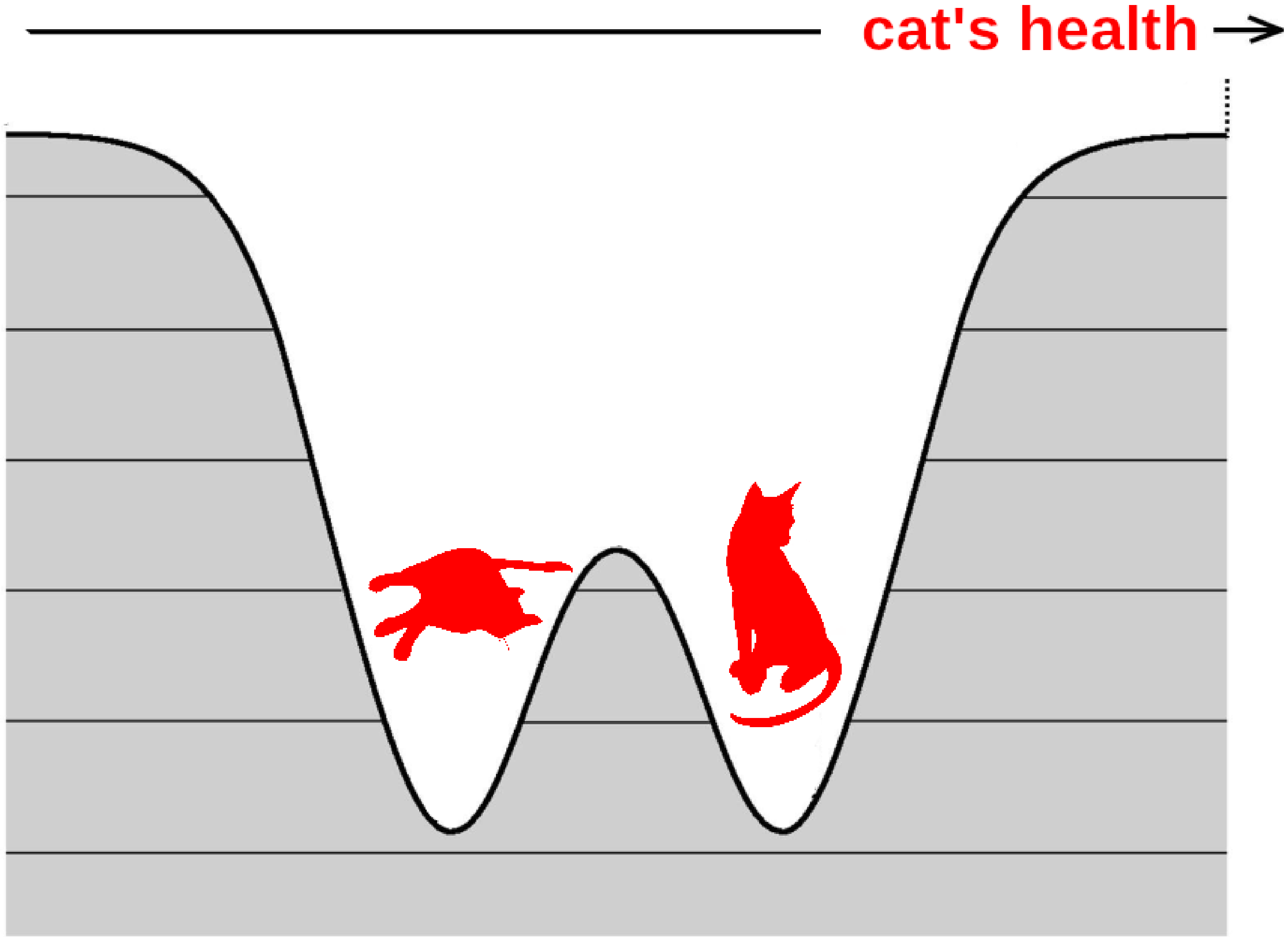
First direct measurement of nuclear chirality in 128Cs.

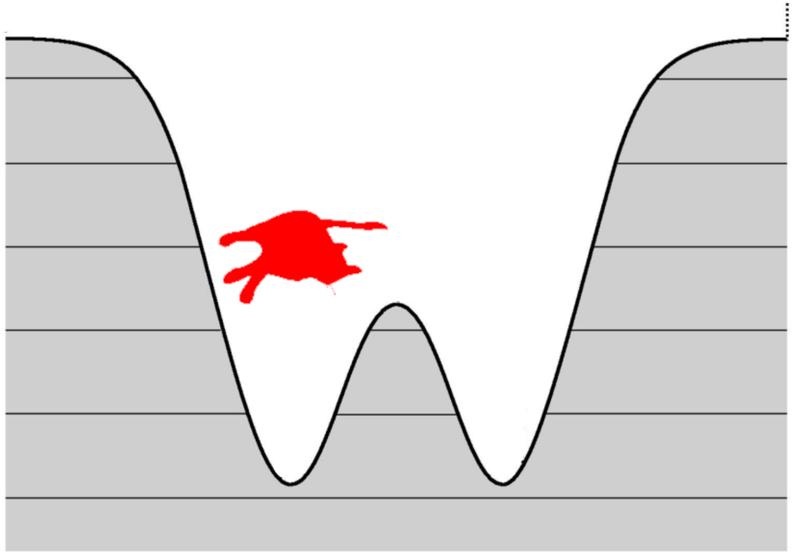
Ernest Grodner
BP1

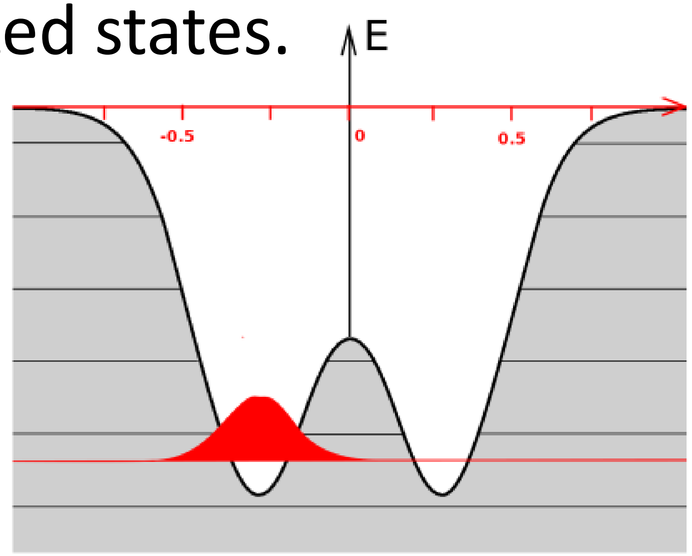
NCNR 16.12.2022

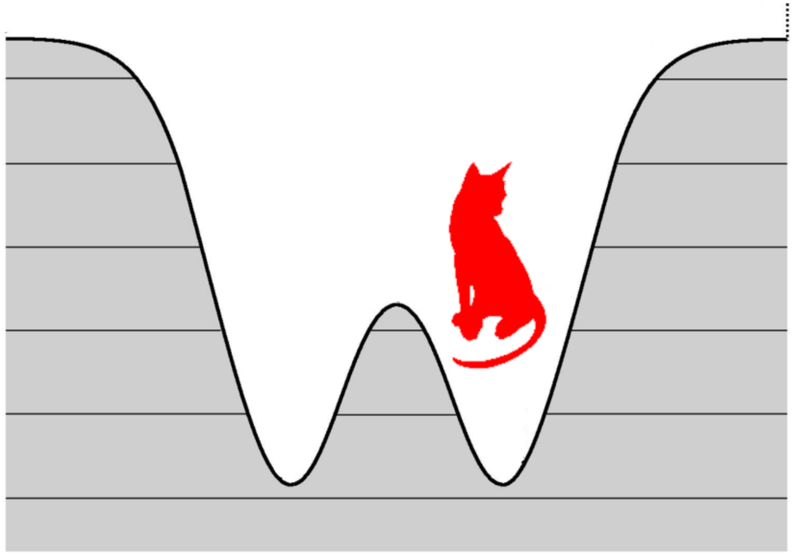
Nuclear chirality is a today's nuclear spectroscopy Schrodinger's cat box problem.

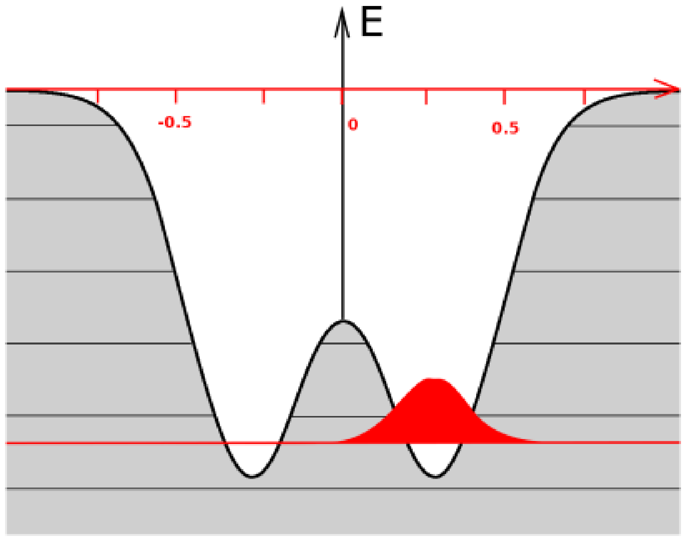


Taking a look into the cat’s box allowed, then cats state can be measured. We deal with localized states.

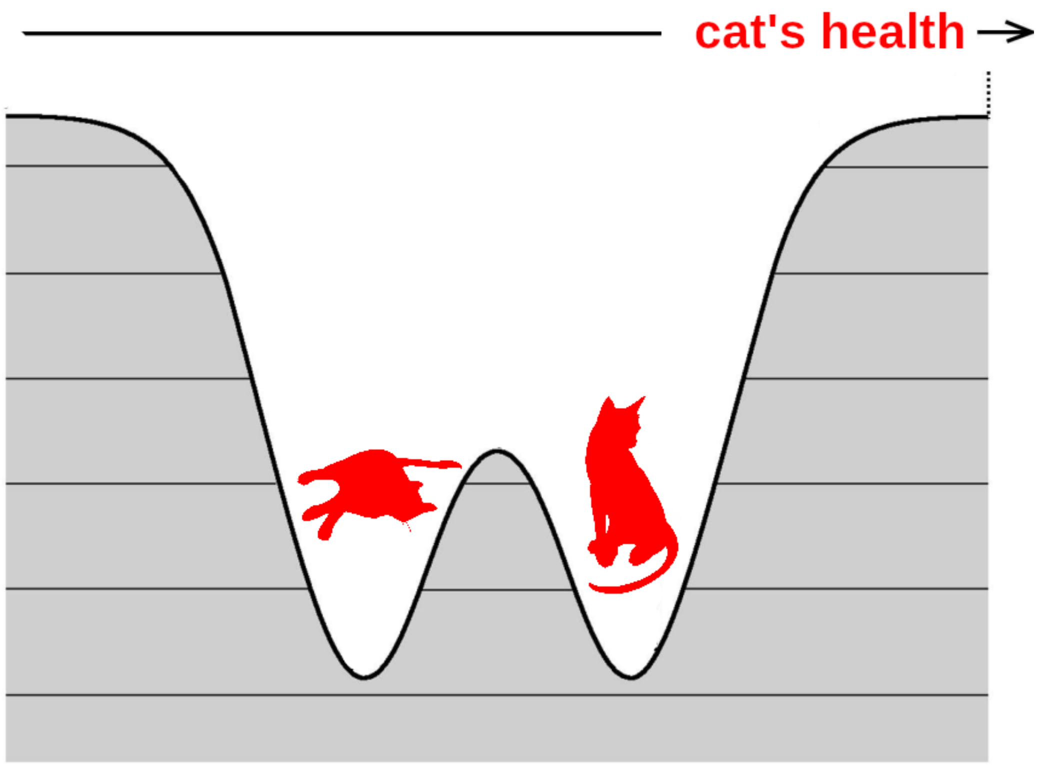


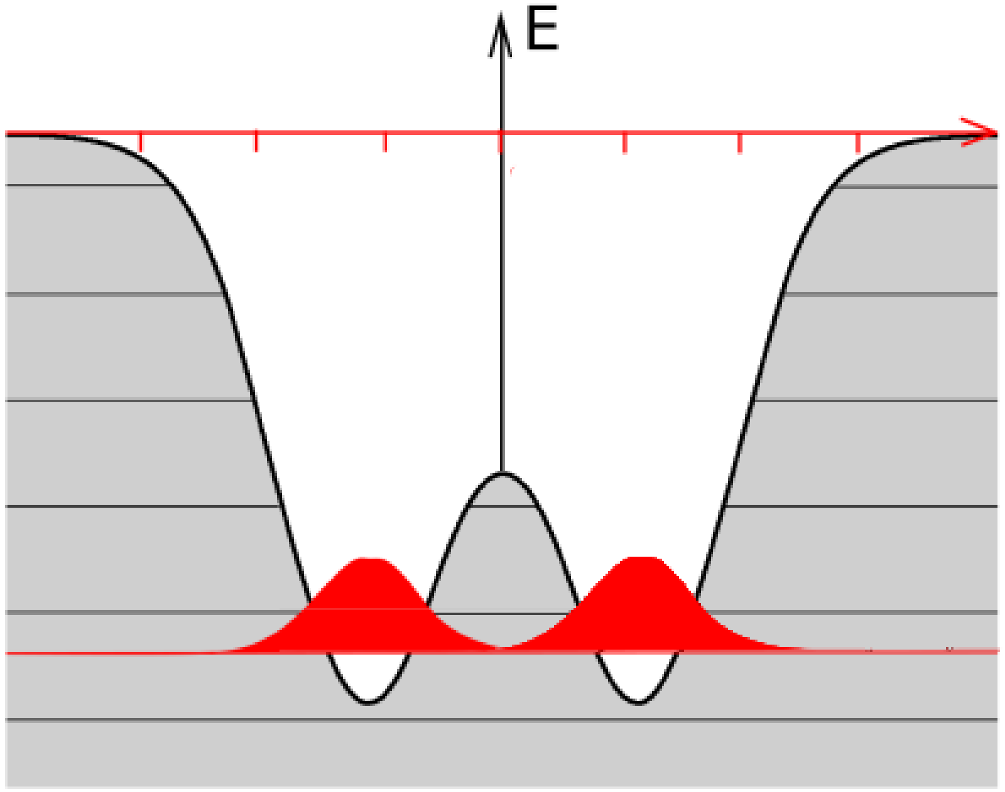






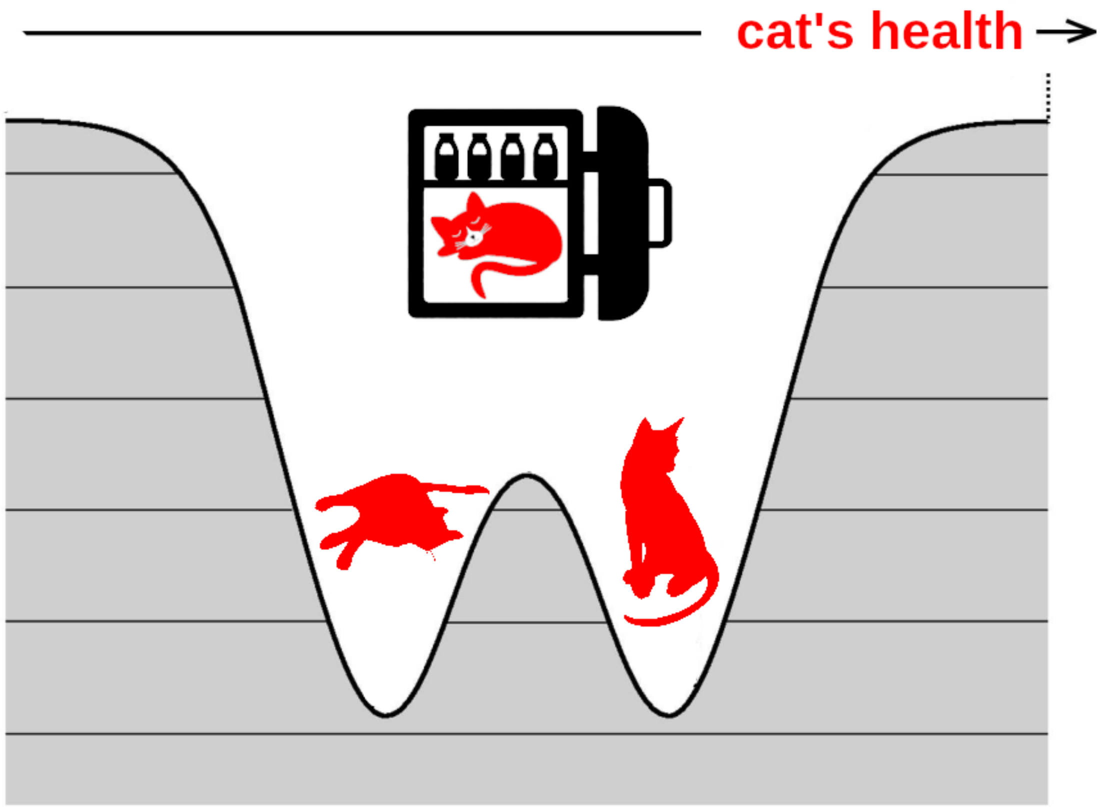
Taking a look into the cat's box forbidden.
We must deal with superimposed states

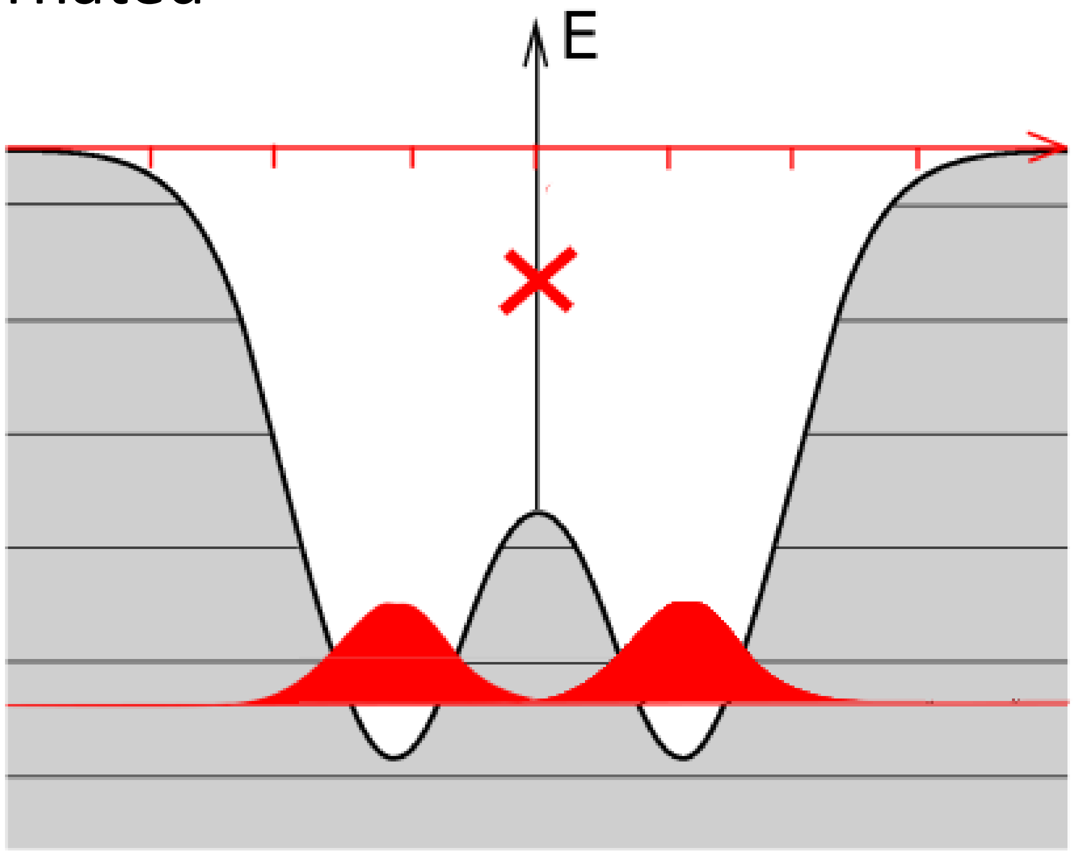




Cat’s health expectation value on superimposed states?

Neither alive nor dead , rather = hibernated



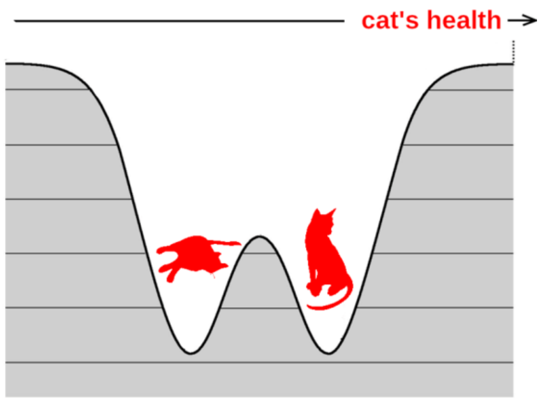


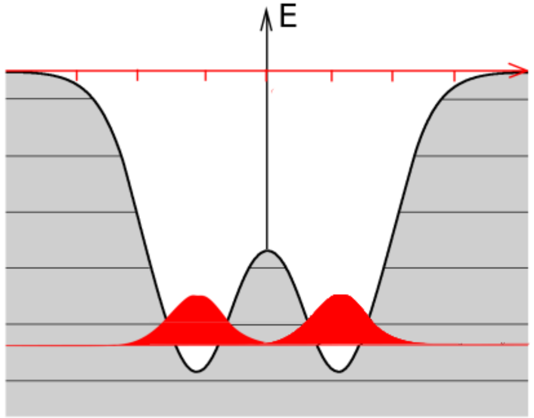
Attention!

Now the clue of the lecture

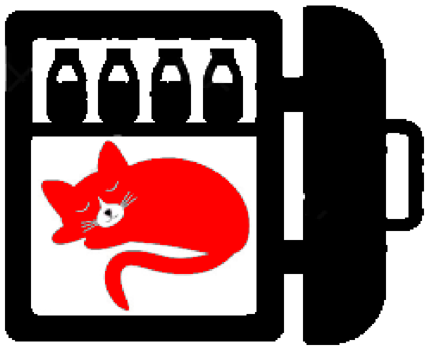
Superimposed states of a cat in the box

Symmetry braking cat inside



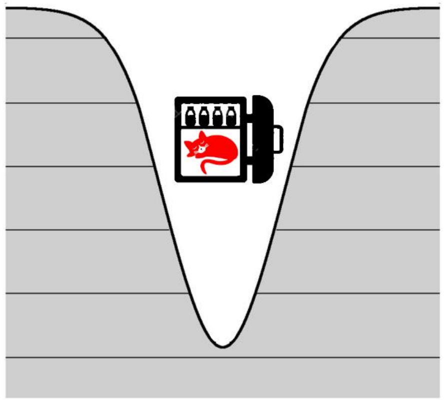


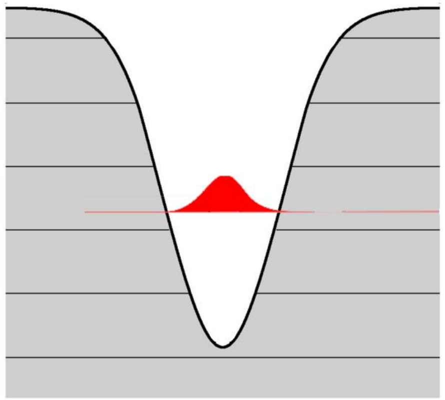
Measured cat’s health: hibernated



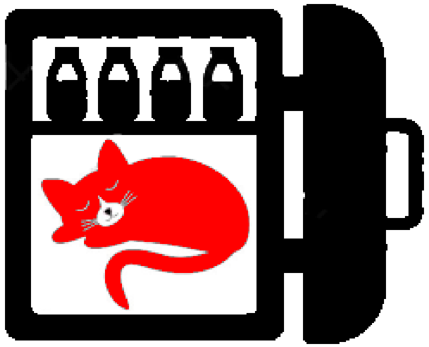
But what if we put a hibernated cat in the box in a first place?

Symmetry conserved cat inside





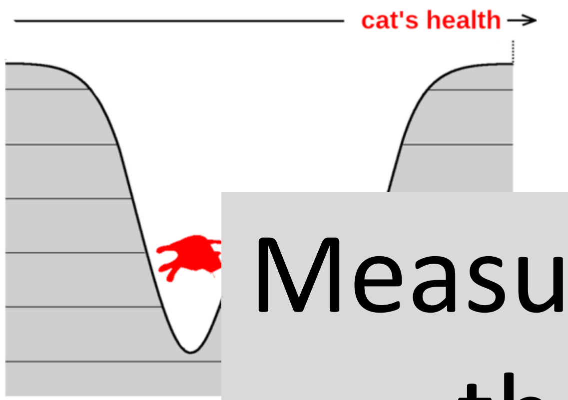
Measured cat’s health: hibernated

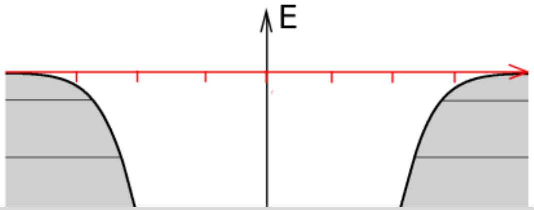


Superimposed states of a cat in the box

Symmetry braking cat inside

Measured cat’s health:
hibernated





Measurement unable to distinguish
the symmetry broken from
The symmetry conserved
cat in the box.

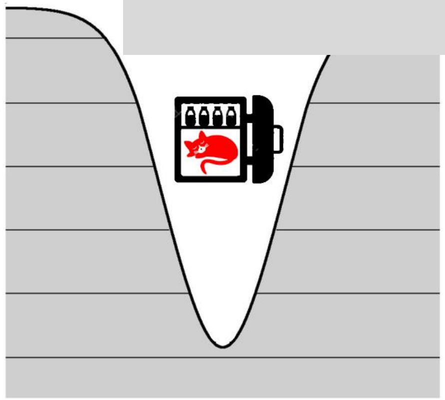
But wh

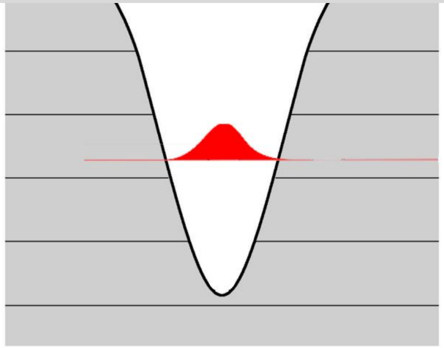
in a firs

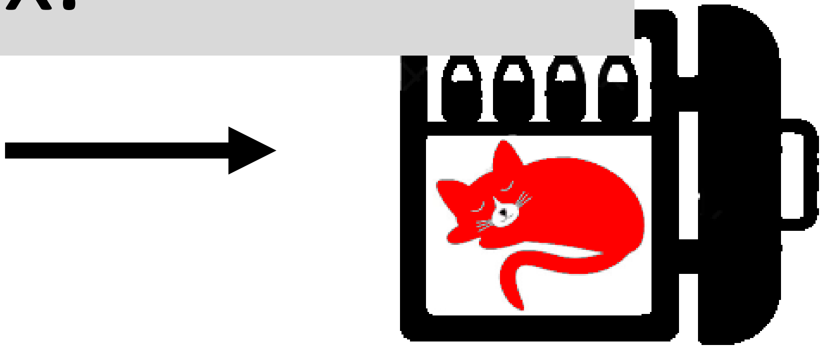
Symme

’s health:

ted





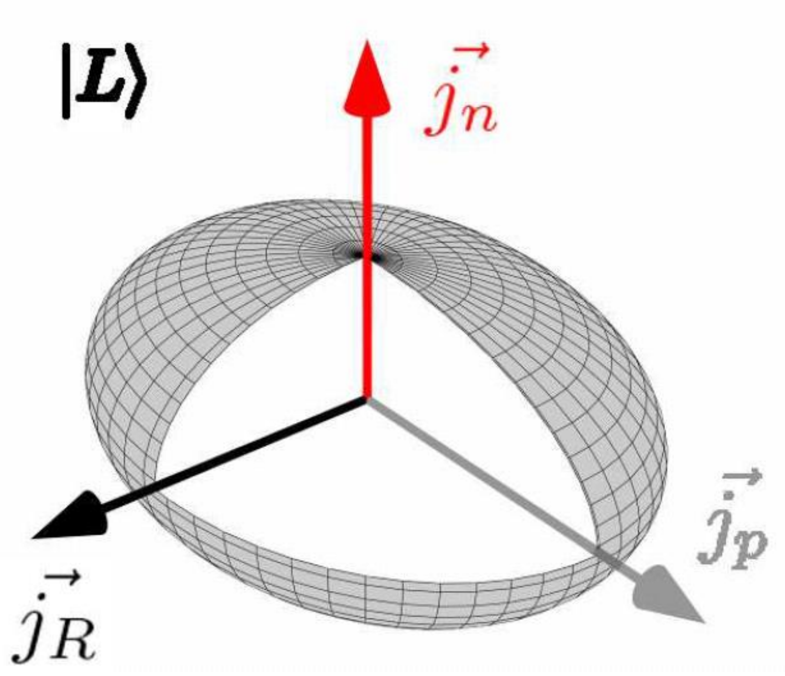


Nuclear chirality

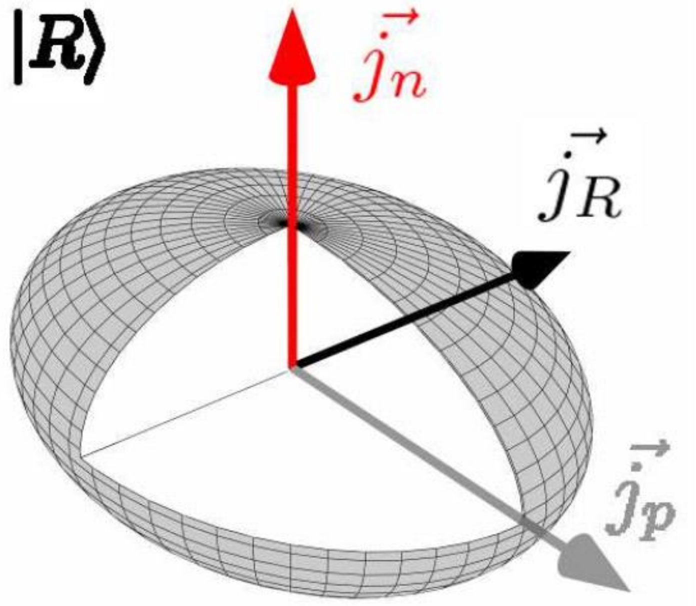
Handedness instead
of cat’s health parameter

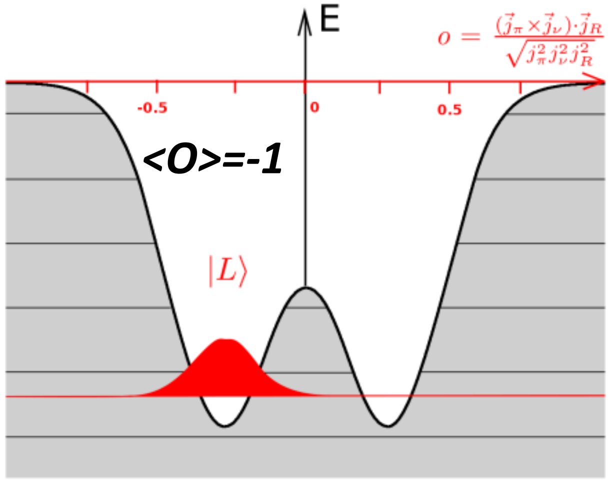
$$O = \frac{(\vec{j}_\pi \times \vec{j}_\nu)\cdot\vec{j}_R}{\sqrt{j_\pi^2 j_\nu^2 j_R^2}}$$

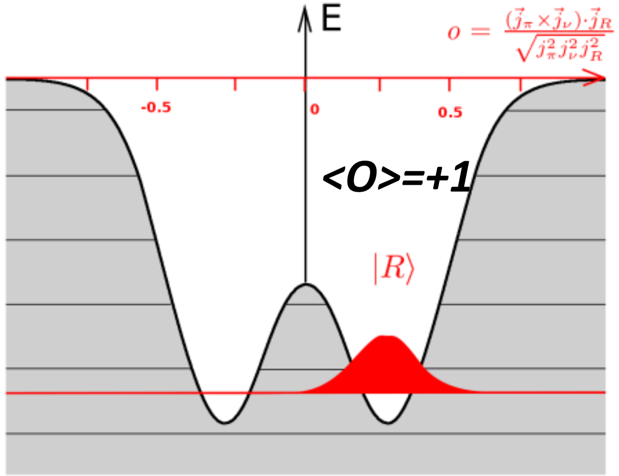
$\langle O \rangle = -1$



$\langle O \rangle = +1$







Fusion-evaporation reactions used to produce highly excited odd-odd isotopes at HIL (U200p cyclotron).

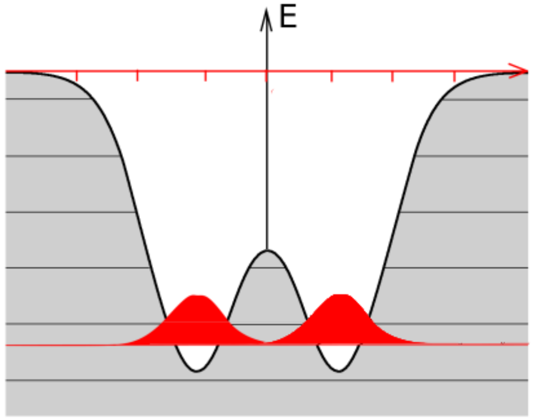
A nucleus cools-down emitting particles and gamma quanta.

At some point is must chose spontaneously the handedness.

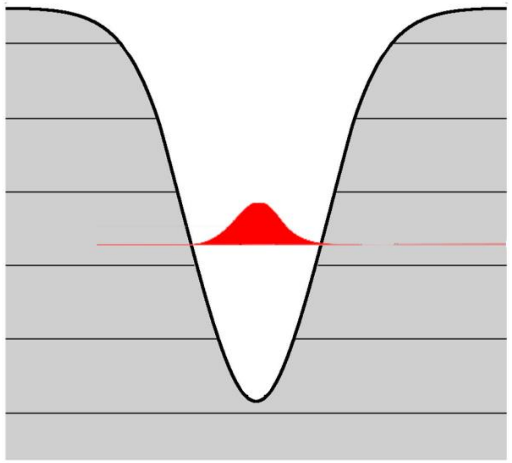
Spontaneous chiral symmetry breaking in nuclear physics.

Stefan Frauendorf *"Spontaneous symmetry breaking in rotating nuclei"*, Reviews of Modern Physics **73**, 463 (2001)

Broken symmetry



Conserved symmetry



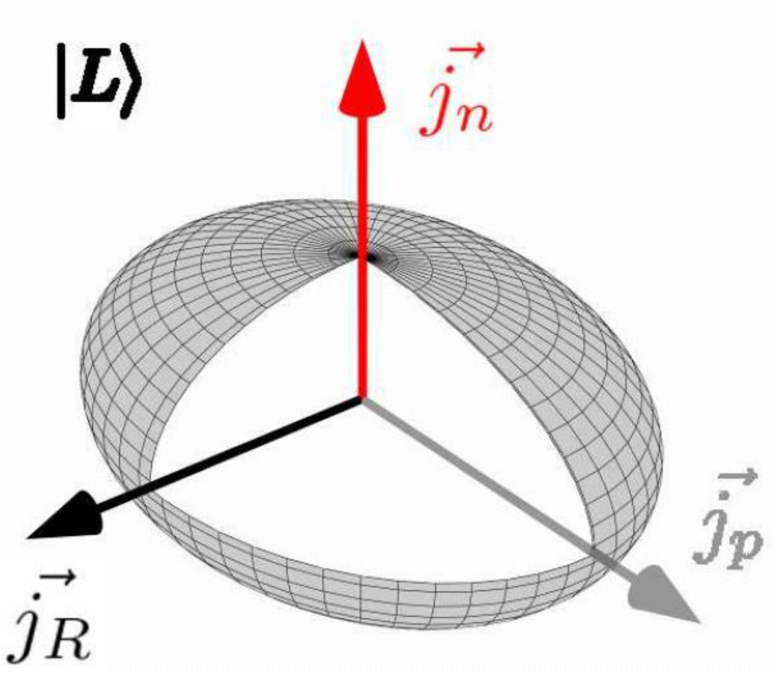
In both cases the same measured handedness value =0.0
(a hibernated cat again)

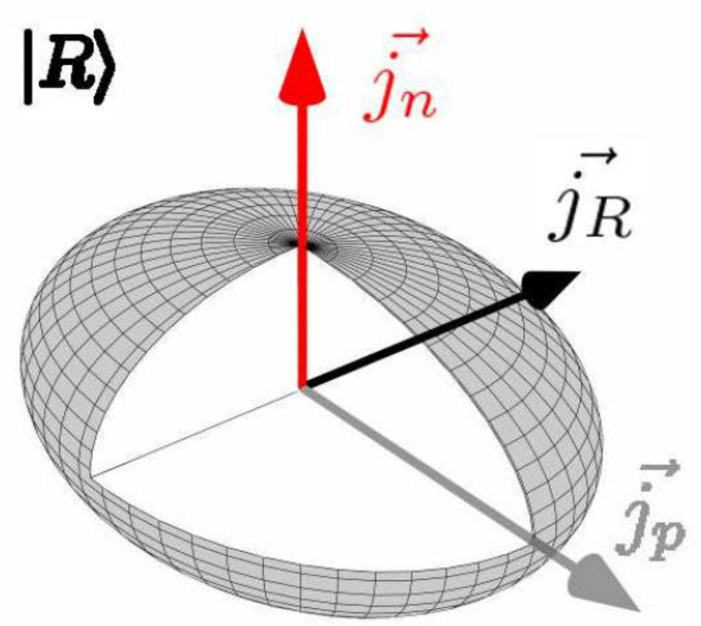
$$<O> = \frac{(\vec{j}_\pi \times \vec{j}_\nu)\cdot\vec{j}_R}{\sqrt{j_\pi^2 j_\nu^2 j_R^2}} = 0.0$$

Expectation value of handedness does not distinguish the symmetry broken from the symmetry conserved nucleus since handedness is a signed value.

Measuring unsigned observable may distinguish symmetry broken from symmetry conserved state.

<g>=+1	*<g>=0*	*<g>=+1*
Left handed	planar	Right handed

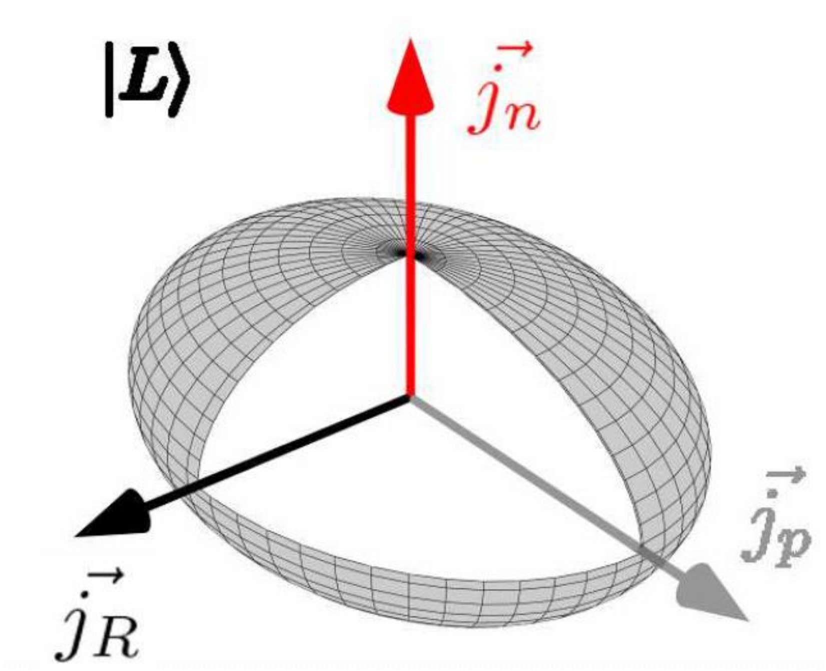


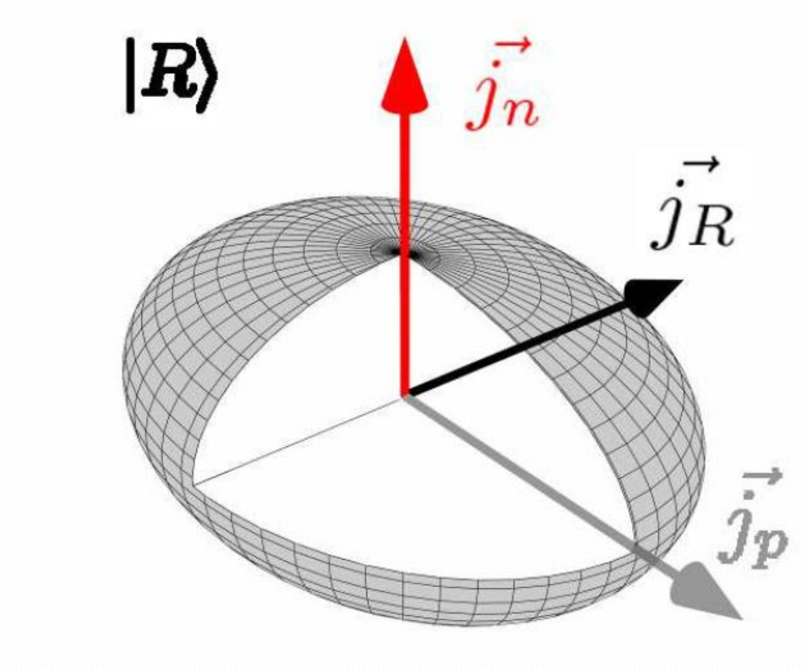


Magnetic dipole moment is a hit! Measured value: the g-factor

$$\frac{1}{\langle J^2 \rangle} \left(g_p \langle \vec{j}_n \cdot \vec{j}_R \rangle + g_n \langle \vec{j}_p \cdot \vec{j}_R \rangle + g_R \langle \vec{j}_p \cdot \vec{j}_n \rangle \right)$$

<g>=0	*<g>=+0.1*	*<g>=0*
Left handed	planar	Right handed





First Measurement of the *g* Factor in the Chiral Band: The Case of the ^{128}Cs Isomeric State

E. Grodner,[1,2] J. Srebrny,[3] Ch. Droste,[2] L. Próchniak,[3] S. G. Rohoziński,[2] M. Kowalczyk,[3] M. Ionescu-Bujor,[4] C. A. Ur,[5] K. Starosta,[6] T. Ahn,[7] M. Kisieliński,[3] T. Marchlewski,[3] S. Aydin,[8,10] F. Recchia,[9] G. Georgiev,[11] R. Lozeva,[11] E. Fiori,[11] M. Zielińska,[3] Q. B. Chen,[12] S. Q. Zhang,[12] L. F. Yu,[12] P. W. Zhao,[12] and J. Meng[12,13]

[1]*National Centre for Nuclear Research, 05-540 Świerk, Poland*
[2]*Faculty of Physics, University of Warsaw, 02-093 Warsaw, Poland*
[3]*Heavy Ion Laboratory, University of Warsaw, 02-093 Warsaw, Poland*
[4]*Horia Hulubei National Institute for Physics and Nuclear Engineering, 077125 Bucharest, Romania*
[5]*Extreme Light Infrastructure, IFIN-HH, 077125 Bucharest, Romania*
[6]*Simon Fraser University, V5A 1S6 Vancouver, British Columbia, Canada*
[7]*Department of Physics, University of Notre Dame, 46556 Notre Dame, Indiana, USA*
[8]*Instituto Nazionale di Fisica Nucleare, 2 35020 Legnaro, Italy*
[9]*Dipartimento di Fisica dell'Università di Padova and INFN sez. Padova, I-35131 Padova, Italy*
[10]*Department of Physics, Aksaray University, 68100 Aksaray, Turkey*
[11]*CSNSM, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, 91405 Orsay, France*
[12]*State Key Laboratory of Nuclear Physics and Technology, School of Physics, Peking University, Beijing 100871, China*
[13]*Yukawa Institute for Theoretical Physics, Kyoto University, Kyoto 606-8502, Japan*

(Received 13 June 2017; revised manuscript received 5 November 2017; published 12 January 2018)

PHYSICAL REVIEW C
covering nuclear physics

Examination of nuclear chirality with a magnetic moment measurement of the $I = 9$ isomeric state in ^{128}Cs

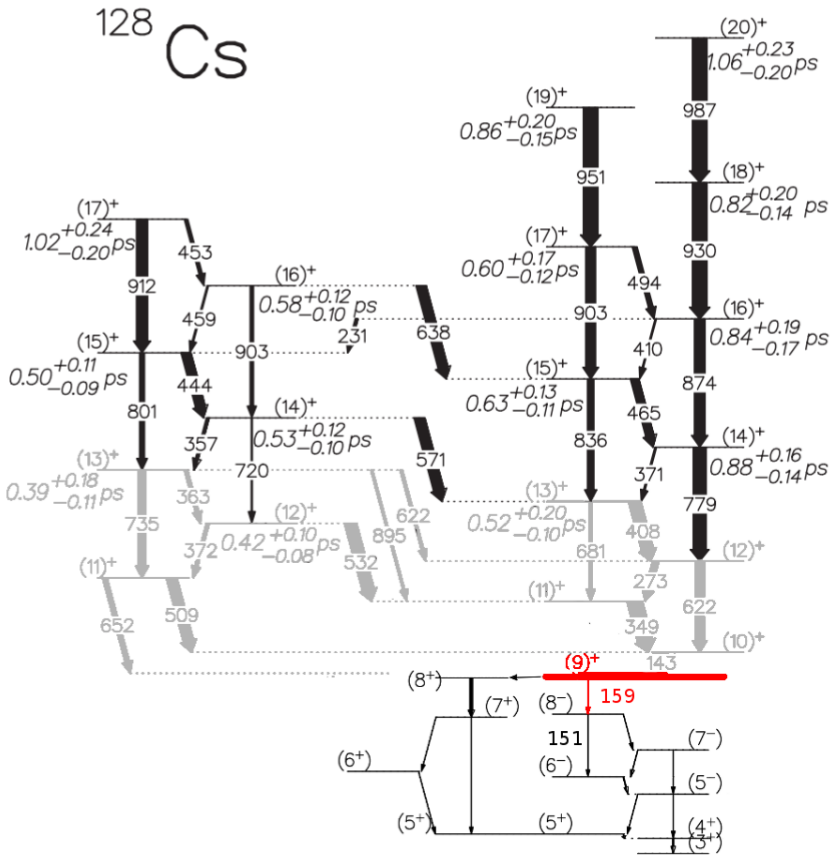
E. Grodner, M. Kowalczyk, M. Kisieliński, J. Srebrny, L. Próchniak, Ch. Droste, S. G. Rohoziński, Q. B. Chen, M. Ionescu-Bujor, C. A. Ur, F. Recchia, J. Meng, S. Q. Zhang, P. W. Zhao, G. Georgiev, R. Lozeva, E. Fiori, S. Aydin, and A. Nałęcz-Jawecki

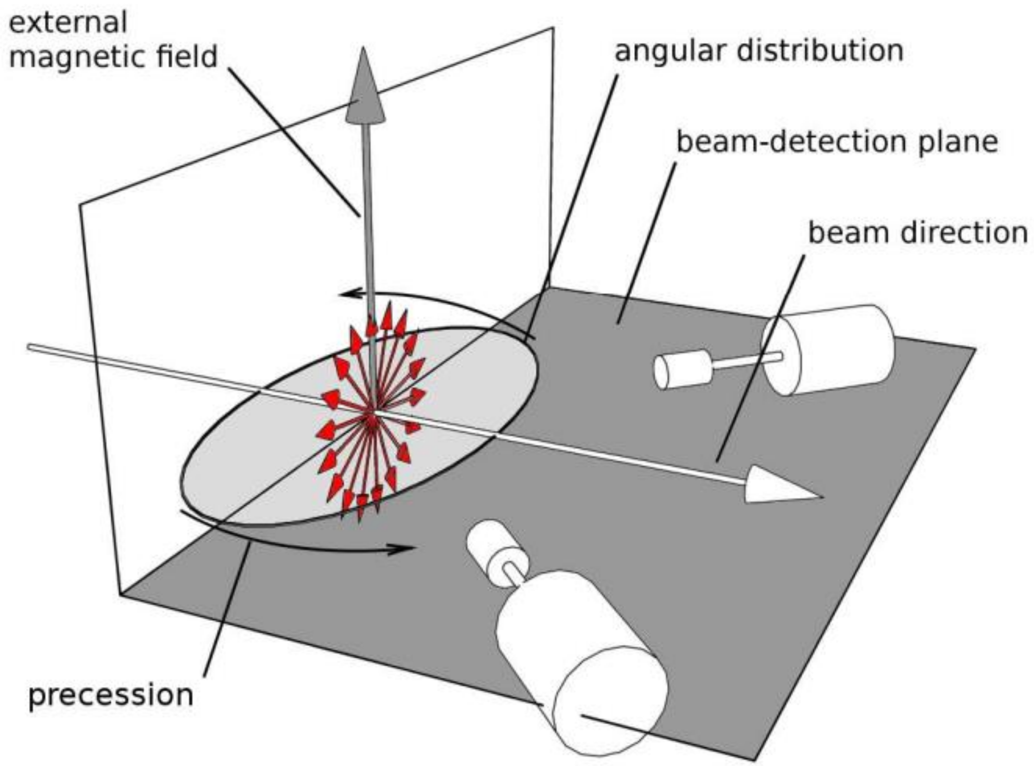
Phys. Rev. C **106**, 014318 – Published 28 July 2022

ABSTRACT

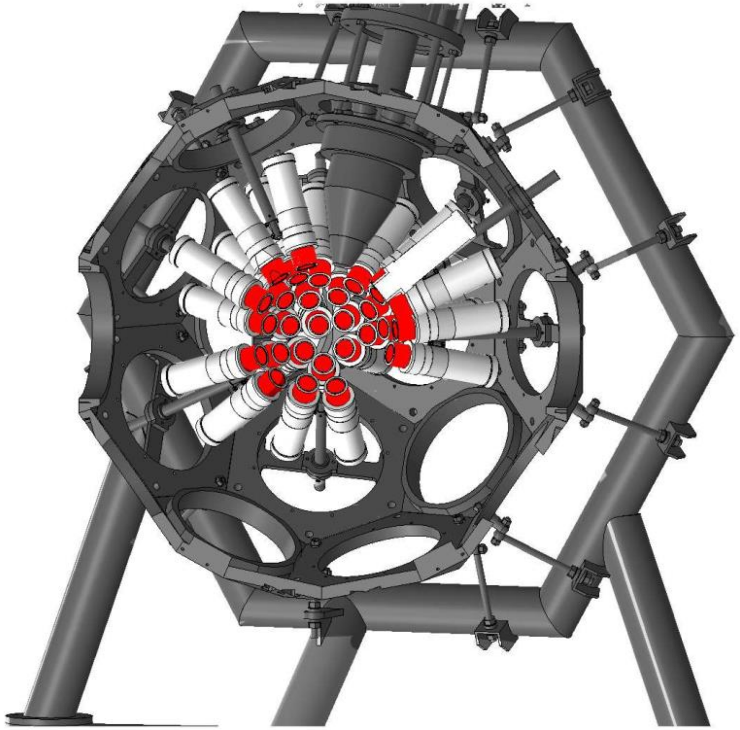
The g factor of the isomeric $I = 9^+$ bandhead of the yrast states in ^{128}Cs is obtained from the time differential perturbed angular distribution measurement performed with the electromagnet at IPN Orsay. An external magnetic field of 2.146 T at the target position was attained with GAMIPE reaction chamber surrounded by four high-purity germanium detectors, of which two were low-energy photon spectrometer type. The results are in accordance with $\pi h_{11/2} \otimes \nu h_{11/2}^{-1}$ $I = 9^+$ bandhead assignment and are discussed in the context of chiral interpretation of the ^{128}Cs nucleus as a composition of the odd proton, odd neutron, and even-even core with their angular momentum vectors. The obtained g -factor value was compared with predictions of the particle-rotor model. The experimental g factor corresponds to the nonchiral geometry of the isomeric bandhead. This observation indicates the existence of the chiral critical frequency in ^{128}Cs and may explain the absence of the chiral doublet members for $I < 13\hbar$.

Just two detectors with magnet on a table. The cheapest experiment with an expensive idea.

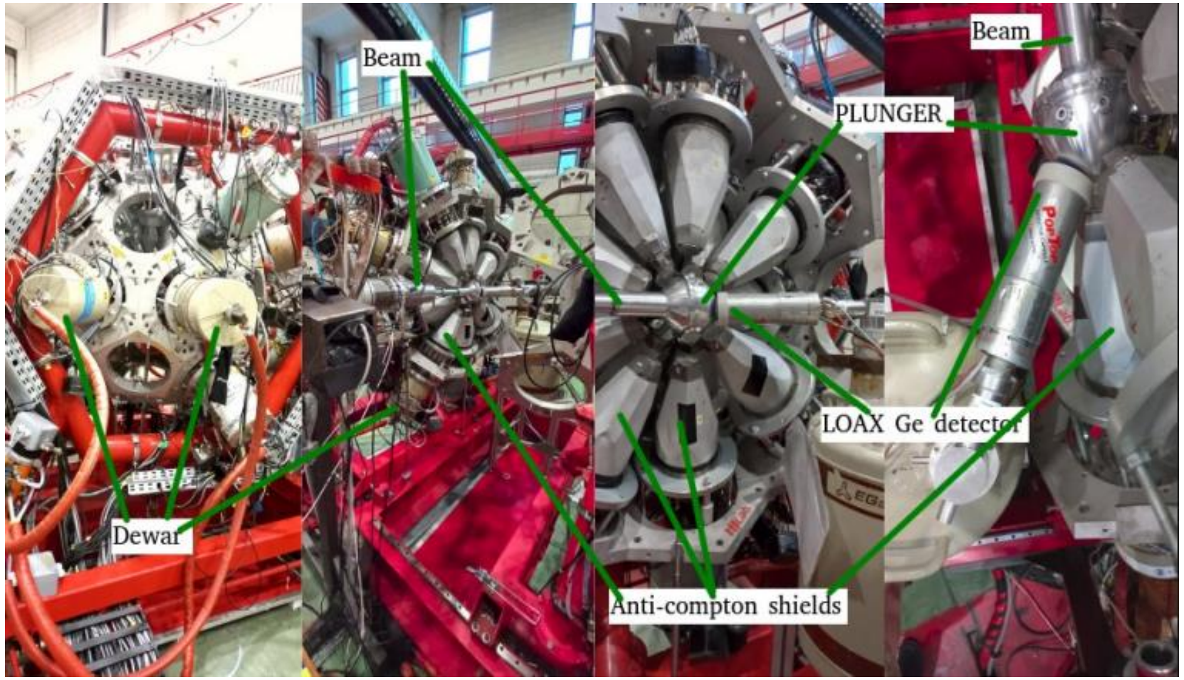




Future: preparations for similar measurements in other excited states. Fast-Timing and Plunger lifetime measurements.
PHD thesis of Adam Nałęcz-Jawecki (NCNR).



EAGLE-EYE



EAGLE-PLUNGER