

# Probing Nucleon Spin Structure Through a Polarized Helium-3 target



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For the Hall A Polarized  $^3\text{He}$  Collaboration

## Nucleon Structure and Spin

### Nucleon Structure

Nucleon (proton/neutron)  
made of quarks and gluons  
 $p = up + up + \text{down}$  (quarks)  
 $n = up + \text{down} + \text{down}$  (quarks)



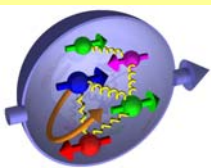
### Spin

relativity, fast rotation  
orbital angular momentum  
proton, neutron: spin 1/2

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## Nucleon Spin Structure and GDH Sum Rule

Spin related to magnetic property through Sum Rule  
Integral of Spin Structure  $\rightarrow$  anomalous magnetism  
Relation between quark/gluon pictures and nucleon



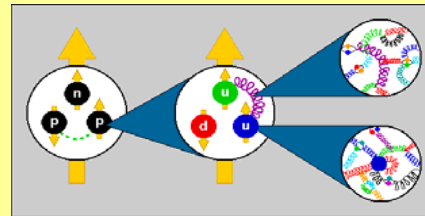
$$\sigma_{IL}^e = \text{spin} - \text{spin}$$

Sum Rule



## Nucleon Spin Structure with a Polarized Target

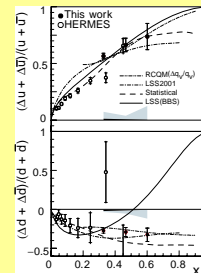
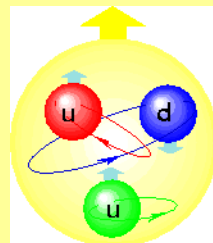
Spin is an important part of nucleon structure  
Spin was the first evidence that proton has structure (1930s)  
Spin is a fundamental property, same as charge or mass  
Spin is related to other property, such as magnetism  
**Spin crisis: quark spin does not add up to proton spin! (1980s)**  
Forefront research on nucleon spin at JLab



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## Valence Quark Spin Structure

Valence Quark Spin Structure of the Nucleon  
Learn the strong interaction among quarks (QCD)  
The role of quark orbital angular momentum



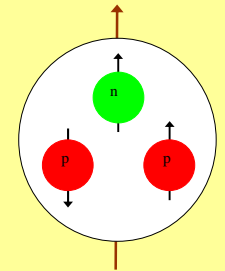
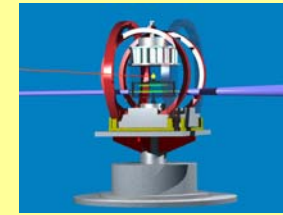
## Polarized Helium-3 Target

Polarized Helium-3 as a Neutron Target

Glass cells are filled with  $^3\text{He}$  gas  
Helium-3 = 2 protons + 1 neutron

When polarized, proton spins "cancel," leaving only the neutron's

World highest polarized luminosity  $10^{36}$  e-N/s



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## Transverse Spin Structure

Transversity and Nucleon Structure in Amplitude Level

Learn quark's relativistic properties  
3-D Imaging of Nucleon Spin Structure

