Magnetic Rotation Across the Pb Chain

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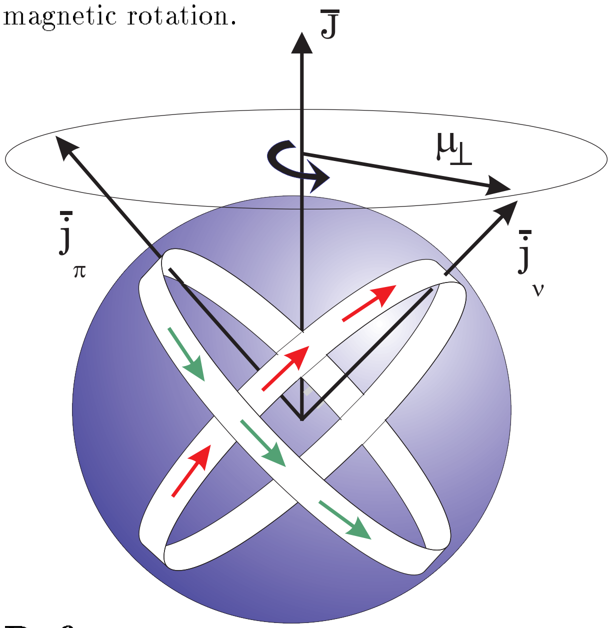
The observation of cascades of magnetic dipole (M1) transitions in the neutron–deficient Pb nuclei has posed a serious challenge to conventional collective models. The properties of the bands are extremely unusual: 1) most of the structures follow the linear behavior of spin, I, as a function of ω typical for rotational bands despite very low deformations; 2) the levels are linked by strong M1 transitions with weak E2 crossover transitions (typical B(M1)/B(E2) ratios $\geq$20–40 $(\mu_N/\mathrm{eb})^2$); 3) the ratio $\Im^{(2)}$/B(E2) is roughly an order of magnitude larger than that for normal or superdeformed bands, indicating that a substantial portion of the inertia is generated from effects other than quadrupole collectivity.

It has been suggested that the bands represent a novel mode of nuclear excitation, namely 'magnetic rotation' which arises as a consequence of breaking the rotational symmetry of the nucleus by an anisotropic arrangement of current loops generated by a few valence protons and neutrons within the nucleus (as opposed to our more familiar concept of nuclear rotation which arises when the rotational symmetry is broken by a deformed mass (and charge) distribution). This situation is illustrated in the figure. The component angular momentum vectors of the protons and neutrons point in different directions and the result is a large magnetic dipole. The nucleus generates angular momentum by aligning the component vectors (the so-called 'shears mechanism'). This results in a characteristic behaviour of the reduced magnetic dipole transition probability, B(M1), along the band. This can be tested experimentally by estimating the lifetimes of states in the band using Doppler Shift Attenuation (DSA) techniques.

We have performed a series of high–precision DSA measurements on the M1 structures in $^{193-197}$Pb using the Gammasphere array. The deduced B(M1) values show remarkable agreement with calculations (as an example see the case of ^{199}Pb shown in the accompanying contribution). Combined with our earlier measurements on bands in ^{198,199}Pb [1], the results represent a considerable body of evidence supporting the shears mechanism and the new concept of magnetic rotation.



References

[1] R.M.Clark et al., Phys. Rev. Lett 78 (1997) 1868