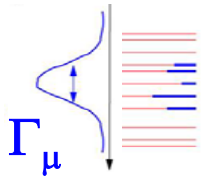
T≠0 onset of chaos:

mixed states (residual interaction)

The damping of Nuclear Rotation







$\tau = \hbar/\Gamma_\mu$

$|\alpha\rangle = \Sigma_\mu X_\alpha^\mu |\mu\rangle$

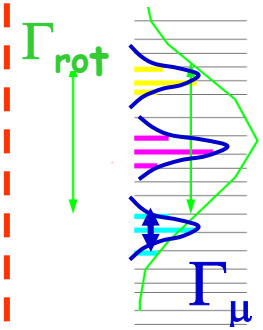
Loss of Selection rules

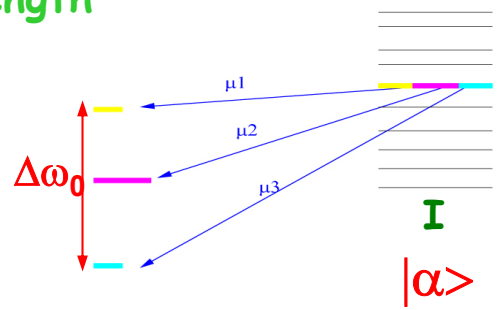
Compound Nucleus

CHAOS

U ≈ 8 MeV

E2 strength



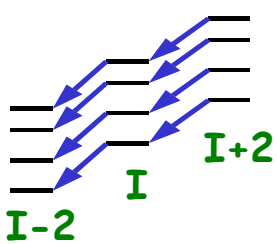


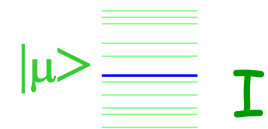
Rotational Damping

strongly interacting bands

U= 1-5 MeV

np-nh states





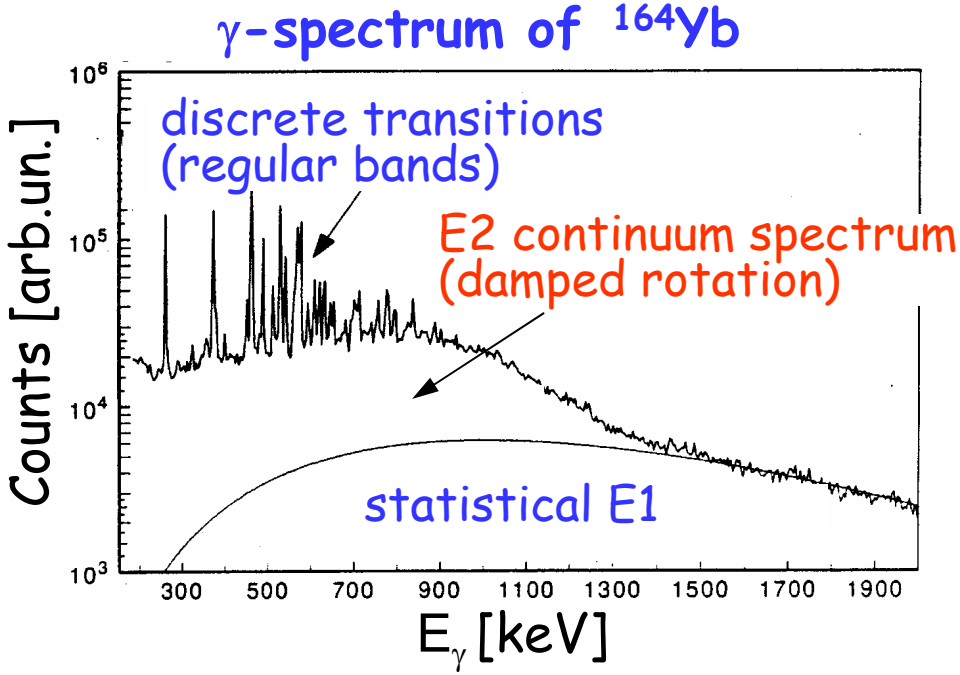
Selection rules (E,I,K,α, ...)

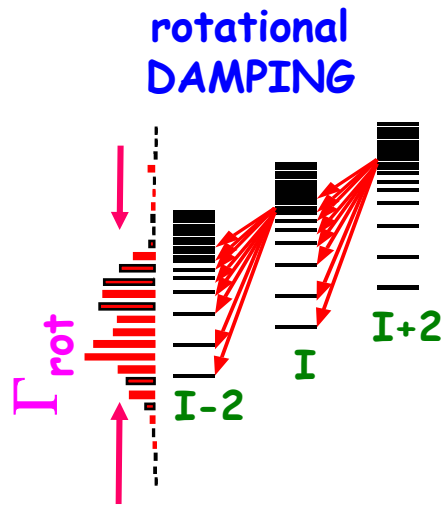
Regular Bands

mean field ORDER

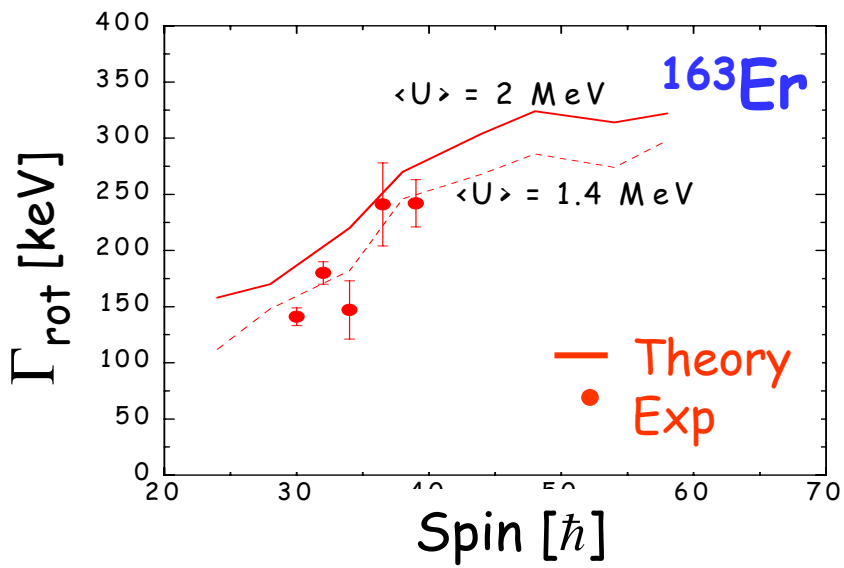
U < 1 MeV

Experimental Signature of Damped Rotation





The damping width Γ_{rot}
is a basic quantity for the understanding
of nuclear structure at finite temperature



A. Bracco and S. Leoni, Rep, Prog. Phys. 65(2002)299