

2007-2008 Published Works
Dr. Hachemi Benaoum

Title : h-analogue of Fibonacci numbers
Author : H. Benaoum

Abstract

In this paper, we introduce the h-analogue of Fibonacci numbers for non-commutative h-plane. For $h = 0$, these are just the usual Fibonacci numbers as it should be. We also derive a collection of identities for these numbers. Furthermore, h-Binet's formula for the h-Fibonacci numbers is found and the generating function that generates these numbers is obtained.

September 2008, submitted for publication

**Title : High Resolution Spectroscopy of $^{16}N_{\Lambda}$
by Electroproduction
Author : H. Benaoum et al.**

Abstract

An experimental study of the $^{16}O(e, e'K^+)^{16}N_{\Lambda}$ reaction has been performed at Jefferson Lab. A thin film of falling water was used as a target. This permitted a simultaneous measurement of the $p(e, e'K^+)\Lambda, \Sigma_0$ exclusive reactions and a precise calibration of the energy scale. A ground-state binding energy of $13.76 \pm 0.16 \text{ MeV}$ was obtained for $^{16}N_{\Lambda}$ with better precision than previous measurements on the mirror hypernucleus $^{16}O_{\Lambda}$. Precise energies have been determined for peaks arising from a Lambda in s and p orbits coupled to the $p_{1/2}$ and $p_{3/2}$ hole states of the ^{15}N core nucleus.

October 2008, submitted for publication

Book

Title : Parity-Violation Electron Scattering and Strangeness in Nucleon

Author : H. Benaoum

Abstract

There is currently enormous interest in the determination of the strangeness content of the nucleon which is crucial in the understanding of quantum chromodynamics (QCD) in the non-perturbative regime. In this regime, the QCD coupling constant is large and in addition to the valence quarks (up and down quarks) there is a sea of gluons and $q\bar{q}$ pairs that plays an important role at these distance scales. Because the strange quark mass is comparable to the QCD mass scale Λ_{QCD} , it is reasonable to assume that it might have non-negligible contributions to the nucleon properties. The parity-violating (PV) electron scattering in the electron-nucleon elasticscattering offers a new opportunity to study the contribution of the strange quarks to the electroweak structure of the nucleon. This work shows the results of parity-violating asymmetry APV for longitudinally polarized electrons from both hydrogen and helium cryogenic targets, at small angles. The asymmetry for hydrogen is a function of a linear combination of G_E^s and G_s^M the strange quark contributions to the electric and magnetic form factors of the nucleon respectively, and that for helium is a function of solely of G_s^M . The combination of the two experimental results therefore allow G_s^E and G_s^M to be separately determined.

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**Title : Probing Cold Dense Nuclear
Matter**

Author : H. Benaoum et al.

Abstract

Recent experiments have found that a significant fraction of the protons and neutrons in a nucleus form strongly overlapping nucleon pairs. These pairs have a local density of several times the average density of nuclear matter. Our investigations of this cold dense nuclear matter in ^{12}C yielded the counter-intuitive result that neutron-proton pairs are nearly twenty times more prevalent than proton-proton pairs and, by inference, neutron-neutron pairs. This difference between the types of pairs is due to the nature of the nuclear force, and has far-reaching implications for our understanding of cold dense nuclear systems such as neutron stars.

**Published in Science, Volume 320,
1476-1478,2008**

Title : Strangeness in Nucleon
Author : H. Benaoum

Abstract

Results of the parity violating asymmetry A_{PV} for longitudinally polarized 3 GeV electrons from both hydrogen and helium cryogenic targets, at small scattering angle $\theta_{lab} \sim 6^\circ$ are presented. The asymmetry for hydrogen is a function of a linear combination of G_E^s and G_M^s , the strange quark contributions to the electric and magnetic form factors of the nucleon respectively, and that for ${}^4\text{He}$ is a function solely of G_E^s . The combination of the two results therefore allows G_E^s and G_M^s to be separately determined.

**Published in American Institute
of Physics Conference Proceedings,
Volume 1006, 53-57,2008**

Title : Deeply Virtual Compton Scattering off the neutron

Author : H. Benaoum et al.

Abstract

The present experiment exploits the interference between the Deeply Virtual Compton Scattering (DVCS) and the Bethe-Heitler processes to extract the imaginary part of DVCS amplitudes on the neutron and on the deuteron from the helicity-dependent $D(\vec{\epsilon}, \epsilon' \gamma)X$ cross section measured at $Q^2=1.9 \text{ GeV}^2$ and $x_B=0.36$. We extract a linear combination of generalized parton distributions (GPDs) particularly sensitive to E_q , the least constrained GPD. A model dependent constraint on the contribution of the up and down quarks to the nucleon spin is deduced.

**Published in Physical Review
Letter, Volume 99, 242501,2007**

**Title : High Resolution
Spectroscopy of $^{12}B_{\Lambda}$ by Elec-
troproduction**

**Author : H. Benaoum et
al.**

An experiment measuring electroproduction of hypernuclei has been performed in Hall A at Jefferson Lab on a ^{12}C target. In order to increase counting rates and provide unambiguous kaon identification two superconducting septum magnets and a Ring Imaging Cherenkov detector (RICH) were added to the Hall A standard equipment. An unprecedented energy resolution of less than 700 keV FWHM has been achieved. Thus, the observed $^{12}B_{\Lambda}$ spectrum shows for the first time identifiable strength in the core-excited region between the ground-state s -wave Λ peak and the 11 MeV p -wave Λ peak.

**Published in Physical Review
Letter, Volume 99, 052501,2007**

Title : Investigation of Proton-Proton Short-Range Correlations via the $^{12}\text{C}(e, e'pp)$ Reaction

Author : H. Benaoum et al.

Abstract

We investigated simultaneously the $^{12}\text{C}(e, e'p)$ and $^{12}\text{C}(e, e'pp)$ reactions at $Q^2 = 2 (\text{GeV}/c)^2$, $x_B = 1.2$, and in an $(e, e'p)$ missing-momentum range from 300 to 600 MeV/c . At these kinematics, with a missing-momentum greater than the Fermi momentum of nucleons in a nucleus and far from the delta excitation, short-range nucleon-nucleon correlations are predicted to dominate the reaction. For (9.5 ± 2) of the $^{12}\text{C}(e, e'p)$ events, a recoiling partner proton was observed back-to-back to the $^{12}\text{C}(e, e'p)$ missing momentum vector, an experimental signature of correlations.

Published in Physical Review Letter, Volume 99, 072501, 2007

Title : Precision Measurements of the Nucleon Strange Form Factors at $Q^2 \sim 0.1 GeV^2$
Author : H. Benaoum et al.

Abstract

We report new measurements of the parity-violating asymmetry A_{PV} in elastic scattering of 3 GeV electrons off hydrogen and ^4He targets with $\theta_{lab} \sim 6.0^\circ$. The ^4He result is $A_{PV} = (+6.40 \pm 0.23(stat) \pm 0.12(syst)) \times 10^{-6}$. The hydrogen result is $A_{PV} = (-1.58 \pm 0.12(stat) \pm 0.04(syst)) \times 10^{-6}$. These results significantly improve constraints on the electric and magnetic strange form factors G_E^s and G_M^s . We extract $G_E^s = 0.002 \pm -0.014 \pm 0.007$ at $\langle Q^2 \rangle = 0.077 GeV^2$, and $G_E^s + 0.09 G_M^s = 0.007 \pm 0.011 \pm 0.006$ at $\langle Q^2 \rangle = 0.109 GeV^2$, providing new limits on the role of strange quarks in the nucleon charge and magnetization distributions.

Published in Physical Review Letter, Volume 98, 0323011, 2007