Scientific Session of the Division of General Physics and Astronomy, USSR Academy of Sciences (17-18 January 1973)

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A scientific session of the Division of General Physics and Astronomy was held on January 17 and 18 at the conference hall of the P. N. Lebedev Physics Institute. The following papers were delivered:

1. K. I. Gringauz, The Formation of the Plasmapause and Its Influence on the Physics of the Earth's Ionosphere.

2. I. A. Zhulin, Dynamics and Physical Nature of Particles According to Coordinated Studies in the Magnetically Conjugate Regions.

3. A. D. Sytinskiĭ, The Relation of the Earth's Seismicity to Solar Activity.

4. N. D. Devyatkov, Influence of Millimeter-Band Electromagnetic Radiation on Biological Objects.

5. É. B. Bazanova, A. K. Bryukhova, R. L. Vilenskaya, E. A. Gel'vich, M. B. Golant, N. S. Landau, V. M. Mel'nikova, N. P. Mikaélyan, G. M. Okhokhonina, L. A. Sevast'yanova, A. Z. Smolyanskaya, and N. A. Sycheva (General Editor: N. D. Devyatkov), Certain Methodological Problems and Results of Experimental Investigation of the Effects of Microwaves on Microorganisms and Animals.

6. L. A. Sevast'yanova and R. L. Vilenskaya, A Study of the Effects of Millimeter-Band Microwaves on the Bone Marrow of Mice.

7. A. Z. Smolyanskaya and R. L. Vilenskaya, Effects of Millimeter-band Electromagnetic Radiation on the Functional Activity of Certain Genetic Elements of Bacterial Cells.

8. V. F. Konrat'eva, E. N. Chistyakova, I. R. Shmakova, N. B. Ivanova, and A. A. Treskunov, Effects of Millimeter-band Radio Waves on Certain Properties of Bacteria.

9. S. E. Manoĭlov, E. N. Chistyakova, V. F. Kondrat'eva, and M. A. Strelkova, Effects of Millimeter-band Electromagnetic Waves on Certain Aspects of Protein Metabolism in Bacteria.

10. N. P. Zalyubovskaya, Reactions of Living Organisms to Exposure to Millimeter-band Electromagnetic Waves.

11. R. I. Kiselev and N. P. Zalyubovskaya, Effects of Millimeter-band Electromagnetic Waves on the Cell and Certain Structural Elements of the Cell.

12. V. I. Gaĭduk, Yu. I. Khurgin, and V. A. Kudryashova, Outlook for Study of the Mechanisms of the Nonthermal Effects of Millimeter- and Submillimeter-band Electromagnetic Radiation on Biologically Active Compounds.

We publish below brief contents of some of the papers and an outline of remarks offered in discussion by D. S Chernavskiĭ.

N. D. Devyatkov. Influence of Millimeter-band Electromagnetic Radiation on Biological Objects

The development of microwave electronics is attended by steadily widening opportunities for use of its achievements not only in the areas that are traditional for it (transmission and reception of various types of information), but also in new areas, such as biology and medicine.

Study of the possible uses of coherent electromagnetic oscillations in recently opened bands has now acquired special importance. We refer here to the millimeter and submillimeter wavelength bands and shorter-wavelength regions of the electromagnetic spectrum—those in which lasers are now operating.

The present scientific session of the Division of General Physics and Astronomy, USSR Academy of Sciences, to which specialists working in the fields of biophysics, microbiology, biochemistry, and medicine have been invited, is devoted basically to experimental study of the effects of exposure of various biological objects to millimeter-band electromagnetic fields, on the molecular and cellular levels and at the level of more complex living organisms.

Several years ago, organizations of the USSR Ministry of the Electronics Industry and the Institute of Radiophysics and Electronics of the Ukrainian Academy of Sciences (Khar'kov) completed the development of millimeter- and submillimeter-band generators of the backward-wave-tube type, which make possible a broad range of continuous frequency variation of the waves generated. Special machines for biological studies were built on the basis of the newly developed millimeter-wave generators. Beginning around 1965, a number of organizations in the USSR began systematic research on the effects of millimeter waves on biological objects.

Experimental studies made in the millimeter band at very low microwave energy flux densities (no more than a few milliwatts per square centimeter) produced highly interesting specific effects of irradiation. It was found for almost all of the biological objects studied that:

a) the effect of irradiation depends strongly on the frequency of the microwaves;

b) in certain microwave-power ranges, the effect of exposure depends weakly on variation of the power through several orders of magnitude;

c) the effects are observed to depend significantly on time of irradiation.

The results obtained are of great scientific and practical interest. For example, it was established that the vital activity of microorganisms is affected by millimeter-wave irradiation. The effect may be positive or negative, depending on the particular part of the band and the particular conditions of irradiation.

The effects obtained on irradiation of microorganisms may eventually form a basis for new methods of producing vaccines and increasing the productivity of antibiotic-production methods. Another possibility that had not been excluded is that of millimeter-wave irradiation to treat burns and other suppurating wounds in order to accelerate the healing process.

Using as an example one of the studies that we made jointly with K. S. Rozhnov and his staff at the Leningrad Electrical Engineering Institute, I should like to demonstrate graphically the strength of the effect of millimeter-wave electromagnetic irradiation on cell division. A machine for irradiation of microorganisms and direct observation of their behavior during and after irradiation was designed around an MIS-51 comparison microscope.

Various yeast cultures were irradiated. A resonant effect of millimeter-wave irradiation on the division rate of the cells being irradiated was observed. Thus, for example, irradiation of a culture of Rhodotorula rubra for 15 hours at wavelengths of 7.16, 7.17, 7.18, and 7.19 mm (10 experiments were performed for each frequency), showed a sharp frequency dependence (Fig. 1; the ordinate is the ratio of the number of cells in the experiment to the control): cell division is stimulated at 7.18 mm and slightly depressed at the other wavelengths.

Irradiation of a Candida culture caused a marked change in the nature of cell division as compared with the control. Figures 2–4 show clearly the difference between control and experiment at various stages during irradiation.

Figure 5 illustrates the behavior of irradiated and unirradiated (control) cultures after about 15 hours of irradiation (which was administered at 20–21°C. After the 15 hours of irradiation, the culture temperatures were about 16–17°C).

An explanation of the mechanism of the resonant effect of irradiation and some of its other properties would be of enormous interest from the scientific standpoint. As yet, we have no rigorous scientific explanations for the effects of millimeter-band electromagnetic waves. There have been only a few attempts to develop approximate hypotheses to account for the resonant effect, and they require further experimental and theoretical confirmation.

It would be desirable to have scientific manpower at the institutes of the Division of Biochemistry, Biophysics, and Chemistry of Physiologically Active Compounds of the USSR Academy of Sciences put to work on a scientific explanation of the observed phenomena.

In addition to the scientific groundwork, a more active search should be made for fields of practical application of the effects of millimeter-wave irradiation. In this matter again, we look for assistance to the competent specialists at the Institutes of the USSR Academy of Sciences.

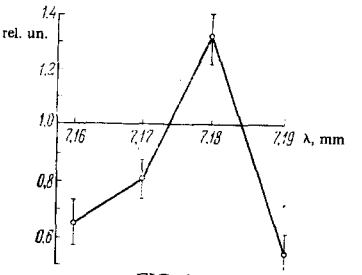

FIG. 1

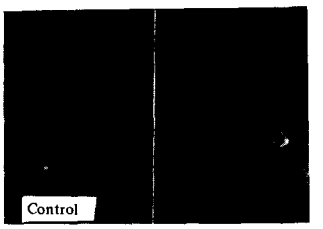

FIG. 2

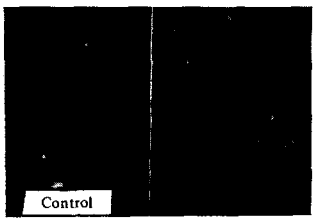

FIG. 3

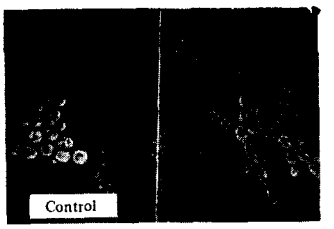

FIG. 4

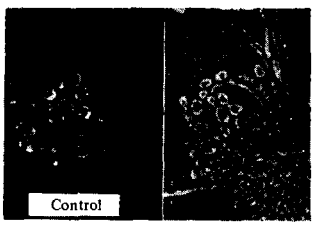

FIG. 5

É. B. Bazanova, A. K. Bryukhova, R. L. Vilenskaya, É. A. Gel'vich, M. B. Golant, N. S. Landau, V. M. Mel'nikova, N. P. Mikaélyan, G. M. Okhokhonina, L. A. Sevast'yanova, A. Z. Smolyanskaya, and N. A. Sycheva (General Editor: N. D. Devyatkov), Certain Methodological Problems and Results of Experimental Investigation of the Effects of Microwaves on Microorganisms and Animals

1. Research methodology problems and general relationships

Since this was the first time that we had worked in the millimeter band, we began by giving serious attention to problems of the experimental method. A diagram of the experiment appears in the figure. The effects of frequency, power flux density, exposure time, ambient temperature, and the identity of biological conditions were investigated in detail and recorded. The polarization was held constant through all experiments. All were performed with continuous irradiation.

It was found in the course of the experiments that the observed effects are not very critical in regard to the incident power flux density. In particular, it was established for a wide variety of microorganisms and tests that, beginning at a certain threshold power flux density of about 0.01 mW/cm^2, the effects vary weakly over several (two and five) orders of magnitude when a marked thermal effect is already beginning to make its appearance. We note that heating by other sources did