

PACS number: **01.90.+g**

Physics news on the Internet (based on electronic preprints)

DOI: 10.1070/PU2005v048n06ABEH002323

1. Quark – gluon plasma

New data on the formation of quark – gluon plasma in collisions between ultrarelativistic gold ions have been obtained at the Relativistic Heavy Ion Collider (RHIC) at the Brookhaven National Laboratory in the US. The center-of-mass collision energy was 40 TeV. Based on the characteristics of the particles flying away from the collision point, a physical picture of what has been happening in these collisions was reconstructed. The decays of the nuclei, first into nucleons and then into hadrons and quarks, gave rise to a fireball consisting of a mixture of quarks and gluons, a state of matter thought to exist early in the evolution of the Universe, only in the first millionth of a second after its birth. Within about 10^{-24} s, the ball expanded to a radius of 5 fm, and the resulting cooling of the quark – gluon plasma caused the quarks to combine into hadrons registered by detectors. The experiments have provided solid evidence for claiming that the state created in heavy ion collisions is indeed that of quark – gluon plasma. The key difference from previous experiments at the CERN laboratory in Geneva and at RHIC is that the quark – gluon plasma here behaves like an ideal liquid rather than a gas — possibly because quarks and gluons interact rather strongly between themselves.

Source: http://physicsweb.org/articles/news/9/4/10/1

2. A hybrid meson

A 3940-MeV/c^2 mass meson consisting of a c-quark and a c-antiquark has been discovered by the international Belle collaboration at the KEK Laboratory in Japan. The new mesons were created in electron – positron collisions and identified by their decay into two well-known Ω and J/ψ particles. Some of the characteristic features of the decays suggest that the new meson is not merely a $c\bar{c}$ pair but rather also contains a gluon — making it the first discovery of the 'hybrid meson' predicted by theorists back in 1978. The mass of the new meson, however, is much smaller than theoretically predicted.

Source: *Phys. Rev. Lett.* **94** 182002 (2005)
http://arXiv.org/abs/hep-ex/0412041

3. Zinc-54

An international team of researchers at the GANIL laboratory in France has for the first time succeeded in creating nuclei of the ^{54}Zn isotope, containing 30 protons and 24 neutrons. The ^{54}Zn nuclei were produced by colliding a beam of ^{58}Ni ions with a nickel or beryllium target and were found to undergo the two-proton decay, with exactly the predicted values of the outcoming proton energy and the decay half-life of the nucleus equal approximately to 3.7 ms. Since its prediction by V I Gol'danskii in 1960, the only material to experimentally exhibit the two-proton decay has been the ^{45}Fe isotope (see *Usp. Fiz. Nauk* **172** 1224 (2002) [*Phys. Usp.* **45** 1107 (2002)]).

Source: http://arXiv.org/abs/nucl-ex/0505016

4. Sodium melting

E Gregoryanz and his colleagues at the Carnegie Institution of Washington have observed the melting curve behavior of sodium to be quite unusual at high pressures. As in most other materials, its melting point first increases with increasing pressure, reaching 1000 K at a pressure of 30 GPa, but a further increase in pressure starts to lower it — even down to room temperature at a pressure of 118 GPa. Scientists have observed such 'negative melting curves' in several substances, but at much lower temperatures and pressures.

Source: *Physics News Update*, Number 730
http://www.aip.org/pnu/2005/split/730-1.html

5. Metamaterials in the optical range

V Shalaev and his colleagues at Purdue University in the US have for the first time created a material with a negative refractive index $n = -0.3$ in the optical range, at a wavelength of 1.5 μm. The existence of metamaterials with both a negative electric permittivity and a negative magnetic permeability was theoretically predicted by V G Veselago in 1967 (*Usp. Fiz. Nauk* **92** 517 (1967) [*Sov. Phys. Usp* **10** 509 (1968)]), but so far this property has only been implemented (in composite materials) for the radio frequency band (*Usp. Fiz. Nauk* **170** 552 (2000) [*Phys. Usp.* **43** 520 (2000)]). The new material consists of an array of closely spaced pairs of parallel gold nanowires, and the sample studied was 2 mm by 2 mm in size. The refractive index was experimentally evaluated by the amount by which the phase and amplitude of the transmitted and reflected waves changed. The negative refractive index effect is due to plasmon resonances in the wires, which can be visualized as occurring in *LC* circuits with the wires and the dielectric-filled space acting as inductors and capacitors, respectively. The new metamaterials appear to be promising for practical applications and, in particular, as perfect lenses.

Source: http://arXiv.org/abs/physics/0504091

Taking a different approach, a University of California team led by X Zhang has shown that a very thin (35 nm) silver film may possess a negative refractive index. This property, due to plasmon excitations occurring in the film, can be used to detect electromagnetic waves near the surface of objects. Surface waves, unlike ordinary light, decay exponentially with distance. By placing the object under examination and the photoplate very close to the film, it proved possible, using an ultraviolet laser, to produce object images with a resolution of one sixth the laser wavelength — which means surpassing the diffraction limit. The idea of using metamaterial lenses to detect surface waves was suggested by J Pendry, a theorist at Imperial College in London, in 2000.

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Uspekhi Fizicheskikh Nauk **175** (6) 642 (2005)
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