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1. Landau levels in graphene

Researchers at the National Institute of Standards and Technology (NIST) and the Georgia Institute of Technology carried out for the first time direct measurements of Landau levels in a graphene specimen using a scanning tunneling microscope (STM). Landau levels (LLs) are spoken of as discrete quantum energy levels of electrons executing a cyclotron motion in a magnetic field. The velocity of free electrons in graphene (i.e., in a single layer of carbon atoms arranged in a honeycomb-like array) is almost independent of their energy; in other words, their law of dispersion resembles that of massless quasiparticles. As shown in theoretical investigations, this implies that energy spacings between consecutive Landau levels in graphene are not all equal as they are in ordinary metals and in a two-dimensional electron gas. It was also predicted that at the zero level (the $n = 0$ LL) the energy of electrons is zero regardless of the strength of the applied magnetic field. Graphene films were grown on a silicon carbide (SiC) substrate and were studied in a high vacuum at an ultralow temperature. Conductivity was measured as a function of applied voltage using an STM tip. About 20 Landau levels were detected by recording conductivity jumps. The experiment showed that in agreement with theoretical expectations, Landau levels in graphene are not equidistant and electron energy at the zero level is permanently zero.

Source: *Science* **324** 924 (2009)
http://dx.doi.org/10.1126/science.1171810

2. Collective quantum tunneling in nanowires

A Bezryadin, P Goldbart and their colleagues at the University of Illinois discovered the effect of quantum tunneling of an entire bunch consisting of about 10^5 electrons. Since the number of simultaneously tunneling electrons was so considerable, this phenomenon can be called macroscopic quantum tunneling. Tunneling took place owing to a quantum phase slip in a superconducting wire (with a diameter of about one nanometer) from higher electric current states to lower electric current states. Excess energy was dissipated in this quantum transition as heat; the wire warms up and switches from the superconducting state to a more highly resistive state. It is likely that the discovered effect of macroscopic tunneling will find applications in quantum computing.

Source: *Nature Physics*, 17 May 2009 (online publication)
http://dx.doi.org/doi:10.1038/nphys1276

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3. Acoustic lasers

P M Walker and his colleagues at the University of Nottingham (UK) and the V E Lashkarev Institute of Semiconductor Physics in Kyiv (Ukraine) designed a coherent source of sound waves working in the terahertz frequency range. A collimated beam of phonons with a wavelength of about one nanometer is generated in a layered semiconductor structure (superlattice) with specially selected spacings between fifty alternating layers of gallium arsenide and aluminium arsenide. Each layer is only several atoms thick. The new device has been given the name saser (sound laser). The generation mechanism is based on strong electron–phonon coupling in semiconducting layers. Electrons in the upper layer are excited by nanosecond pulses of a low-average power conventional laser and emit phonons. Phonons are reflected from interfaces between layers and returned to the upper layer, where they again interact with electrons; this leads to synchronization and coherence of the emitted sound pulses. Sound lasers have already been created before but they used other principles for sound generation and worked at much lower frequencies — in the GHz range. The acoustic emission of the new saser at frequencies on the order of one THz may find many useful applications in the fields of computing, imaging and so forth.

Source: *Phys. Rev.* **B 79** 245313 (2009)
http://dx.doi.org/10.1103/PhysRevB.79.245313

4. Gamma-ray burst during the reionization epoch

The gamma telescope BAT (Burst Alert Telescope) on the NASA's Swift satellite has detected the most remote cosmic gamma-ray burst, GRB 090423, on 23 April 2009. Immediately after detection of the gamma burst, X-ray and optical afterglow was observed by several telescopes and certain features of its spectrum led to the determination of the redshift of the burst: $z \approx 8.3$. The host galaxy of the burst GRB 090423 has not yet been identified. Judging by the shape of the burst, it belongs to the class of long gamma-ray bursts produced by explosions of a special class of supernovas known as hypernovas. The burst GRB 090423 flared up at the epoch when the age of the Universe was only about 625 million years. However, its properties (total energy output, peak luminosity and shape of the light curve) do not differ from those of typical gamma bursts that arrive from intermediate and small redshift sources, which points to similarity in the processes involved in explosions of early and contemporary stars. The burst GRB 090423 took place at the reionization stage which ended only at $z \approx 6$; hence, observing gamma-ray bursts at high redshifts can help in understanding the physics of reionization processes and star formation in the early Universe. In particular, the conjecture that the rate of gamma burst generation follows that of star formation is found to be wrong because if it were true, the probability of observing gamma-ray bursts with redshifts

$z > 8$ would be very low. A possible hypothesis is that a relatively higher number of very massive stars were formed during early cosmological epochs than now, and that the UV radiation of these stars could be the source of reionization of the Universe.

Sources: http://arXiv.org/abs/0906.1578
http://arXiv.org/abs/0906.1577

5. Exoplanet in the M31 galaxy

More than 300 planets outside the Solar System have been found by now from periodic fluctuations of brightness or trajectories of stars. Eight more planets were found by observing microlensing at lensing stars which gravitationally focus radiation of more remote source stars on the line of sight. Planets gravitationally affect the light curve in the course of the random passing of the lens across the source star as background, warping this curve in a certain manner. A number of papers have analyzed the probability of this type of planet detection in the nearest neighbor galaxies. G Ingrosso (University of Salento, Italy), A F Zakharov (ITEP and JINR, Russia), and their colleagues carried out a new theoretical study of the strategy of searching for new planets in other galaxies. They predicted the characteristics of corrections to the light curve and found other parameters of lensing events involving planets, and also gave Monte Carlo predictions of the probabilities of specific observations with telescopes working with mirrors of different diameters. Thus, this lensing technique can detect planets in other galaxies only 20 times more massive than Earth. The authors of the paper analyzed earlier observations of lensing of stars in the galaxy M31 (Andromeda galaxy) and noticed that one of the stars in M31 may have already displayed the signs of a planet. It was assumed earlier that a binary lensing star consisting of a pair of ordinary stars may have been responsible for the microlensing event PA-99-N2 recorded in 2004. However, according to G Ingrosso, A F Zakharov et al., the satellite of the main star is only 6.34 times more massive than Jupiter. This mass is approximately one-half of the mass of the lightest stars — brown dwarfs — so that the satellite can be treated as a planet.

Source: http://arXiv.org/abs/0906.1050v1

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