CURRENT HIGH ENERGY DENSITY PHYSICS ISSUES IN SCIENCE AND TECHNOLOGIES

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High energy density physics (HEDP), one of the areas in applied scientific research, actually, emerged in the 20-th century. Development and enhancement of its capabilities are in progress. Beginning of this way was marked by the findings of singularities and processes in mechanics. First of all, it should be emphasized that the HEDP research area has not been clearly defined yet, for example, as compared to the research in conventional physics areas (mechanics, thermodynamics, fluid dynamics, statistical physics, quantum mechanics, etc.). The definition of this research area is conditional. It is based on two concepts. The first one is energy, being the most critical feature used to characterize the state of physical systems. Conservation of the state in closed systems is directly caused by the uniformity of the physical dependences on time. The second concept uses a qualitative characteristic of the high energy density level, which makes compression of dense matter in normal conditions, a possible phenomenon. Arriving at this level of investigations was not easy. One can consider, conceptually, that without singularities of the physical laws it was impossible to pass this way.

Gravity field was the first among these singularities. It was not discovered at once. Moreover, the scale and importance of this singularity were underestimated for some time after the discovery. They have not been completely understood yet. This deals with the gravity fields of the Earth, the Sun, and other planets. A long and difficult way of the human civilization in science began from the experiments by Galileo. It went on by the execution of Giordano Bruno, building of the Solar System model by Copernicus, induction of the laws for the planet orbits by Kepler, estimation of the Comet Halley flight, up to the advanced models of the space flight dynamics, models of galaxies and the Universe.

The next one deals with the development of continuum mechanics and some other associated areas of physics (thermodynamics, statistical physics, etc.). This list is to be continued by the emerging areas of physics research: classical field theory and electrodynamics, nuclear physics and quantum mechanics, electrodynamics of continuous medium and quantum electrodynamics, quantum field theory. Formation of these areas in physics was accompanied by rapid development of both production and research technologies. Discoveries of electron, atomic nucleus, neutron, radioactivity, U-235 fission, artificial nuclei transformations… Among numerous technological discoveries, discovery of condensed explosives seems to be remarkable. Along with the scientific discoveries, people created mechanisms, various locks, clock mechanisms, code systems. Concurrently, different types of machinery: steam engines, electrical generators, and electrical machines, combustion engines, jet-turbine and jet-propulsion engines, different types of nuclear reactor facilities were invented.

In the course of this development, different types of singular processes emerged. A cumulative process produced by stockwhip is the first illustration. But the bubble collapse in the incompressible fluid (the problems of Bunsen (1859) and Rayleigh (1918)) is the first in the series of the investigated singularities. Finding of the self-similarity properties of their solutions was critical for the singular phenomena studies. A self-similar converging shock wave and a hollow shell, cumulative jets produced by plane or conical claddings in chemical high explosives (HE) of appropriate configurations are well-known singular processes. Self-similar problems of a centered compression wave are urgent for the problems with the energy flux laser amplification.

In conclusion, note two types of the HEDP problems. The first one deals with expanding the fields of application of non-analog mathematical simulation for the problems with the nuclear energy release density, for example, inside the nuclear reactor in operation. The second one is associated with the response of a small asteroid Dimorphos approaching the Earth (characteristic dimensions ~170мм) to an impact by a space module (mass 500kg) with the asteroid surface. The estimated released energy was considerably superior to the energy of kinetic impact.