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XI International Vavilov conference on nonlinear optics (Akademgorodok, Novosibirsk, 24 – 28 June 1997)

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According to the tradition established by Academician R V Khokhlov, the programs of the Vavilov Conferences are drawn up from review lectures on topical problems of modern optics, though small in number. The subject-matter of the XI Vavilov conference, held after a 7-year recess, included the following themes: nonlinear interference effects in multiphoton processes occurring in atomic and molecular gases; nonlinear phenomena in light guides, heterostructures and clusters; optical orientation of atoms and polarization spectroscopy; atomic optics and coherent transient processes. These problems, rather dissimilar in concrete physical processes and objects, have many features in common which are representative of such fundamental concepts as the coherence of oscillations and waves. The dominance of a coherence notion in modern optics and physics as a whole was discussed in the opening address of the conference.

I would like to elaborate here on one reason which does not seem to me to lack a common physical meaning. I guess that everybody will go along with the opinion of progress in detailing and specification scientific research as one of the most conspicuous trends in optics, physics and science. This individualizing inevitably follows the extension of our knowledge. Against the background of these trends one can put a natural question: is it possible to point at or distinguish some globally dominating and consolidating idea that would run through the whole of modern optics and might also affect the entire current physics? I shall elucidate my question by recalling several facts from the history of physics. Mechanics constituted the major part of physics in Newton's days and for one hundred years afterwards. The deterministic doctrine, the idea of a close connection between forces and motion served as the main guiding principle which formed the world perception, attitude, philosophy, and intuition of scientists. Within the XIX century a novel idea, to a certain extent an antipode to determinism, was strengthened as a global one, namely, the idea of stochastic, random processes and regularities. The grandiose building of statistical physics was raised on the foundation of this idea. Quantum physics came into force in the XX century with its global idea of quantization of stationary states of physical systems, which radically altered our concept of the structure of the Universe. I do not set myself the object of analyzing all the major general ideas and their evolution. I cited several instances here only to elucidate the kind and importance of ideas the above question touches upon in. Thus, has a fresh global concept or doctrine of similar scale and comparable importance arisen during the last 70 years, i.e. since 1928 when the combination scattering of light (Raman effect) and hyperfine splitting of spectral lines had been discovered and the skeleton of quantum physics had been for the most part set out? I believe that we live and work in an epoch when a modern idea – doctrine is forming and strengthening in the hypostasis of a global one and it calls for a transformation of our general physical thinking, our intuition and the physical picture of the world. This idea is known as COHERENCE. I shall adduce several arguments in favor of this opinion. The notion of coherence (or its equivalents) is fairly long-lived but the first really important and major breakthrough in its application was due to Augustin Jean Fresnel [1]. We are indebted to the genius of Fresnel for developing novel wave optics on the basis of the principle of interference. Fresnel's work on the problems of optics lasted for a short period roughly between 1817 and 1827. Academician G S Landsberg defined the results of this work as follows: ''Optics was transformed when Fresnel's activity ceased due to his illness and death at the close of that decade'' [1]. Fresnel's success did not combine optics with other divisions of physics under the banner of a general idea; this success rather removed and distinguished optics and added some particular status to it. With its global concepts of coherence and interference, optics still stood aside from the rest of physics for 150 years. It goes without saying that coherence figured locally in acoustics, radiophysics, and quantum mechanics. Nonetheless, the doctrine of coherence was not a uniting global one for the whole of physics for a century and a half after Fresnel's untimely decease. And now, in 1997, this fact can be easily understood and clarified: the material 'coherence carrier' or 'coherence source' did not exist at the time, i.e. an instrument whereby coherent states of substance could be intentionally generated. That instrument, that source of coherence, as we all are well aware, emerged in 1960 in the form of coherent laser radiation. Changing a laser frequency enables us to tune to any quantum state. Due to its high power, the coherent radiation wins over stochastic tendencies and creates highly-concentrated coherent physical states in gases, liquids, solids, and plasma, as well as attacking all the degrees of freedom — single-particle and collective, translation and rotation, electronic and nuclear. It is common for the laser to be defined as a source of coherent radiation, with an emphasis laid

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implicitly on the word 'radiation' and 'coherent' being kept in the shade to a degree. But I accentuate coherence and say: "the laser is a source of coherence and this assertion is principal in terms of general physics". I shall illustrate the difference with the aid of an obvious but hackneyed case. The chisel in the hands of a sculptor may be defined as an instrument for breaking off small pieces of marble from the boulder whilst at the same time one may say that a chisel is an instrument for removing all the unnecessary parts and sculpting a harmonic and beautiful statue. In my opinion, the concept or doctrine of coherence has begun to reach the foreground over the last decade. It has been converted from a particular local argument into an ideology or global guiding principle with a common physical meaning. Beside these general considerations partly cited above, our impression gains substance from numerous studies of coherent effects in nuclear physics, atomic and molecular physics, the physics of condensed matter, and plasma physics, both in the laboratory and in natural conditions. I believe that the next decade will pass under the badge of widening and extending the concept of coherence as the doctrine of a common physical meaning. And this doctrine will influence our physical thinking, our intuition and present view of the potential of science. Hopefully, when popularizing the coherence doctrine I am guided not by the patriotism of an orthodox optical physicist but by objectively established circumstances in the scientific world. As many of us remember, the period of the fantastically wide and fruitful applications of lasers in science, engineering, industry, private life, medicine, etc. began approximately 20 years ago. In 1977, I ventured to advance a witty slogan: "Lasers can do everything!" at a seminar here, at the Akademgorodok [2]. It can be imagined that we are reaching a new stage of the so-called 'laser revolution', when laser sources make it possible to obtain a wealth of concrete results as before, but further more (and, possibly, owing to this!) they actively form a new ideology for the physicist by promoting the doctrine of coherence. I guess that it is pleasant for everyone to realize their participation in so important and interesting a period in the progress of physics. From the viewpoint the implications of conference for physics and optics, it is significant that the present XI Vavilov Conference is being held at the threshold of a new stage of the 'laser revolution', namely, the stage of deepest penetration of the coherence concept into the numerous and various branches of physics. And this trend, as I believe, is of importance for physics as a whole.

References

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