 

***PHYSICS NEWS***

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## 1. Interaction of Higgs boson with W- and Z-bosons

In the theory of electroweak interactions, the Higgs boson coupling constants with W- and Z-bosons include modifying parameters $\kappa_W$ and $\kappa_Z$. In the Standard Model, $\kappa_W = \kappa_Z = 1$, and the difference of $\lambda_{WZ} = \kappa_W/\kappa_Z$ from 1 would testify to the multiplicity of the Higgs boson or to the presence of other effects beyond the Standard Model. According to the ATLAS and CMS data obtained in experiments proceeding at the Large Hadron Collider, the absolute value of $|\lambda_{WZ}|$ is equal to unity to an accuracy of 6%, but the signs of $\kappa_W$ and $\kappa_Z$ could be different, because, in the studied processes, W- and Z-bosons were born in pairs and $\kappa_W$ and $\kappa_Z$ entered the result quadratically. The ATLAS collaboration has presented the results of a new analysis [1] which confirm with $5\sigma$ confidence that the signs of $\kappa_W$ and $\kappa_Z$ are identical. Those processes were examined where the Higgs boson was born owing to coupling with either W- or Z-bosons with a subsequent decay into a pair of b quarks. In the case $\lambda_{WZ} < 0$, we would have constructive interference of the indicated channels and an increase in the cross section. The absence of such an increase in the experimental data suggested the conclusion that $\lambda_{WZ}$ is positive.

## 2. Controlled photoionization of $H_2$ molecules

The technique of measurements using attosecond pulses ($\sim 10^{-18}$ s) has been greatly developed in recent years, and one of the main objects of research is the photoionization and dissociation of molecules. F Shobeiry (Max Planck Institute for Nuclear Physics, Germany) and his co-authors have performed an experiment in which the photoionization of $H_2$ did not occur randomly, but was controlled using two laser pulses, namely, in the extreme UV and IR ranges [2]. Position-sensitive electron and ion detectors were used in measurements with subfemtosecond resolution. By varying the relative delay between laser pulses, it was possible to create conditions when an electron flies out into one hemisphere or another. This method of control is based on quantum entanglement of electrons. It may prove useful for studying large molecules or even solids, as well as for creating controlled, high-speed quantum devices.

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## 3. Galvanomagnetic waves in a 2D electron system

Transverse electric (TE) modes of electromagnetic oscillations can propagate in plasma in the presence of an external magnetic field or under electric current passage. As distinct from the properties of waves in volume plasma, the properties of such oscillations in 2D electron systems are not well known. In their theoretical work, A S Petrov and D Svintsov (Moscow Institute of Physics and Technology, National Research University) have predicted the existence of new TE modes in 2D systems and clarified some of their properties [3]. The calculations showed that the interaction of the drift of direct-current charge carriers with a TE-wave magnetic field, which can be called the high-frequency Hall effect, exerts a considerable influence on the electromagnetic properties of the system. A corresponding electrodynamic conductivity tensor was obtained, which showed the existence of galvanomagnetic waves co-directed with the current, the energy transfer from the current to the TE-modes being an analogue of the Vavilov–Cherenkov effect. Provided the problem of strong damping of the predicted TE modes in the long-wave region is solved, they may find application in microelectronics.

## 4. New type of gamma-ray flashes in thunderstorms

A high potential difference in thunder clouds can accelerate electrons up to relativistic energies, fostering an avalanche-like increase in their flux in collisions with air molecules. These 'runaway electrons' are responsible for a number of interesting phenomena, including gamma-ray emission [4]. Previously, two types of gamma-ray emission were observed during thunderstorms. The first is called terrestrial gamma-ray flashes (as distinct from cosmic gamma-ray bursts). They have a high intensity and duration from tens to hundreds of microseconds and are often accompanied by radio and optical pulses, which is indicative of the participation of lightning leaders in their generation. The second type of radiation, called gamma-ray glow, lasts from 1 to hundreds of seconds, has a moderate intensity, and is not accompanied by noticeable radio or optical signals. The possibility of the existence of gamma-ray emission with intermediate properties was discussed, but it was not possible to record it earlier. N Ostgaard (University of Bergen, Norway) et al. have become the first to reliably register pulsating gamma-ray emission, called 'flickering gamma-ray flashes' (FGFs), which can be an intermediate link between the two indicated types of gamma-ray emission [5]. In a series of 10 measurements from an airplane at an altitude of 20 km above thunderstorm areas, 24 FGFs with a duration of 20–250 ms were recorded. A typical FGF begins as a gamma-ray glow, but at a certain point its intensity begins to increase exponentially and pulsate. Like a gamma-ray glow, FGFs have no noticeable accompanying radio or optical radiation. However, lightning like 'narrow bipolar events' sometimes occurred after the last FGF pulse. This may mean that FGFs are associated with lightning preparation processes in at least some cases.

## 5. Problem of reionization of the Universe

At the age of approximately 550–800 million years, the Universe experienced a hydrogen reionization, after hydrogen recombination, which occurred at the redshift $z = 1100$. This is evidenced by the data on relic radiation and the hydrogen absorption lines (Lyman-$\alpha$ forest). As was shown by recent observations with the J Webb space telescope, the main ionizing photon sources were early galaxies, which appeared to be much more numerous than expected. J B Munoz (University of Texas at Austin, USA) and his coauthors have performed a new analysis of the available astrophysical data on the properties of galaxies and an analysis of J Webb observations to conclude that hydrogen ionization by early galaxies must have been much more intense than required to explain the observed ionization pattern [6]. And the reionization itself must accordingly have occurred earlier (by about 350 mln years) than follows from the relic radiation data. To avoid overproduction of ionizing photons, it is necessary to assume that UV photons were emitted by early galaxies with less efficiency for some reason, but the theoretical models proposed so far cannot explain this discrepancy. The ionization could also be accelerated by the radiation generated under accretion onto supermassive black holes at the centers of early galaxies, and an additional contribution could have been made by weak galaxies inaccessible to observation, meaning that excessive ionizing photons were even more numerous, and the problem of reionization of the Universe is more serious.

## References


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