Istituto Nazionale di Fisica Nucleare
LABORATORI NAZIONALI DI FRASCATI

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Report

on the thesis by Anush Sargsyan titled "Some Features of Electromagnetic Radiation in Spherically Symmetric Media" presented for the degree of Candidate of Physical and Mathematical Sciences in Specialization A.04.07- Condensed Matter Plasma

As known, the presence of media can significantly influence the properties of the electromagnetic field generated by charged particles that results in the formation of various types of radiation, such as Cherenkov Radiation (CR), transition radiation, diffraction radiation, etc. Research carried out in various scientific centers, as well as at IAPP NAS RA, over the past three decades, have been proving that the influence of the boundaries of media with cylindrical and spherical symmetries on the characteristics of the electromagnetic field created by relativistic charged particles moving along different trajectories can be significant, revealing in some well-defined cases, resonant features. The problems addressed in the dissertation represents further research in this area.

Introduction contains an overview of articles on the research topic. The practical significance, generalization of the results obtained, as well as the content of all chapters are also briefly described.

Chapter 1 is devoted to the study of oscillations of the electromagnetic field created by a charged particle normally crossing the flat boundary of a conducting semi-infinite medium with a vacuum, including the case when a charged particle crosses a plane-parallel plate and generates electromagnetic oscillations on both surfaces of the plate. The novelty of the work lies in the fact that it considers (a) a plate of microscopic thickness and (b) frequencies, for which the dispersion of the dielectric constant is important, and the real part of the dielectric functions of the plate material and the semi-infinite one is negative. The results of theoretical studies of both the

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spectral and angular distributions of radiation emitted by a train of electron bunches crossing a dielectric ball were also studied. Numerical examples are given for a dielectric fused silica ball. It is shown that at certain values of the parameters, strong peaks appear in the spectral-angular distribution of radiation intensity. The peaks heights for the spectral density of the emitted energy increase significantly when the repetition frequency of the bunches in the train becomes equal to the corresponding resonant frequency of the ball.

In **Chapter 2,** considering the dispersion of electromagnetic waves inside the ball material, studying the phenomenon of scattering of a plane electromagnetic wave on a no magnetoactive conducting ball is presented. The solution of fundamental equations characterising the propagation of electromagnetic waves in an inhomogeneous spherically symmetric medium is presented when the parameters of the medium depend on a single variable, i.e. the radial coordinate. Analysis is based on the corresponding exact analytical solutions of Maxwell equations via the expansion of the vector potential of electromagnetic field over the spherical functions. The solutions are based on the Green function method.

In **Chapter 3** the angular distribution of the "resonant" radiation from a charged particle uniformly rotating along an equatorial orbit around dielectric and conducting balls in the gigahertz and terahertz frequency ranges is studied. The numerical examples are given for a dielectric ball made of either strontium titanate, melted quartz or teflon. It is shown that for some parameters and in the case of weak absorption in the ball material, the radiation intensity on a given harmonic can be essentially larger than that for the same charge rotating in the vacuum or in a homogeneous transparent medium characterising by the real part of dielectric permittivity equal to that of the ball material. At a certain (resonant) frequency of rotation of the particle and at small distances from the surface of the ball, localised oscillations of the electromagnetic field of large amplitude can be generated on a given harmonic inside the ball. Moreover, at large distances from the particle trajectory, these localised oscillations are accompanied by intense radiation on the same harmonic, which is many times more intense than

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the similar radiation at the ball absence. The possibility of practical applications of that phenomenon is discussed.

Chapter 4 considers a problem related to Strong Shock Waves (SSW) delivered by acoustic anti-hail "cannon". According to ground-based observations the propagation of directed SSW in atmosphere is followed by very low frequency electromagnetic radiation in the range 2 − 5kHz and a lower frequency acoustic signal (≈ 1kHz). It is shown that the propagation of directed SSWs in the atmosphere should be also accompanied by radio frequency electromagnetic radiation in the 1-2 MHz range because charged particles circulate in the presence of the Earth's magnetic field, emitting synchrotron radiation. It is also shown that it becomes possible to record the radiation just after forming the shock wave. It happens in a short time interval, when the characteristic size of the front of the directed shock wave is smaller than the wavelength of electromagnetic radiation.

To summarize, I can conclude that the dissertation represents a fairly complete study, and Anush Sargsyan demonstrated knowledge and understanding of the topic. The main scientific novelty of the study is the discovery of the possible resonant influence of the spherically symmetric boundary of the medium on various electromagnetic processes. Research may contribute to the creation of sources of high-intensity monochromatic electromagnetic radiation with controllable characteristics in the gigahertz frequency range.

My comments on the content of the dissertation are as follows:

1. In problems involving a dielectric ball, I think the study will be even more complete if to consider the dependence of the dielectric constant on frequency (dispersion). This may lead to the emergence of new unique phenomena, the study of which is of special interest.

2. I think, evaluating problems for other geometries, for example, for an ellipsoid, can enrich the understanding of the processes being studied.

3. In a few places, the thesis contains minor grammatical errors and typos.

However, my comments do not have a negative intent and can be seen as suggestions for further research. The thesis meets the requirements of the Supreme Certifying Committee of the

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Republic of Armenia for theses for the scientific degree of Candidate of Physical and Mathematical sciences. The results obtained in the dissertation are fully presented in publications. The abstracts fully reflect the content of the thesis.

Based on the above, we can conclude that Anush Sargsyan is worthy of being awarded the degree of Candidate of Physical and Mathematical Sciences in specialization A.04.07 – "Condensed Matter Plasma".

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