Conference Paper

Registration of CBS Effects from Wedge-shaped Samples Containing Particles of Alumina

Sh. M. ISMAILOV[1,2] and V. G. KAMENEV[2]

[1]National Research Nuclear University MEPhI (Moscow Engineering Physics Institute), Kashirskoe shosse 31, Moscow, 115409, Russia
[2]N. L. Dukhov All-Russian Scientific Research Institute of Automatics
Address: 22, Sushchevskaya St., Moscow, 127055, Russian Federation

Abstract

The paper looks at recent results of research dealing with a coherent backscattering (CBS) on the particles of alumina. It was developed a system of registration of CBS with a tunable dynamic sample. During the experiment the transport mean free path over the width of the peak of angular profile of signal intensity of CBS was determined. Moreover, new scientific data about the CBS's profiles from randomly inhomogeneous environments were obtained.

Corresponding Author:
Sh. M. ISMAILOV
shamil.ismailov.1995@list.ru

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1. INTRODUCTION

Nowadays, there is a huge interest in research of light distribution and scattering in inhomogeneous disordered environments. Passing through an inhomogeneous disordered environment, a coherent beam loses its coherence properties due to multiple scattering. However, contrary to the dissipation, which causes a random wave phase change, there are various effects, in which a coherence and interference characteristics appear. Currently the effects of coherent backscattering (CBS) have been studied intensively[1].

The phenomenon of coherent backscattering of light consists of a sharp increase of the intensity of light is strongly dissipated by inhomogeneous environment at a small solid angel. The direction is opposite to the direction of light [2].

The results of measurements of the coherent backscattering profile from a dust cloud enable to solve the problem of determinating the scattering coefficient of a dispersed environment and the characteristic size of the inhomogeneities of the environment [3].

2. METHODS

A disadvantage of majority of CBS registration systems is the impossibility of smooth adjustment of the thickness of the sample a dispersed environment. The thickness of the sample is controlled by changing the number of discrete layers. A smooth adjustment of the thickness of the sample makes it possible to provide greater efficiency and informative nature of ongoing researches and this adjustment allows specifying the influence of dispersed medium on the peak of coherent scattering [4–6].

The purpose of this research work is a development of a coherent backscattering (CBS) registration system with a tunable dynamic sample, which is intended to be further used to detect a signal from dispersed media of various thicknesses.

During the analysis process of these solutions, applying of 3D modeling has been selected as the most optimal and functional version. There has been developed a specified scheme for selected version. Afterwards, a dynamic sample with a smooth adjustment of probed layer thickness which admits to simulate dust layers with diverse thickness and concentration has been generated.

In Figure №1 A scheme of the experimental installation for registration of coherent backscattering (CBS) in dispersed environments is illustrated.

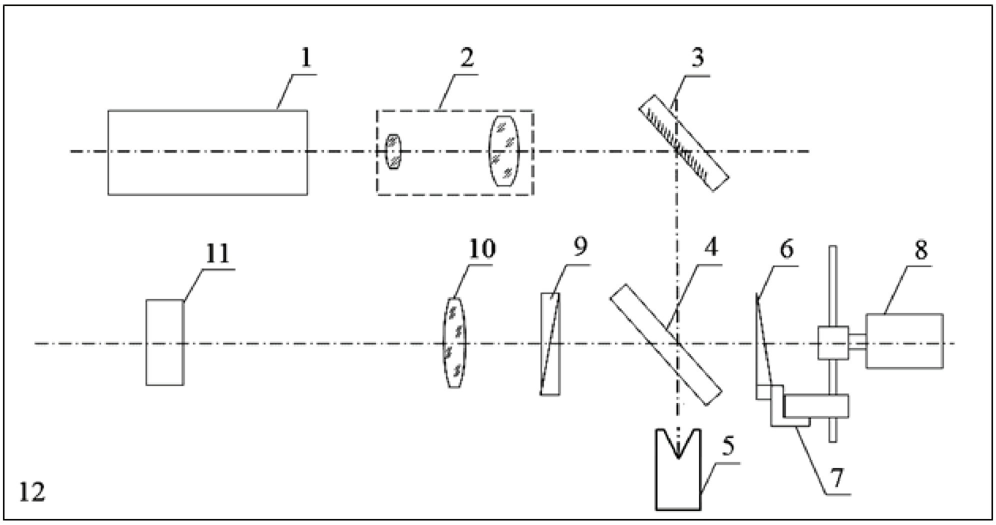

Figure 1: A schematic optical diagram of static installation. 1 - laser illuminator; 2- telescope; 3- mirror; 4 - semitransmitting mirror; 5 – absorber; 6 - wedge-shaped sample; 7 – plate; 8 – motor; 9 – polarizer; 10 – lens; 11- registrar; 12 – optical plate.

A ray emanating from the illumination laser 1 enters to the telescope 2 where the divergence and the width of laser ray are regulated. Mirror 3 rotates the beam 90 degrees. A semitransparent mirror 4 directs the radiation to the object and passes through radiation scattered from the wedge-shaped sample 6 which is moved by a

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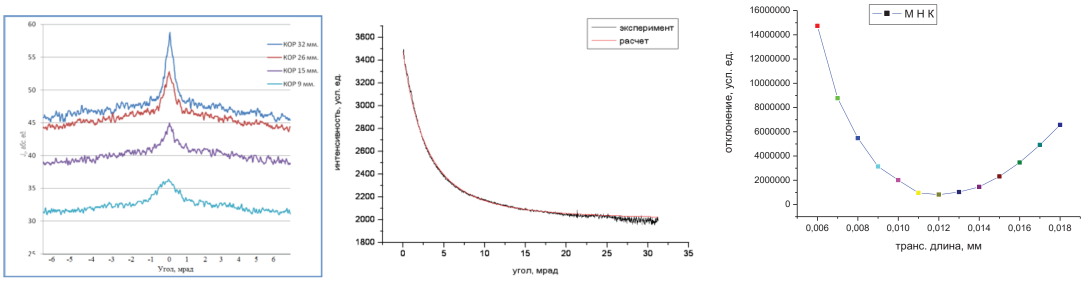
plate 7, while the wedge-shaped sample 6 with the plate 7 of smooth adjustment are allocated on the axis of rotation of the motor 8. An absorber 5 eliminates the radiation passing through, a polarizer 9 cuts off the depolarized part of the scattered radiation. The objective of the registrar 11 is tuned on the focal plane of the long-focus lens 10 and transfers images from it to the CCD matrix of the registrar, where the light signals are converted into electrical signals and angular distribution is read. The intensity of useful signal is controlled by changing of radiation power of backlight and changing of exposure time of registrar 11. All the structural elements are located on single optical plate 12.

The neodymium dtl-317 laser operating at the second harmonic (532 nm) was used as the illumination laser 1, the mirror 14-AM1 of the company STANDA was used as the rotary mirror 3, the laser beam splitter of the BK7 glass of the company "Special" system can be used as the translucent mirror 4, Polarizer 14PBT-1-532-2 of the company STANDA was used as polarizer 9, CMV-20000 matrix of CMOSIS company was used as the recorder 11, beam blocker 10BD01 of the company STANDA was used as an absorber of 5 beam, the system of two lenses from the set of lenses 14LK-1-1 of the company STANDA was used as the lens telescope 2, a lens from a set of lenses 14LK-1-1 of the company STANDA was used as the long-focus lens 10, two plane-parallel plates fastened with bolts M2 between which a plexiglass ply was clamped were used as a wedge-shaped cuvette 6, a metal rod with applied strokes (divisions), multiples of the length unit (millimeter), on which the wedge cuvette 7 with the sample will be fixed, that will move with an adjustable clamp, was used as as a smooth adjustment 7, the electric motor 25GA370 DC12V130RPM was used as the electric motor 8, the optical plate 1HT10-20-20 of the company STANDA was used as the optical plate 12, on which all elements of the circuit are located.

Experiments were conducted on a wedge-shaped sample of loose environment 540 mg / cm^3. The registered illustration contained data about the profile of an angular distribution of backscattered radiation. The noises were eliminated owing to an axial averaging. The coherent backscattering profiles were constructed after the axial averaging (Figure № 2).

3. RESULTS

The profile shapes corresponds to expect according to the theoretical data. Thus, it proves the correctness of laboratory installation work and the technique of experiment conduction.



a *b* *c*

Figure 2: The analysis of received data. a - the CBS profile from corundum particles $Al_2O_3$with a diameter of 9 μm with a concentration of 540 mg / cm^3; b - a comparison of experiment with calculations; c - finding the transport length.

As the thickness of the environment increases, the background and height of the angular cone increase and the ratio of peak maximum to the substrate tends to saturation. For obtaining the experimental dependence an approximation was produced by the theoretical dependence in the diffusive approximating due to the method of least squares, see Fig. 2 (b, c).

4. DISCUSSION

A diffusive approximating is applicable when it is possible to neglect an absorption and when a thickness of sample is much greater than the transport path length of photons [7–9]. In this case, the radiation transfer can be described by the diffusion equation. The interference peak in backward direction is described according to the diffusive approximating. A calculated graph, which is maximally close to the empirically obtained, has been constructed with varying the values of background and signal amplitude. It was the most accurate with the minimum value of the sum of squares of the deviations between calculated and experimental amounts. Thus the sums of squared of deviations for various transport lengths: (0.006-0.018) mm. It is evident from the graph that the value of the transport length situates in the interval (0.011-0.012) mm. There is a comparison of experiment with the theoretical calculation over a transport length equals to 0.012 mm. This result demonstrates that the diffusive approximating describes explored samples satisfactorily [10, 11].

5. CONCLUSION

In conclusion, the results confirmed a fulfillment by prototype its functional mission and allowed to obtain new scientific data about coherent backscattering profiles from randomly inhomogeneous environments. A dynamic cuvette with a smooth adjustment of the thickness of the sounded layer, making it possible to simulate dust layers with different thicknesses and concentrations, has been developed and manufactured. Experimental studies of the CBS registration system in static using dynamic cuvette have been carried out. The obtained results were compared with the calculated ones obtained from the diffusion approximation. The results of the experiments indicate that the diffusion approximation satisfactorily describes the samples under study.

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