# why are odd electric moments zero ?

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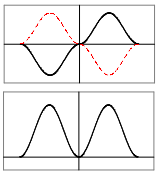
## Why are odd electric nuclear multipole moments zero ?

- Definition of the parity operator in 3D :
  *change the sign of all three dimensions:* x→-x, y→-y, z→-z, hence r→-r
- Real eigenvalues: +1 or -1
- Meaning of parity in one dimension (x→-x):



P f(x) = f(-x) = -1 f(x) odd

P f(x) = f(-x) = +1 f(x) even

- Integrals over all space for a function with odd parity are zero.
- Observational fact: nuclear states have a well-defined parity (i.e. +1 or even, or -1 or odd)

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classical dipole moment: $Q_x = \int x\rho(\vec{r})\,d\vec{r}$ (x-component of dipole moment vector only, as example)

translate to quantum mechanics: $Q_x = \int \Psi_I^*(\vec{r})x\Psi_I\,d\vec{r} = \langle I|\hat{x}|I\rangle$

Parity of ρ is always even (product of two states with the same parity).
Parity of the x-operator is odd.
The parity of the integrand is odd → the dipole moment expectation value is zero.

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## Why are odd electric nuclear multipole moments zero ?

Symmetry explanation:


Imagine nuclei would have an electric dipole moment.
The parity operator leaves the spin unaffected.
The parity operator flips the dipole moment.
The orientation of the dipole moment w.r.t. the spin is changed.
→ this does not agree with parity being a good quantum number for nuclei
→ the electric dipole moment must be zero.

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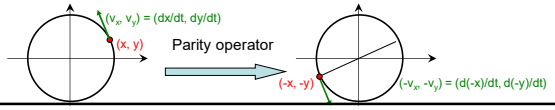


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