Open system for measuring the chemiluminescence of crop seeds

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ABSTRACT

The theoretical analysis of the open electrodynamic system, which is a symbiosis of an open resonator and a segment of a rectangular waveguide, is carried out in the work. It is shown that the transverse dimensions of the waveguide made at the center of one of the mirrors of the open resonator are uniquely determined by the geometric parameters of the resonator and the working wavelength. In this case, the maximum efficiency of excitation of the main wave TE_{10} *in a rectangular waveguide with the help of the fundamental oscillation of the open resonator* TEM_{00q} *is 88%. As it turned out, in this case the normalized transverse dimensions of the waveguide are oversized, and the considered system can be used to measure the ultra-weak luminescence of seeds of grain crops*

To measure the chemiluminescence of sunflower seeds, the cuvette should be irradiated with an electromagnetic field (EMF). In the millimeter wavelength range for these purposes, it is advisable to use resonators, since single-mode waveguides have small transverse dimensions. However, a number of difficulties arise here. The placement of a cuvette with seeds in a resonant volume will result in a frequency shift. In this case, when tuning the frequency of the master oscillator in the resonator, another type of oscillation can be excited, which in the end distorts the measurement results. Therefore, a cavity resonator should have a single-frequency response in order to avoid ambiguity in the measurement. On the other hand, since the quality factor of the excited oscillation is determined by the energy stored in the resonant volume, in a mm range, single-mode volume resonators should have a low factor because of their small geometric sizes and ohmic losses in the walls. In addition, placing a measured object in a resonant volume can in general lead to disruption of oscillations. Therefore, in the range under consideration, to conduct studies on the effect of EMF radiation on seeds, it is necessary to proceed to resonance system, which are adequate to this range - open resonators (OR) 1. But here there is another problem. As a rule, OR have an axially symmetric form with localization of the oscillation field near the axis. And for carrying out measurements of a cell with seeds, each time should be placed in an area with the same EMF intensity. In the case of traditionally used ORs, this presents a complex technical challenge. Therefore, it is necessary to carry out an analysis of an open electrodynamic system that will allow measuring super-weak luminescence of seeds of grain crops.

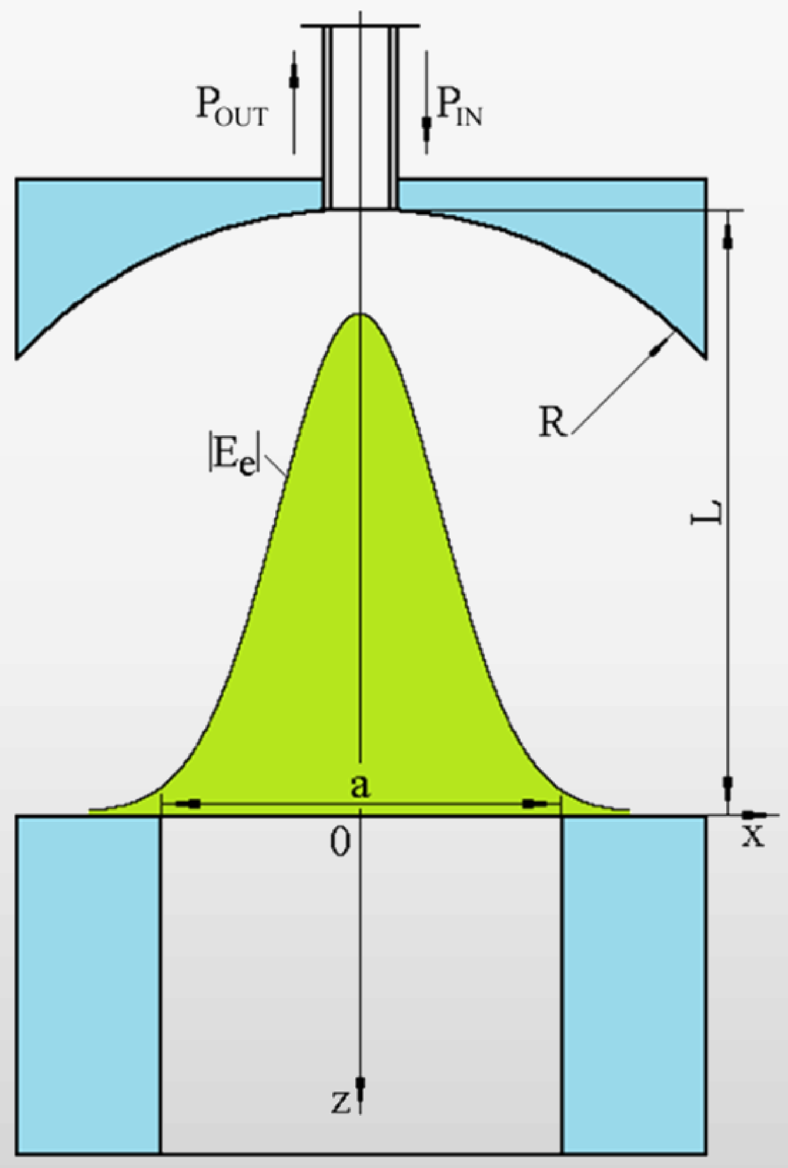

Figure 1. A hemispherical OR with a segment of a rectangular waveguide.

A distinctive feature of such ORs is their geometric dimensions, which significantly exceed the working wavelength. In addition, communication with external space provides additional spectrum selection. The task of measuring super weak luminescence of seeds with the help of OR is similar to the problem of determining the electrophysical properties of various materials. In the mm range, as a rule, only plane samples are investigated, which are located perpendicular to the axis, either on the surface of one of the mirrors or in the waist region, where the phase front of a Gaussian beam is flat. In this case, the fundamental mode TEM_{00q} is excited in the resonance volume. In this situation, the study of cylindrical samples can be carried out only when they are placed along the axis of the resonator, so as not to violate the axial symmetry of the system. And since the EMF intensity for the considered type of oscillations is maximal just on the axis of the OR, the arrangement of the extended sample along the axis will lead to the disruption of the oscillations. A similar situation will occur in the study of a cell with seeds. On the other hand, a cuvette with seeds will lead to a shift in the resonant frequency. Therefore, the OR should provide additional spectrum selection. For this purpose, diaphragms, wire diffraction gratings are used. However, they do not solve the problem of investigating a cuvette with seeds, which should be placed in a region with the same EMF voltage and do not lead to strong disturbance of the OR oscillation.

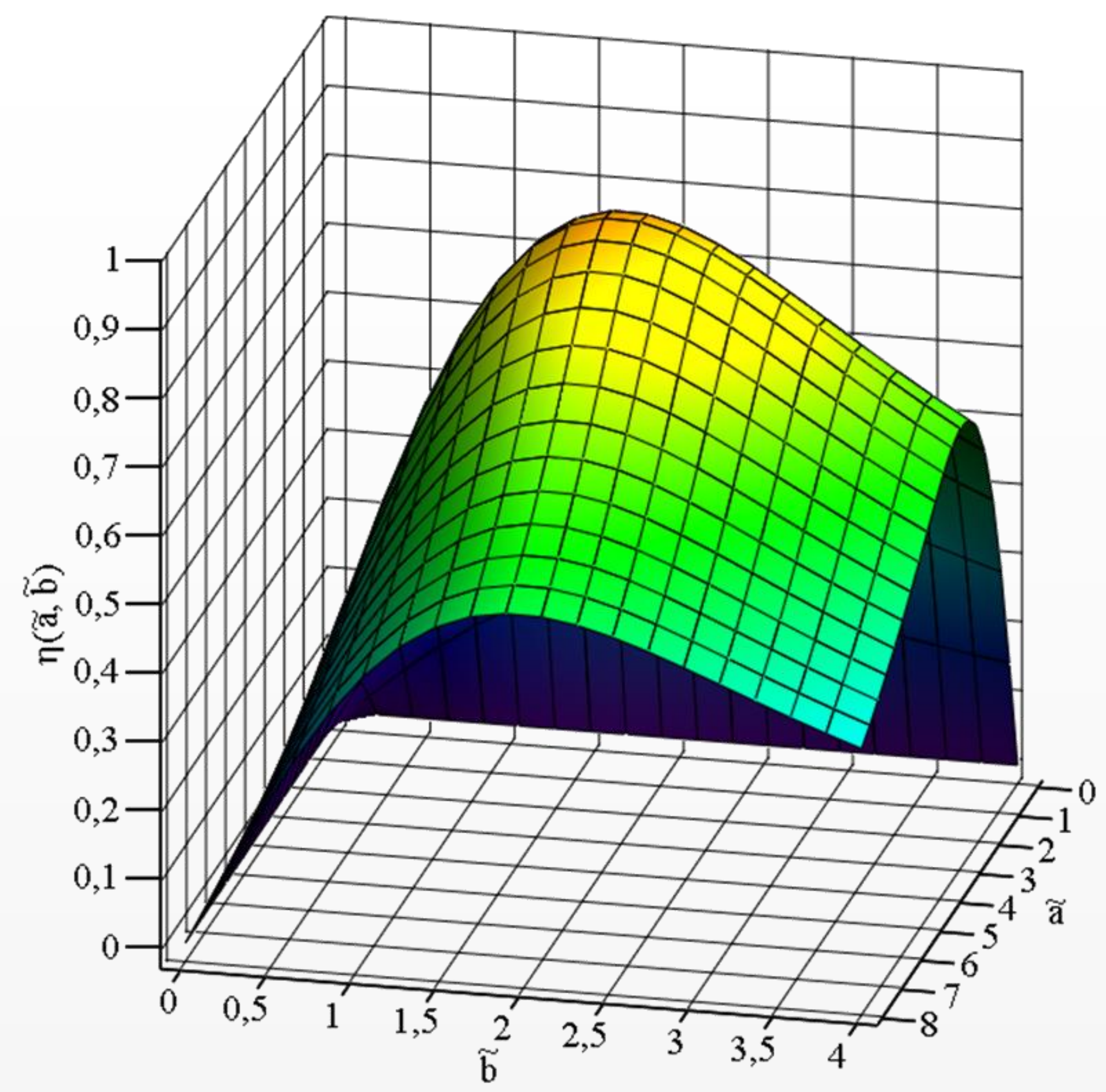

Figure 2. Efficiency of excitation of a TE_{10} wave in a rectangular waveguide with a change in its transverse dimensions.

CONCLUSIONS

The conducted studies showed that in the segment of a rectangular waveguide made at the center of one of the mirrors OR with an efficiency of ≈90%, the main waveguide wave is excited by means of the oscillation TEM_{00q} OR. Since almost all the power goes into exciting this wave, then such an open electrodynamic system must have a single-frequency response in a wide frequency band.

In this case, the waveguide itself is oversized with transverse dimensions of $\tilde{a} = 2.844$ and $\tilde{b} = 1.980$. Therefore, such a system is ideally suited for measuring super-weak luminescence of seeds of grain crops when they are irradiated with EMF mm range. In addition, taking into account the transverse dimensions of the waveguide, the problem of placing a cell with seeds in a region with the same EMF intensity is solved quite simply.