very small proper lifetime of the positronium atoms, this time can serve as a comparison standard for the determination of the rates of even the fastest reactions in which the positronium takes part, lasting billionths of a second.

Positronium turned out to be a sensitive detector of the presence of free atoms and radicals in gases, and also of the structure of the coordination sphere around paramagnetic complex-formers (for example Co^{2+}) in solutions ("smearing" of unpaired electrons over this sphere). A comparison of the reaction rates of hydrogen and positronium (for example, their interaction with Fe^{3+} and Fe^{2+}) makes it possible to reveal the role of diffusion and quantum factors (tunnel effect) in chemical kinetics. By observing the change in the character of the annihilation of the positrons with the composition and with pressure of the gas, it is possible to measure the lifetimes of the intermediate active complexes of gas reactions on the order of 10^{-2} sec and less. Finally, measurements of the positronium-production probability make it possible to describe important elementary processes wherein atomic vibrations in crystal lattices and the energy levels of molecules are excited by positron (and electron) impact.

Very highly promising for chemistry is the ESCA (electron spectroscopy for chemical analysis) method developed by Swedish scientists. The highest level of accuracy of the determination of the energy of photoelectrons with the aid of magnetic or electrostatic spectrometers makes it possible to separate, when complex compounds or mixtures are irradiated by x-ray quanta, the groups of electrons corresponding to each species of atoms and to ensure on this basis a very sensitive elemental analysis (up to 10^{-9} g). Moreover, it becomes possible to establish in how many chemically different positions the various atoms are situated in the investigated system, and in what ratio these atoms are distributed over the different positions. For example, the ionization potentials of the K electrons of the carbon atoms in the benzene ring and in the carboxyl group differ by almost 5 eV, while the accuracy of determination of the kinetic energy of the photoelectrons knocked out when carbon is irradiated by the K_α lines of Mg or Al reaches hundredths of 1%, i.e., tenths of an electron volt.

The paper describes in less detail the results of mesochemical experiments performed with the synchrocyclotron of the Nuclear Problems Laboratory of the Joint Institute for Nuclear Research in Dubna[6,8], and the prospects of their chemical applications. The main features and the chemical significance of precision observations of x-ray absorption and of emission spectra are described just as briefly.

Finally, the author proposes and describes ways of future investigations of spatial and temporal delocalization of electrons in molecular systems[15]. These involve the use of the Mossbauer effect and measurements of giant magnetic fields produced at the nuclei by a hole in the K shell[16], and are based on a comparison of the angular correlations of the cascade γ quanta with the γ quanta or K-conversion electrons preceding them.

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L. V. Al'tshuler, Progress in High-pressure Physics

The use of strong shock waves as a tool of modern physics has made pressures of hundreds of thousands and millions atmospheres the subject of laboratory investigations. During the last two decades this method has filled to a considerable extent the gap between the experimental region and the region of high-temperature and high-density states amenable to quantitative theoretical calculations. The shock-wave procedure makes it possible to compress and to heat the investigated samples within short time intervals, to determine with high accuracy the compression curves, to record first- and second-order phase transitions, to determine melting curves, and to register the electric, optical and magnetic phenomena in extremal states of matter. The experimental phase of the dynamic methods of determining the compressibility consists of accelerating metallic strikers to high velocities and to measure with precision their velocities and the wave velocities in the target samples. Several methods of smooth acceleration of strikers have been described in the literature: a) acceleration by the explosion products of cylindrical charges, to velocities 0.5—5.5 km/sec, b) acceleration by cumulative charges, to velocities of 8 km/sec (Skidmore, 1962) and acceleration with the aid of helium guns (Jones, USA, 1966). In the Soviet Union, researchers in the field of ultrahigh pressures have developed as far back as in the late forties and in the early fifties sweeping systems for producing pressures of millions of atmospheres, with striker velocities 8—15 km/sec. The attainment of megabar pressures, as shown by a comparison of the publications dates, occurred in our country much earlier than in England and in the USA. To the Soviet Union belongs also the priority in the extensive study of metals having different electronic structures (Krupnikov, Bakanova), optical study of the properties of shock-compressed dielectrics (Kormer, Sinitsyn, Yushko) and investigations of minerals (Trunin). Gandel'man, Dmitriev, and Podval'nyĭ were the first to complete a quantum-mechanical calculation of the energy spectra of compressed metals.

Optical investigations have established that in dielectrics the width of the shock-wave front does not exceed $(2-3)\times 10^3$ Å. At a shock-wave velocity $\sim 5 \times 10^5$ cm/sec, this means that a radical change in the properties of the material takes place within $\sim 10^{-11}$ sec. During these short times the medium is compressed and heated, and in many cases it is melted and its electronic structure altered. The crystallographic aspects of the deformations of the atomic lattice in the front of the shock wave have not yet been fully explained. Its one-dimensional compression is unstable. The transition to three-dimensional deformation and quasi-hydrostatic stressed state is the result of dislocation shifts and displacements at the atomic level. The action of the shock wave produces defects, intermediate donor levels, and a dislocation grid of large density. The motion of the front in a dielectric causes the latter to become polarized.

Shear stresses occurring on the front of a shock wave are powerful catalysts of phase transitions. An example of transitions occurring within $10^{-6}-10^{-8}$ sec are: formation of the ϵ phase of Fe at 130 kbar, the transition of graphite and of BN to the diamond structure, the change of the coordination of KCl and KBr, formation of a superdense modification of quartz in a shock wave, and the occurrence of new phases of minerals. These phases represent, in first approximation, dense anion packings of large oxygen ions, in the voids of which are located small cations of Si, Al, Mg, and other metals. At pressures ~1 mbar there takes place an approximate equality of the equivalent oxygen objects of different minerals and oxides.

The data obtained in the Soviet Union on the compressibility of metals and minerals have made it possible to compare the density of the earth's mantle and core at different depths with their compression curves. It was established that the mantle states agree with the p-ρ plots of ultrabasic mineral rocks, if they contain 12—18% iron oxides. In turn, the earth's core has the density of silicate iron with 10—15% of silicon. The results of dynamic experiments did not confirm the hypothesis that the earth's core is made up of superdense metallic phases of minerals. The questions of the genesis of the earth's core and the distribution of iron in the solar system still remain unanswered.

As shown by experiments on shock compression of more than 50 metals, performed mainly in the Soviet Union, the application of megabar shock pressures leads to a strong smoothing out of the atomic-volume curves. This circumstance points to a large compressibility of elements that have larger atomic volumes under normal conditions. Super-imposed on this general regularity are very substantial singularities connected with the realignment of the electronic structure of the atoms upon compression. The electronic realignment leads to a continuous increase of the elasticity of metals and to the resultant appearance of sharp breaks on the adiabats of the metals. Electronic transformations previously known only for C and Cs were revealed by the shock-wave method for almost all large-period elements of the first five A-groups, i.e., alkali, alkali-earth, rare-earth, and transition metals, occupying the upper positions and the decreasing branches of the atomic -volume curve. Under normal conditions, the atoms of all these elements have unfilled or almost-unfilled internal d-shells. The shift of the external s-electrons to the d-levels causes the formation of denser and less-compressible electronic configurations with an increased number of binding d-electrons. The correctness of the assumed interpretation is confirmed by quantum-mechanical calculations performed in the Wigner-Seitz spherical approximation by the Gandel'man-Dmitriev method.

At the highest shock-compression pressures, and especially in compression of porous bodies, a very important role is played by the thermal components of the energy and of the pressure. It is necessary to distinguish between three temperature ranges: 1. Harmonic-approximation temperatures, at which the thermal contribution to the equation of state is determined by the phonons. 2. Temperatures causing a transition of the atoms and ions from the effectively liquid state to the effectively gaseous state. This transition, which is connected with a decrease of the thermal elasticity of the atoms, is experimentally manifest in the bending of the shock adiabats of porous substances. 3. Temperatures of electron excitation and formation of a high-density hot plasma. The degree of experimental and theoretical mastery of the high-temperature region is demonstrated by the results of investigations of the shock adiabats. The lower sections of the adiabats, up to 10 Mbar and ~60,000°K, have been registered experimentally for many metals. Their thermodynamic characteristics were also calculated by quantum-mechanical methods. The region above 100 Mbar is calculated in accordance with the quantum-statistical theories, while the intermediate intervals are reliably interpolated. Of particular interest to solid state and liquid state physics is the optical registration of the melting curves of a number of transparent dielectrics at pressures 0.5—1 Mbar and temperatures 3,000—5,000°.

The immediate purposes of high- and ultrahigh-pressure physics are to extend the research to new classes of organic and inorganic compounds and to determine the fundamental crystal-chemical laws governing the formation of dense high-pressure phases. Particular attention on the part of both experimenters and theoreticians should be paid to the problem of the transition of dielectrics into the metallic state. Of large scientific and practical significance is the study of the mechanisms of phase transformations and chemical reactions in strong shock waves, and the investigation of the electrical, optical, and magnetic phenomena accompanying the shock compression. One should expect interesting results to be obtained from a study of the expansion of bodies compressed by strong shock waves.

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V. B. Braginskiĭ, Detectors of Gravitational Radiation.

The article discusses the present status of searches for gravitational radiation of extraterrestrial origin. A review is presented of the results obtained in the experiments of J. Weber, and the difficulties in the interpretation of his experimental data are considered. The prospect of increasing the sensitivity of gravitational-radiation detectors are considered, especially detectors of the heterodyne type.

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A. G. Masevich, A. M. Lozinskiĭ, and V. E. Chertoprud, Special Astronomical Observations of Artificial Celestial Bodies for Problems of Geophysics and Geodesy and in the New Large Soviet Telescope for these purposes

Accurate photographic observations of artificial earth satellites, carried out from many stations in accordance with special programs, are used sucessfully to investigate the density of the upper layers of the atmosphere and its variation as a function of the activity of the sun, to solve problems in cosmic geodesy on the basis of simultaneous observations from several stations, and to determine more accurately the earth's figure by determining the higher-order terms in the expansion of the earth's potential. This work has been carried out by the Astronomic Council of the USSR Academy of Sciences since 1957 on the basis of a specially created network of observation stations, which recently have been greatly expanded by adding stations in the African continent.

A new high-accuracy astronomical installation, specially intended for the observation of satellites, has been created in the USSR and comprises at present the largest telescope capable of following a satellite and registering the instant of observation accurate to 1 msec. This telescope is located at the Zvenigorod station of the Astronomic Council and is presently being readied for operation.

The Astronomic Council is performing statistical studies of the fluctuations of the parameters of the upper atmosphere and of the structure of the absorption bands of the variable radiation from the sun.

A. I. Nikishov and V. I. Ritus, Interaction of Electrons and Photons with a Very Strong Electromagnetic Field.

A characteristic value of the intensity of the electromagnetic field in quantum electrodynamics is

$$B_0 = m^2c^3/e\hbar = 4{,}4\cdot 10^{13}\ \text{э}.$$

At the Compton wavelength, such a field performs work equal to mc^2 (we use $\hbar = c = 1$). The parameter B_0 is characteristic of nonlinear quantum-electrodynamic effects (for example, the passage of an electron through a potential barrier, pair production by an electric field in vacuum), which reach their optimal values in fields of the order of B_0. Unfortunately, the intensities of the existing fields are weaker than B_0 by many orders of magnitude, and therefore the probabilities of many effects are exponentially small and incapable of being observed. It is possible, however, to observe certain nonlinear quantum effects also at fields of intensity $B \ll B_0$, by using an ultrarelativistic particle with momentum $p \sim m(B_0/B)$. Then, in the particle rest system, the intensity of the field will be of the order of B_0 and the probability of the process becomes optimal. Regardless of the type of the field in the laboratory system, in the particle rest system it will be very close to the field of a plane wave, for which $\mathbf{E} \perp \mathbf{H}$ and $E = H$. As a result, the probabilities for an ultrarelativistic particle in a constant field will depend on a single invariant parameter

$$\chi = [(F_{\mu\nu}p_\nu)^2]^{1/2}/B_0 m,$$

equal in order of magnitude to the field in the proper system, and referred to B_0 or Bp_0/B_0m; the dependence on purely-field invariants that are small compared with 1 and χ can be neglected. The probabilities $W(\chi)$ describe exactly the processes in a constant crossed field ($\mathbf{E} \perp \mathbf{H}$, $E = H$) and approximately those in an arbitrary constant field; the degree of approxima-