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1. Metallic hydrogen

In the paper "What problems of physics and astrophysics seem now to be especially important and interesting" (see *Phys. Usp.* **42** 353 (1999)), V L Ginzburg placed the possibility of creating metallic hydrogen among the most important and interesting problems. The hydrogen transition to the metal phase under high pressures was theoretically predicted by E Wigner and B Huntington in 1935. The observation of metallic properties of hydrogen had been reported earlier, but these results were not confirmed. R P Dias and I F Silvera (Harvard University) have carried out a new experiment with a diamond anvil and reported the observation of the Wigner–Huntington phase transition corresponding to the hydrogen transformation to the metal phase. The transition was evidenced by the growth of sample reflectance in the optical region up to 0.91. A pressure increase up to 595 GPa was achieved through the removal of defects from the diamond surface in the anvil and by placing the sample into an aluminum oxide envelope, obstructing hydrogen atom diffusion. The phase transition to the state of metallic hydrogen occurred presumably in the pressure range of 565–595 GPa. It is not yet clear whether the obtained metal phase is solid, as follows from the theory, or liquid. The electron concentration determined by the Drude theory corresponds to atomic hydrogen — that is, the molecular hydrogen in the experiment dissociated into atoms. In two separate experiments (at temperatures of 83 K and 5.5 K), the sample was compressed, and in both cases the state of metallic hydrogen was achieved. The other principal possibility of preparing the metal phase relates to plasma compression at high temperatures [see, e.g., V E Fortov et al., *Phys. Rev. Lett.* **99** 185001 (2007)]. In another experiment, M I Eremets, I A Troyan, and A P Drozdov also obtained evidence in 2016 of the formation of metallic hydrogen under a pressure of 360 GPa (https://arXiv.org/abs/1601.04479). To verify the described results, independent experiments are needed. In 1968, N W Ashcroft put forward theoretical arguments suggesting that metallic hydrogen may exhibit superconducting properties even at room temperature [see also the paper by M I Eremets and A P Drozdov in *Phys. Usp.* **59** 1154 (2016)], and in 1972 E G Brovman, Yu Kagan, and A Kholas [*JETP* **34** 1300 (1972)] pointed out that a room-temperature metallic hydrogen can remain metastable even after the high pressure is released. These properties, if confirmed, might be of great practical importance. In nature, according to the calculations, metallic hydrogen occupies a considerable part of Jupiter's and other giant planets' interiors. For the metallic hydrogen problem, see the review by E G Maksimov and Yu I Shilov in *Phys. Usp.* **42** 1121 (1999).

Source: *Science* **355** 715 (2017)
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2. Precision source of weak current

F Hohls (National Metrology Institute of Germany, Braunschweig) and colleagues have developed a new approach to counting single electrons whose stream generates weak electric current. The device in the field transistor configuration was arranged on the basis of a quantum dot in a semiconductor. An electric potential varying with a frequency of 0.5 GHz was applied to the electrode above the dot. During each oscillation period, the quantum dot captures single electrons and then ejects them. This can be exploited to control the number of passing electrons. The current generated by them is amplified and measured with a relative accuracy of 1.6×10^{-7}, which is close to that of the modern standard of current in the SI. Measurements of weak currents can be used, for example, to determine the level of radioactivity in ionization chambers or to count aerosol particles in the air.

Source: http://physicsworld.com/cws/article/news/2016/dec/02/tiny-device-pumps-out-one-electron-at-a-time

3. Quantum measurements

At the Institut Laue–Langevin (France), a new effective method of quantum state tomography has been developed based on a combination of weak and strong quantum measurements. In 2016, researchers at the University of Padua (Italy), G Vallone and D Dequal, predicted theoretically that so-called weak quantum quantities can be determined not only by weak but also by strong measurements with a high degree of impact on the system. S Sponar (Institute of Nuclear Physics, University of Vienna, Austria) and his colleagues have implemented this approach for the first time in their experiment. A neutron beam was split into two beams that interfered after a flight along different paths. Trajectory-dependent neutron spin rotation was realized using a magnetic field, which related the degrees of freedom of the trajectory and the spin. Thus, the trajectories were determined by the value of spin rotation. An additional spin rotation was realized with the aid of the magnetic field: the turns through 15° and 90° represented, respectively, the weak and strong measurement. As predicted, the employment of strong measurements made the process of quantum tomography faster and more effective, which is particularly important for small signal extraction against the background.

Source: *Phys. Rev. Lett.* **118** 010402 (2017)
https://doi.org/10.1103/PhysRevLett.118.010402

4. Hydrogen atom positions in a nanocrystal

L Palatinus (Institute of Physics of the CAS, Czech Republic) and colleagues have developed a method allowing the employment of electron diffraction to localize hydrogen atoms in micro- and nanometer crystal lattices, where X-ray and neutron diffraction methods are inapplicable. The interaction of electrons with charged particles induces multiple declinations of electrons in the crystal, which smears the diffraction pattern and requires improvement of the data processing method. Palatinus and colleagues performed a structural 3D analysis of crystals using the dynamic theory of diffraction, allowing multiple electron scatterings, as distinct from the kinetic theory of diffraction describing single scatterings. Accordingly, the data processing followed more complicated mathematical algorithms. The new method was applied to determine the hydrogen atom positions in both organic (paracetamol) and inorganic (cobalt aluminophosphate) materials. Electron diffraction has already been employed in determining the hydrogen atom positions by B K Vainshtein, B B Zvyagin, and A S Avilov in 1992, but only in powders consisting of macroscopic crystals. The new method proposed by Palatinus and coworkers can be applied to clarify the morphology of organic molecules constituting micro-sized crystals and to provide insight into the functioning of the active components in some drugs.

Source: *Science* **355** 166 (2017)
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5. Localization of a source of fast radio bursts

The nature of the recently revealed fast radio bursts remains unclear, in spite of many models being proposed. Their distinctive feature is a high value of the dispersion measure, testifying to the fact that the radio burst sources are located at cosmological distances. Observations with VLA and the 300-meter telescope in Arecibo made it possible to establish that one of the sources of fast radio bursts, FRB 121102, is co-located with a source of persistent radio emission, the probability of an accidental projection being estimated at a level of approximately 10^{-5}. The origin of the persistent < 1-pc radio source is not yet known either. The positions of FRB 121102 and of the persistent radio source coincide, in turn, with an optical object, which is likely to be a small galaxy with a low star-formation rate at the red shift $z = 0.2$. Perhaps FRB 121102 is related to the nucleus of this galaxy. The source FRB 121102 is the only one from which several (17 to date) fast radio bursts have been registered.

Source: *Nature* **541** 58 (2017)
https://arXiv.org/abs/1701.01098

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