 

PACS number: **01.90. + g**

# Physics news on the Internet (based on electronic preprints)

DOI: 10.3367/UFNe.0184.201408d.0864

## 1. Gluon polarization and the proton spin

The proton spin is determined by the spins of the constituent quarks and gluons and their orbital angular momenta. Earlier experiments on deeply inelastic lepton–proton scattering have demonstrated that the quark spins only explain about a quarter of the proton spin magnitude. The preceding data also pointed out that, even if nonzero, the gluon polarization in the proton (the averaged resultant value of their spins) is insignificant — that is, the contribution from gluon spins to the total proton spin is small. However, D de Florian (University of Buenos Aires, Argentina) and colleagues utilized the large statistical array of data from the Relativistic Heavy Ion Collider — RHIC (Brookhaven National Laboratory, USA) and applied a new modified method of analysis to obtain evidence of the fact that gluons in the proton composition still have general nonzero polarization and, hence, make a considerable contribution to the total proton spin, the contribution of quark and gluon orbital momenta to the proton spin being less than was believed earlier.

Source: *Phys. Rev. Lett.* **113** 012001 (2014)
http://arXiv.org/abs/1404.4293

## 2. Triangular $D_{3h}$ symmetry in the $^{12}$C nucleus

D J Marin-Lambarri (University of Birmingham, Great Britain) and colleagues have established the fact that nucleons in the $^{12}$C nucleus are concentrated in three clusters ($\alpha$-particles) arranged as vertices of an equilateral triangle. Clusterization of nucleons in nuclei to $\alpha$-particles consisting of two protons and two neutrons is, in some cases, energetically more advantageous than a uniform distribution. The described experiment investigated collisions of a beam of $\alpha$-particles from a cyclotron with a carbon target. The momentum and energy distributions of $\alpha$-particles produced in the reaction $^{12}\mathrm{C}(^4\mathrm{He}, 3\alpha)^4\mathrm{He}$ and registered by silicon strip-detectors made it possible to determine the character of nucleon distribution in $^{12}$C nuclei. A new nuclear energy state was revealed at an energy of 22.4(0.2) MeV with spin-parity $J^\pi = 5^-$, which corresponds to the ground rotational state of an equilateral triangular configuration with the symmetry group $D_{3h}$. Such a symmetry was earlier known in triatomic molecules $H_3^+$, but for the nucleus it has been observed for the first time. For $^{12}$C, it was theoretically predicted by R Bijker and F Iachello. The understanding of the $^{12}$C nucleus structure is also important for clarification of the properties of the Hoyle energy level at 7.654 MeV, which plays a significant role in nucleosynthesis in stars. The authors believe that the Hoyle level may be the state $0^+$ of the $^{12}$C nucleus in triangular configuration $D_{3h}$.

Source: *Phys. Rev. Lett.* **113** 012502 (2014)
http://arXiv.org/abs/1405.7445

*Uspekhi Fizicheskikh Nauk* **184** (8) 864 (2014)
DOI: 10.3367/UFNr.0184.201408d.0864
Translated by M V Tsaplina

## 3. Mutual information in quantum measurement

J V Koski (Aalto University, Finland) and colleagues experimentally confirmed the validity of the generalized Bochkov–Kuzovlev and Jarzynski (BKJ) relation, which allows for the contribution of mutual information. The quantity referred to as mutual information is expressed in terms of the correlations between the real state of a thermodynamic system and the records in the memory cells of the device used to measure this state. Thus, mutual information characterizes the precision of measurements. According to the generalized BKJ relation, mutual information affects the thermodynamic properties of the system being measured. A one-electron box was tapped in the experiment, made of two microscopic conductors separated by a thin insulator at a temperature of 100 mK. The state of the box was registered with the aid of a one-electron transistor. When electrons were tunneling through the insulator, the energy of the capacitor made of conductors changed, which affected the magnitude of the alternating current running through the device. Thereby, the presence or absence of an electron in the box influenced the thermodynamic properties of the system via the capacitor energy. The noises that lowered the measurement accuracy but were needed for verification of the generalized BKJ relation were artificially introduced in the experiment. The experiments carried out at the reached level of accuracy validated the generalized BKJ relation and demonstrated for the first time the role of feedback through mutual information in the fluctuation theorem and in the thermodynamics of irreversible processes. The Jarzynski equation derived in 1997 is a particular case of the Bochkov–Kuzovlev relations, which they put forward in 1977–1983 (see *Usp. Fiz. Nauk* **181** 647 (2011) [*Phys. Usp.* **54** 625 (2011)] and *Usp. Fiz. Nauk* **183** 617 (2013) [*Phys. Usp.* **56** 590 (2013)]). A generalization of BKJ relations with allowance for mutual information was proposed by T Sagawa and M Ueda in their papers of 2010–2012 [see *Phys. Rev. Lett.* **104** 090602 (2010); *Phys. Rev. E* **85** 021104 (2012)].

Source: *Phys. Rev. Lett.* **113** 030601 (2014)

## 4. Borospherene $B_{40}$

A team of researchers from Brown University (USA), Shanxi University, and Tsinghua University (China) have become the first to reveal nearly ball-shaped (but with bulges and edges) $B_{40}$ molecules resembling the known fullerene molecule $C_{60}$. Boron molecule $B_{40}$ was called 'borospherene'. The possibility of the existence of $B_{40}$ molecules and their spectral properties were earlier predicted by a complicated computer simulation. In the experiment, boron was evaporated with a laser radiation from a solid sample and then cooled in a helium stream. This process yielded clusters of boron atoms, which were separated according to their masses. These clusters were examined by photoelectron spectroscopy methods, i.e., the energy spectra of electrons ejecting in photoelectron emission under the effect of second laser radiation were measured. The clusters produced exhibit two

different modifications, which had been predicted theoretically, with a flattened and approximately spherical shape. $B_{36}$ molecules, which had already been observed before, were formed of the flattened clusters.Whereas spherical $B_{40}$ molecules have on their surface a rather complicated arrangement of boron atoms in the form of several rings and triangles.

Source: http://www.sciencedaily.com/releases/2014/07/140713155506.htm

## 5. Supervoid as the cause of the Cold Spot in relic radiation

Several regions with a lowered temperature are observed in relic (cosmic microwave background) radiation. Their origin has not yet been fully clarified, but these features are most probably due to the rare large perturbations of matter density. The orbital telescope WMAP revealed what is probably the most extensive of such regions, referred to as the Cold Spot, and then this result was confirmed by the Planck telescope. I Szapudi and his colleagues are the first to reveal with a good accuracy the relation between the Cold Spot and the supervoid, which is a region of the Universe with a lowered concentration of galaxies. The search for the void in the direction of the Cold Spot was undertaken earlier, but the results appeared to be contradictory, namely, very weak indications of the presence of a void (L Rudnick, S Brown, and L R Williams, 2007) were not endorsed in other studies. The gravitational potential of voids must lead to the occurrence of cold spots in relic radiation via the mechanism of the Sachs–Wolfe integral effect or owing to the nonlinear density evolution in later epochs (Rees–Sciama mechanism). According to calculations, the last effect makes the basic contribution to the Cold Spot formation. The data from WISE-2MASS, Pan-STARRS1, and GAMMA galaxy catalogues were used in the work, and a giant (probably the largest ever known) supervoid with $R \sim 270$ Mpc was revealed with the center in the red shift $z = 0.22 \pm 0.01$ and a density nearly 13% lower than the mean matter density in the Universe. This supervoid exactly corresponds to the position of the Cold Spot. Since such a supervoid is a rare formation (fluctuations $\geqslant 3.5\sigma$ are needed), the probability of its random projection onto a cold spot in relic radiation is low. This identification suggests that other extended anomalous regions in relic radiation can also be associated with large-scale structures in the Universe.

Source: http://arXiv.org/abs/1406.3622

Compiled by *Yu N Eroshenko*
(e-mail: erosh@ufn.ru)