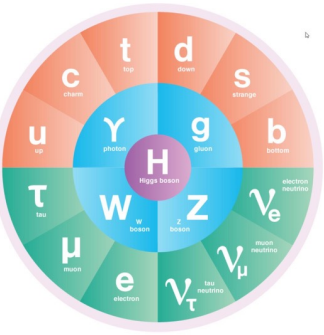
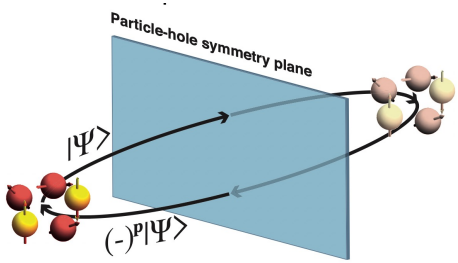
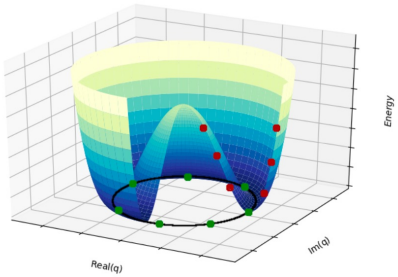
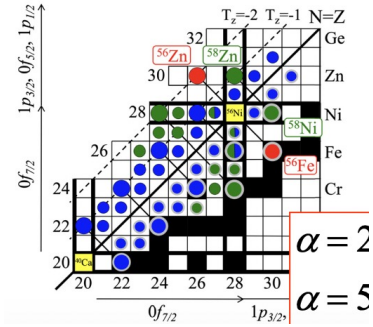
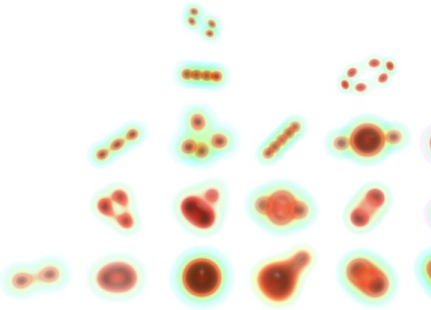










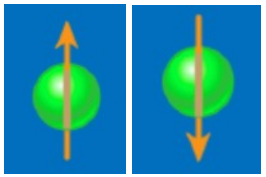
# Symmetry
# Final Discussion session

Converners: Jérémie Dudouet, Denis Lacroix, Piet van Isacker

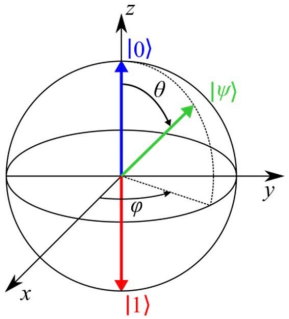
Symmetries are everywhere.
Broken symmetries also

Symmetries in “our” physics case

SU(2) – spin only



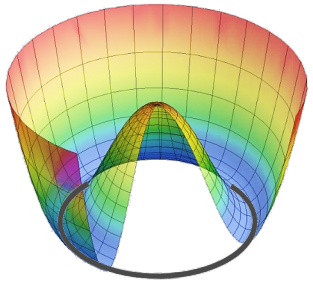
SU(3) - rotation




SU(4) – spin-isospin

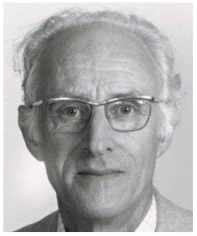
proton
neutron

U(1)-Particle number symmetry



Sp(4) -singlet BCS pairing phase ~ SO(5)

$\mathbb{Z}_2$ discrete symmetry– [Ebran talk]

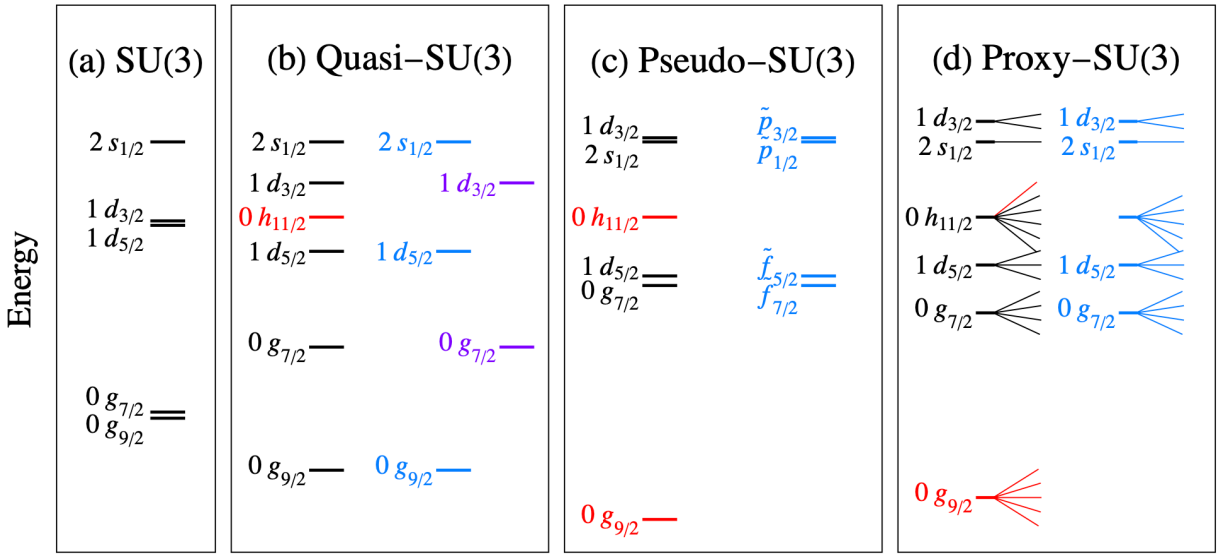


$$\begin{array}{ccccccc} \mathrm{U}(\Gamma_N) & \supset & \mathrm{U}(3) & \supset & \mathrm{SU}(3) & \supset & \mathrm{SO}(3) \\ \downarrow & & \downarrow & & \downarrow & & \downarrow \\ [h] & & [\tilde{h}] & & (\lambda,\mu) & K & L \end{array}$$

...

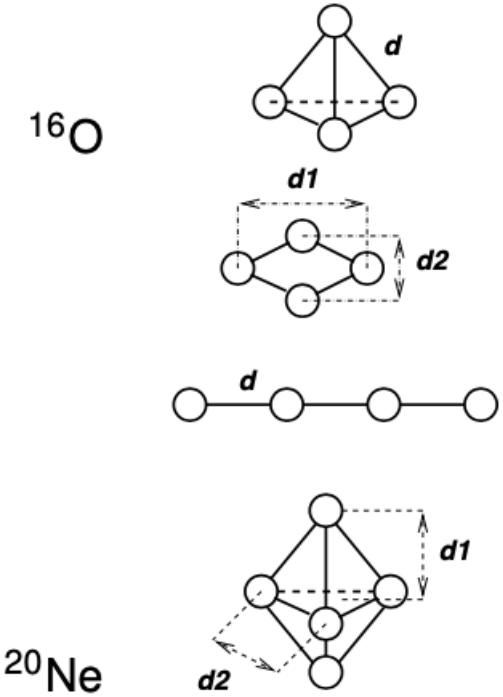
J.P. Elliott, Proc. Roy. Soc. A **245** (19

# Symmetries in physics : the symmetry concept is pushed rather far




Van Isacker talk

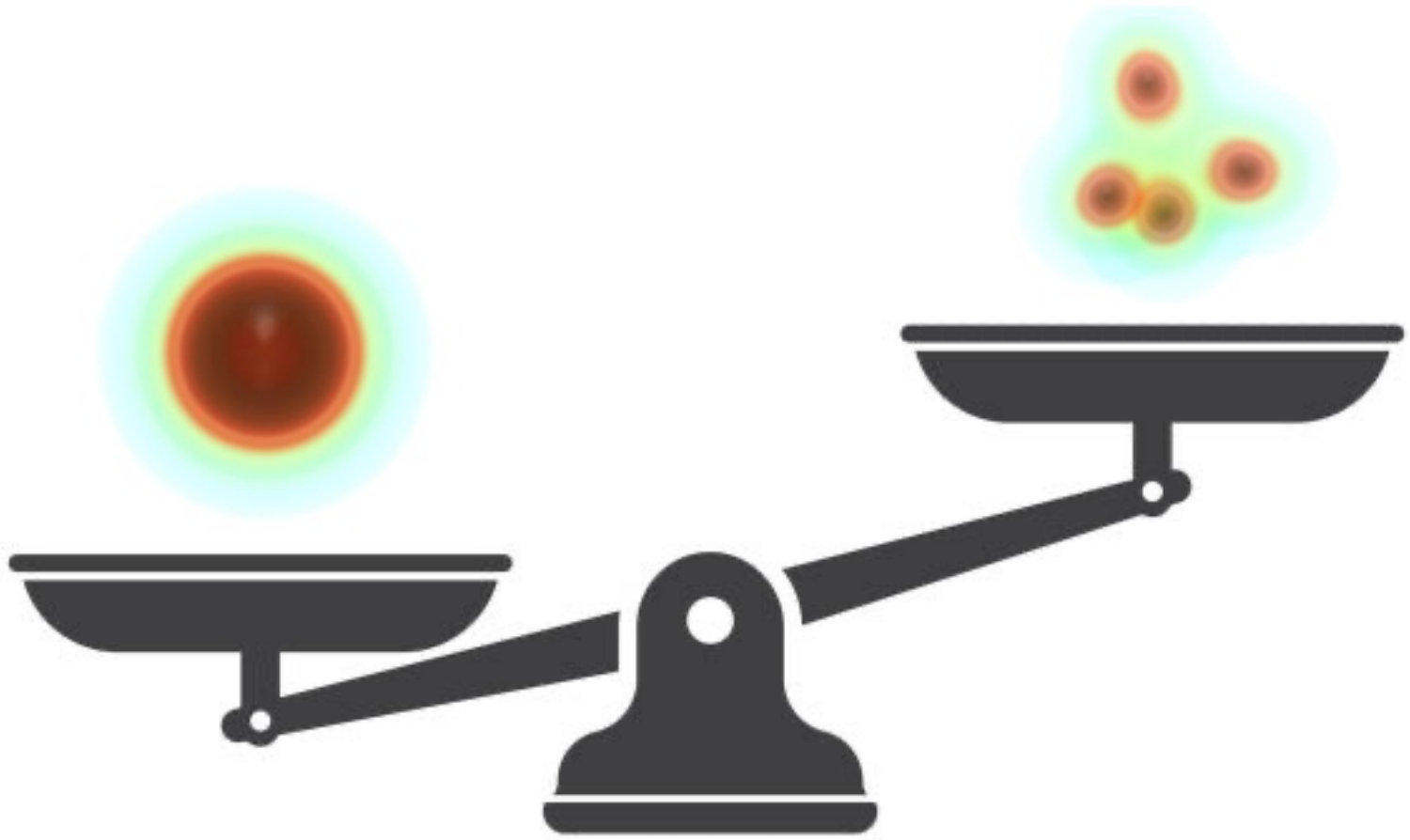
New molecular like symmetries




Nowacki talk

Symmetries are everywhere.
Broken symmetries also

# Symmetries/Broken symmetries

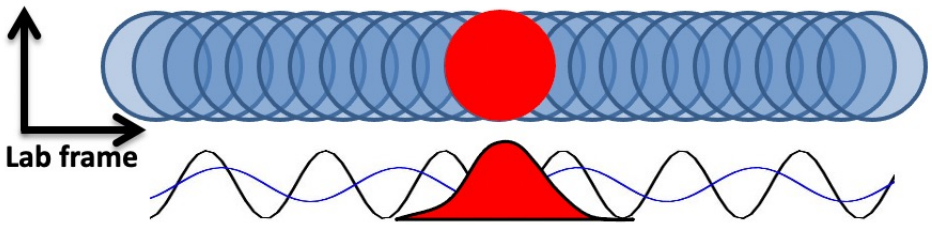


Whatever “game” we play with broken symmetries, fundamental symmetries will win (or not)

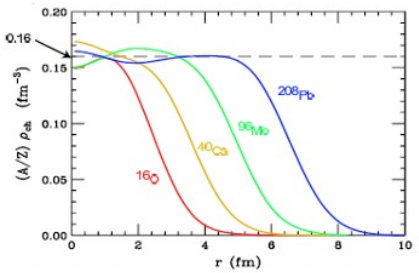
## Symmetries/Broken symmetries

Still spontaneously broken symmetries have observable effects

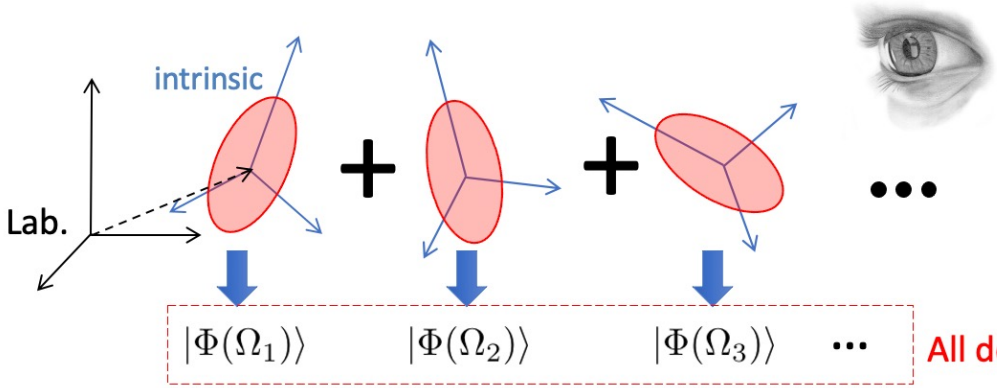
Translation:




But nuclei have a finite size

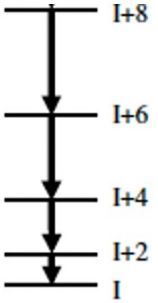



Rotational invariance



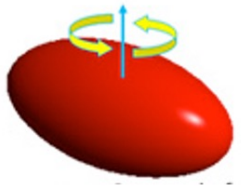

All degenerated

Nuclei do present rotational bands

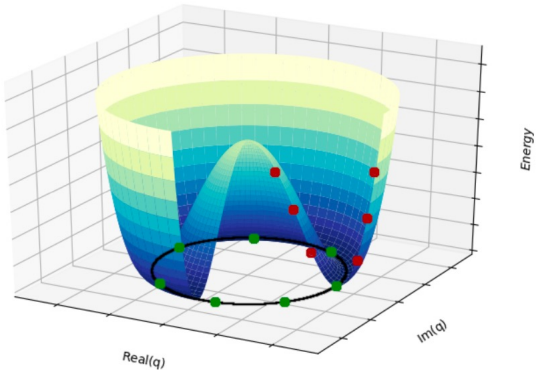


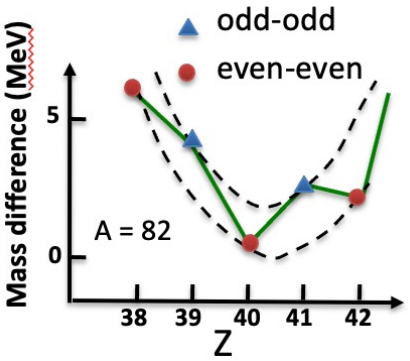

$$E_{\rm rot} = \frac{I(I+1)}{2J}\hbar^2$$

Nuclei might be deformed

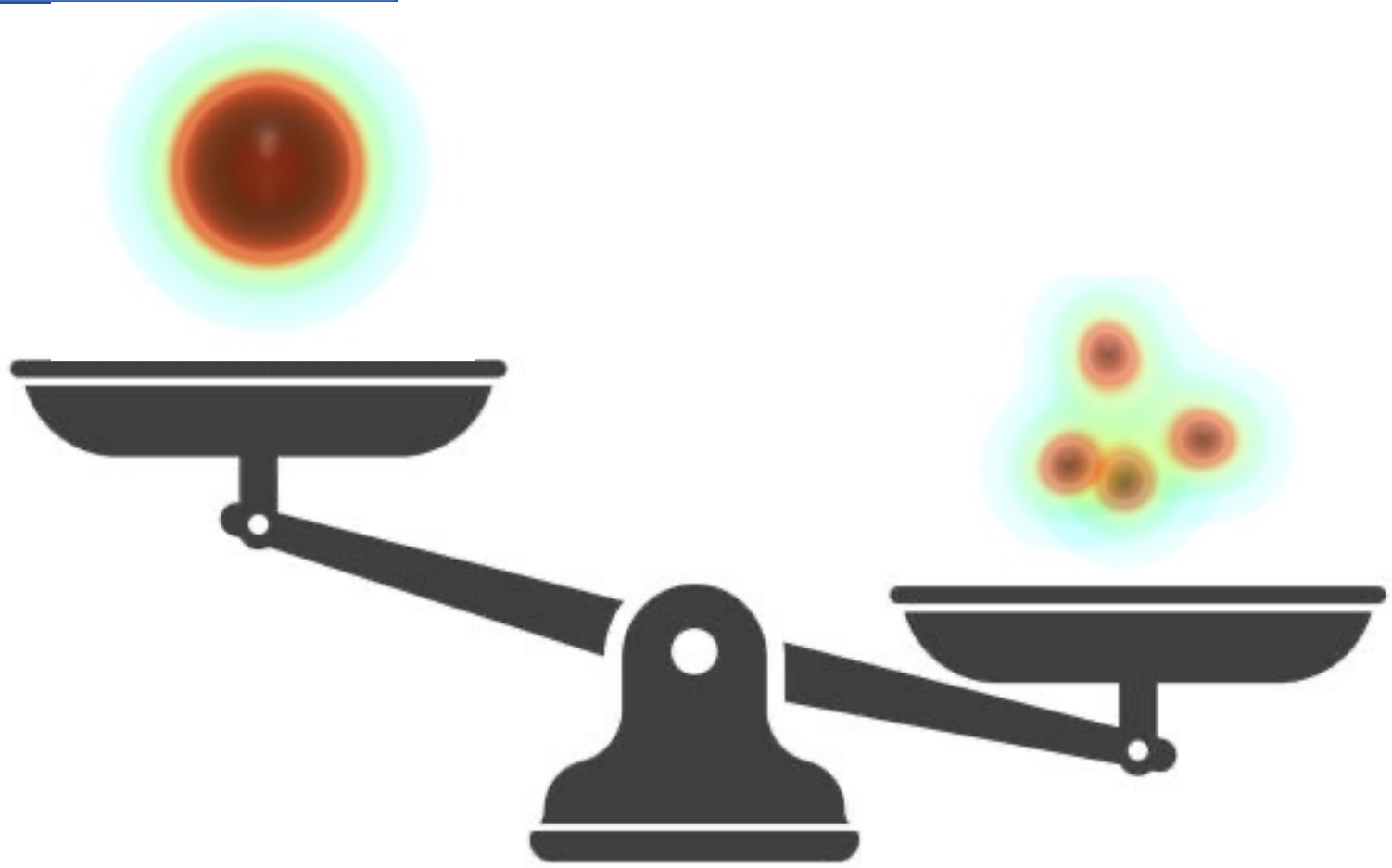


Particle number



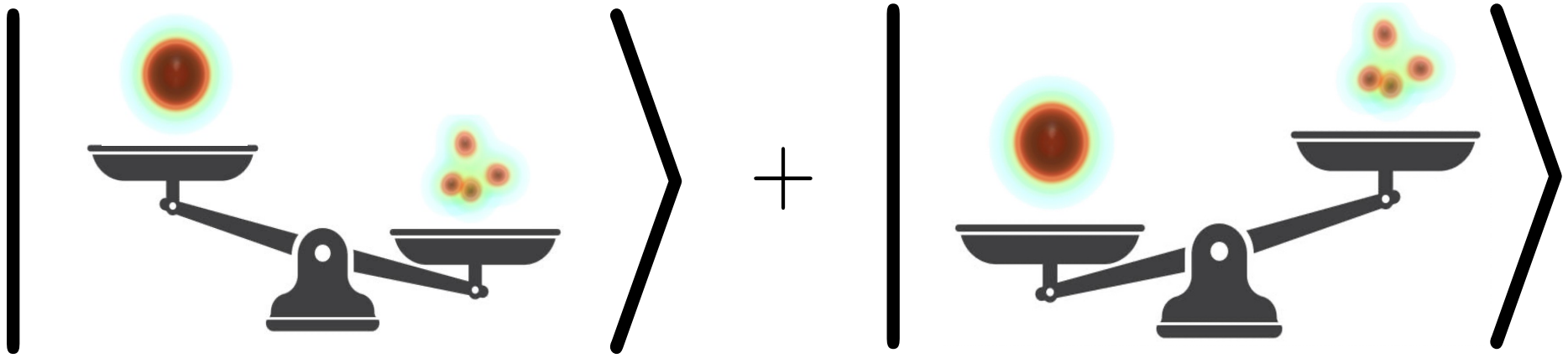



# Symmetries/Broken symmetries



Whatever “game” we play with broken symmetries, fundamental symmetries will win (or not)

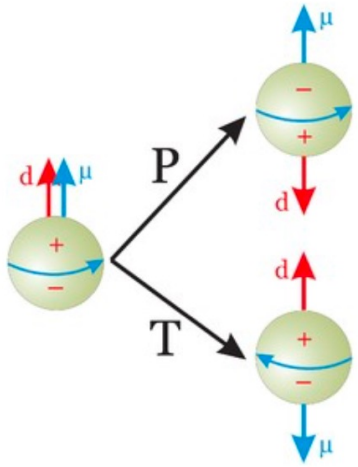
Most probably



Not all symmetries are equivalent

## “Absolutely” fundamental symmetries

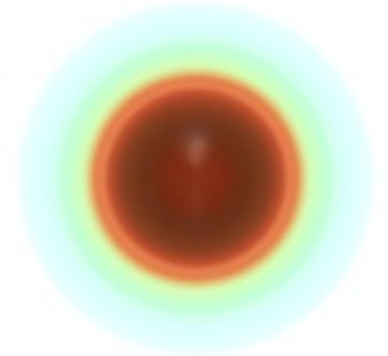
Examples




(Franchoo talk)

## “Absolute” symmetries

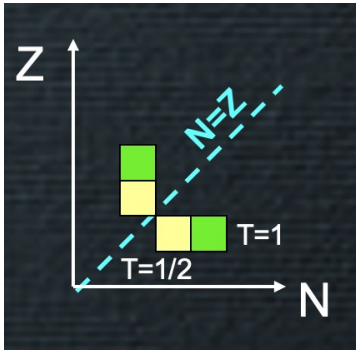
Rotational invariance



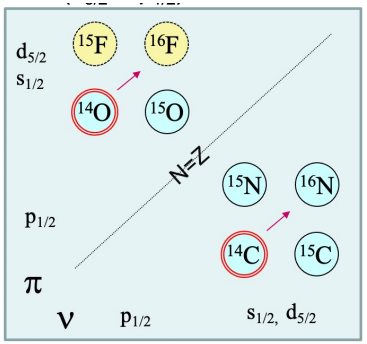
(Ebran or Bally talk)

## “Almost” symmetries

Isospin symmetry



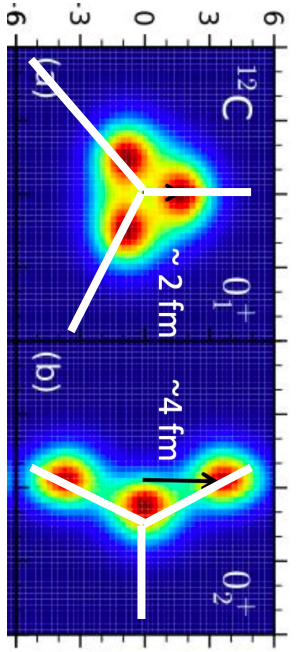

(Lenzi talk)




(Sorlin talk)

## “New emerging” symmetries

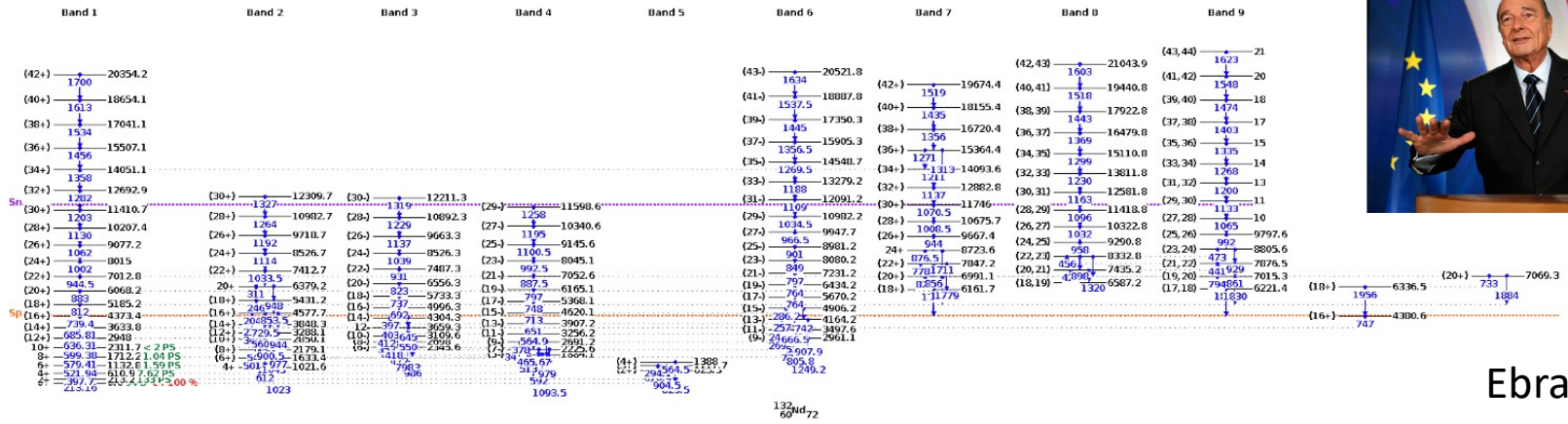
Some new “local” symmetries



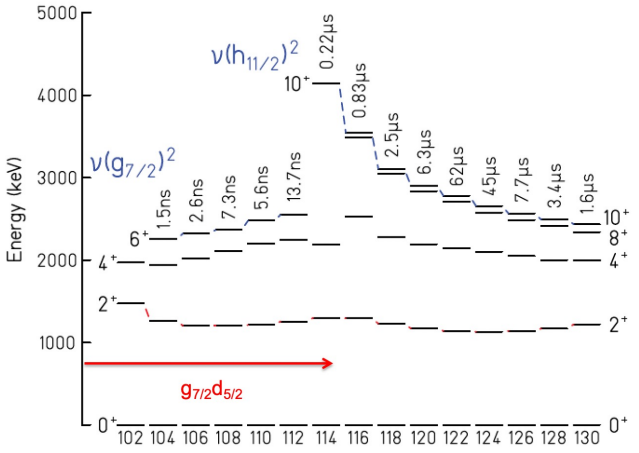

(Shen talk)

# Our Experimental tools

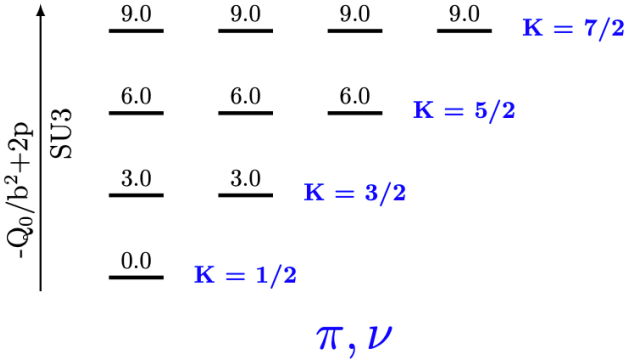
➡ Energy: we have to find regular/specific patterns

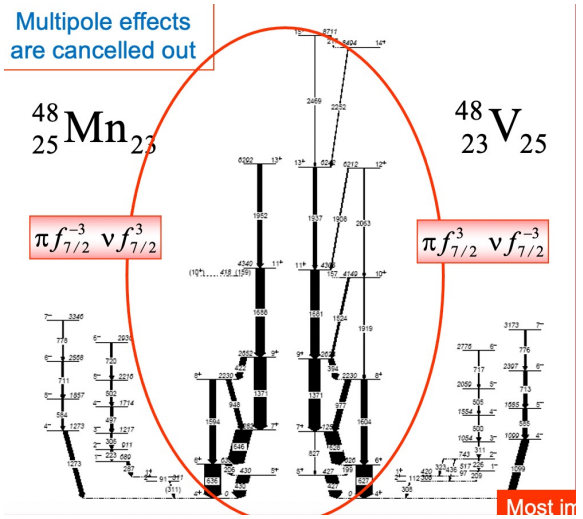

Ebran talk




Valiente Dobon talk

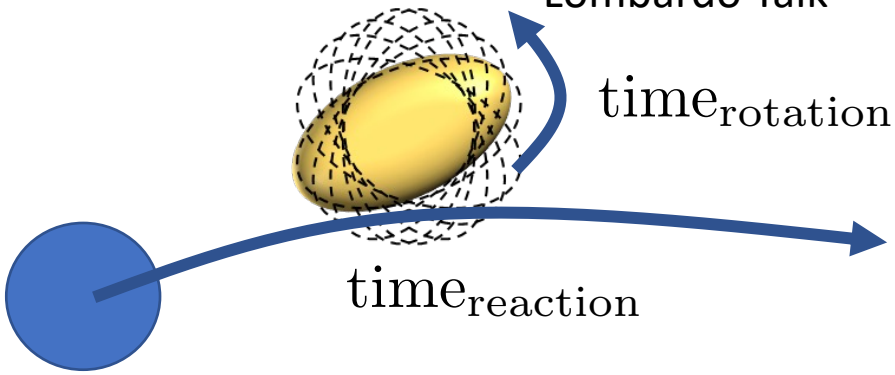



Nowacki talk

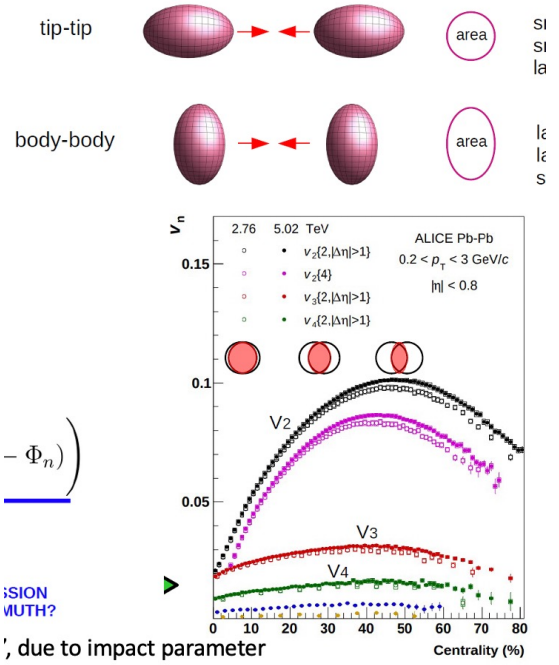



Lenzi talk

# Reaction tools




Very High energy

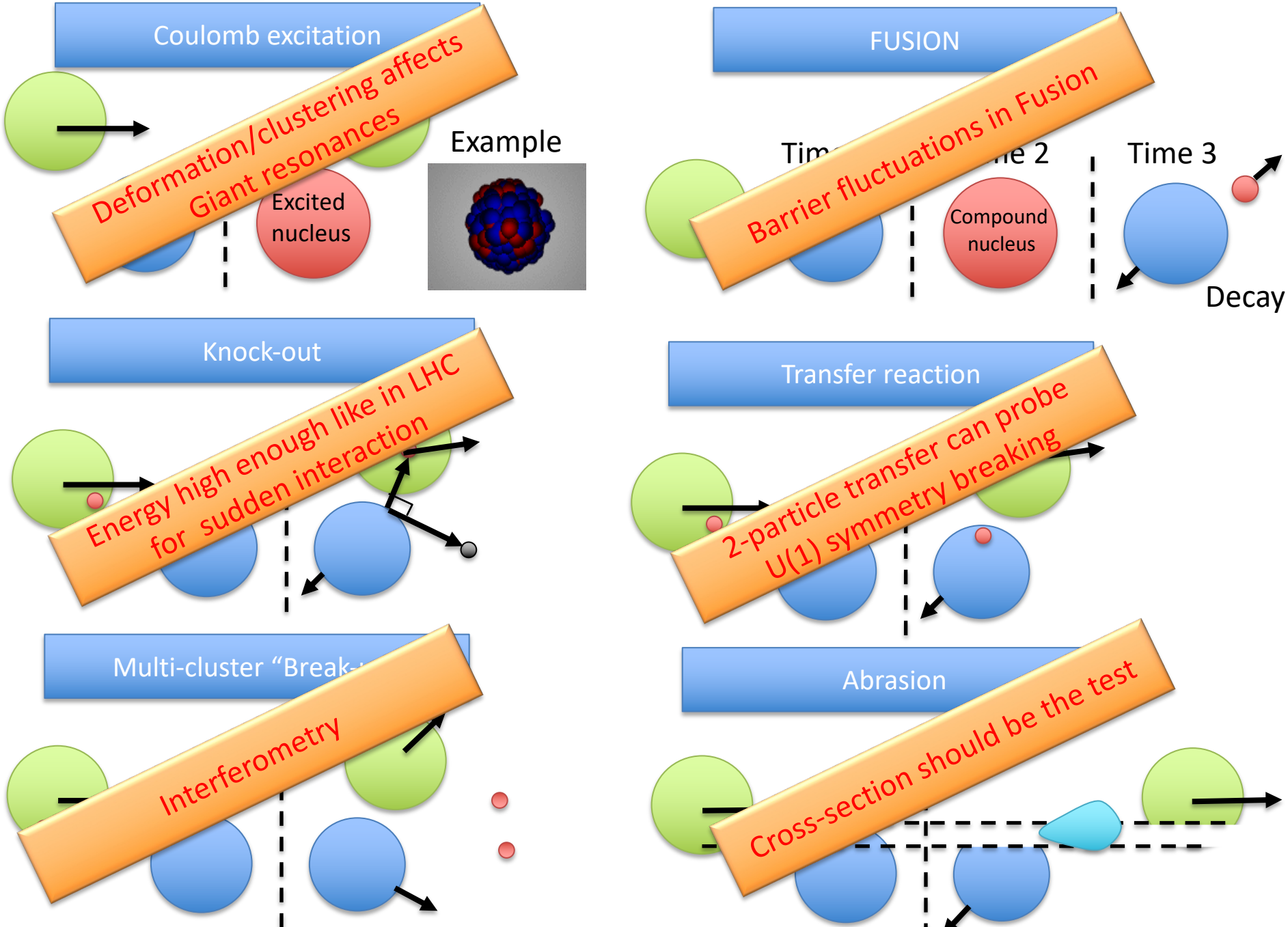



Verney Talk

- To be sensitive to "deformation", orientation, shape, We should have $\text{time}_{\text{rotation}} \ll \text{time}_{\text{reaction}}$
- Nuclear (short-range) interaction is the key

$$\text{time}_{\text{rotation}} \ll \text{time}_{\text{reaction}}$$

# Some specific channels illustrated: terminology



# Remarks, Questions from participants?

# Future perspectives and issues (Valiente Dobon)

- Need accurate measurements of the transitions probabilities of the states below the isomers. We need systematics not only isomers like in the Pb or the 2+ like in the Sn, we need all the states.
  - Lifetimes (RDDS or fast timing)
  - Coulex

- From the nice discussion with F. Nowacki. Are really Sn good seniority behaved nuclei? My felling is that proton excitations are more prominent that in the Pb case. We might need especific reaction to study this. O. Sorlin was suggesting (p.p') to look into $M_p$ and $M_{n.}$

- Going beyond j=9/2 shell, e.g. j=11/2 (e.g. beyond $^{218}$Pb), …

- Other mid-shell cases to look into the Berry phase:
  - $^{73}$Ni with five neutrons in $0g_{9/2}$
  - $^{95}$Rh N=50 mid-shell in $0g_{9/2}$
  - $^{213}$Fr with five protons in $0h_{9/2}$

- How to further look into seniority: Transfer reactions: complications with the reaction dynamics … Denis Lacroix, if I understood correctly  had some ideas from the PRL 113, 052501 (2014). I am not really expert on this but could be a good starting.

- From SM would be nice to have calculations with three body forces and two body operators or a larger model space pr p-h exiattions to get proper B(E2) values with «universal» effective charges 0.5 and 1.5 and not state dependent effetive charges. For BMF calcualtions this things are quite difficult. Maybe now with programs like TAURUS are possible.