ILLUMINATION OF A BUBBLE CHAMBER BY MEANS OF A RUBY OPTICAL GENERATOR

PHYSICS

1965

SovietRxiv

Abstract

Full Text

UDC 621.375.8:539.1.073.3

PHYSICS

V. M. GORBUNKOV, V. V. KOROBKIN, A. M. LEONTOVICH

ILLUMINATION OF A BUBBLE CHAMBER BY MEANS OF A RUBY OPTICAL GENERATOR

(Presented by Academician V. I. Veksler on 21 January 1965)

As is well known, bubble chambers are usually illuminated by pulsed lamps ([1]). When photographing tracks in a chamber consisting of individual bubbles, only a small part of the light energy incident from the light source on the bubbles enters the objective of the photorecording system and exposes the photographic layer. The exposure of the photographic layer H, according to ([1]), is

$$H = AB\sigma d^2 \Delta t, \tag{1}$$

where B is the brightness of the light source; σ is its area; d is the bubble diameter; Δt is the illumination time; A is a constant coefficient depending on the refractive index of the liquid and on the geometry of the optical system as a whole.

In experiments with a bubble chamber it is necessary to be able to record bubbles of the smallest possible diameter with a minimal exposure time. For this purpose, as is seen from (1), it is necessary to increase the brightness of the source.

In the present work an attempt was made to use a ruby optical generator as the illumination source for a bubble chamber. In optical generators the brightness of the light is several orders of magnitude higher ([2]) than in ordinary incoherent sources; moreover, it is possible to use the entire light flux obtained from the generator by directing the beam into the required solid angle. In this case the size of the effective source can be made sufficiently small. The duration of the light pulse when using the method of pulsed Q-switching can be brought to a value of the order of 10^{-8} sec ([3]). The light from a ruby generator is polarized ([4]), which makes it possible to extinguish the depolarized stray parasitic light and reflections. The high monochromaticity of the generator light makes it possible to use special objectives, designed for a single wavelength, with high resolving power or with large fields of view.

Fig. 1

Figure 1: Fig. 1

Fig. 2

Figure 2: Fig. 2

In the work a ruby generator was used ($\lambda = 6943$ Å) with a concentric resonator, which gives a uniform angular distribution of the radiation ([5]), necessary for uniform illumination of the chamber. A generator with a plane-parallel resonator is inapplicable here, since its beam has a nonuniform distribution ([6]). The resonator mirrors Z_1 and Z_2 (Fig. 1) were concave spherical mirrors with dielectric coatings, having a transmission of $\approx 1\%$, with radii of curvature of 50 cm, located at a distance of 100 cm from one another. A ruby crystal P, 75 mm long and 9 mm in diameter, was placed at the center of the concentric resonator with an IFK 1500 flash lamp at an electrical pumping energy of 4 kJ. The light energy in the generation pulse

was 0.1 J, the duration $\Delta t \approx 0.6$ μsec. The radiation beam from the generator, with a divergence angle $\approx 2°$, had a fairly uniform distribution. Shown in Fig. 2, this photograph was obtained in one pulse on photographic film placed directly in front of mirror Z_0. The beam from the generator, with the aid of an objective O of focal length 50 mm, was expanded by $\approx$ 10 times—to 20°. This led, in accordance with the Lagrange-Helmholtz law, to a reduction of the smallest cross section of the caustic of the beam, corresponding to the effective source, at the point D' (Fig. 1) by approximately 10 times in comparison with the cross section at the point D, and, as the measurement showed, it was ≈ 0.4 mm.

Fig. 1. Scheme of the system for illumination and photography of bubbles

Experiments were carried out with a model of a bubble chamber—with the so-called bubble test, which was a glass plane-parallel plate with air bubbles inside. According to the conditions of photometric modeling, the air bubbles in glass, with respect to light scattering, behave under the experimental conditions in the same way as gas bubbles in liquid hydrogen with a diameter approximately 2.4 times smaller.

Fig. 2. Distribution of the radiation of the ruby generator behind the generator mirror. Taken on film with contrast coefficient $\gamma = 2$, printed on contrast photographic paper No. 7

The bubble test T, located at a distance of 50 cm from the objective O, was illuminated autocollimationally ([7]) by means of the concave spherical mirror Z_0 (Fig. 1) with radius of curvature $R \approx 65$ cm and diameter 23 cm, installed at a distance of 70 cm from the objective O. The geometrical scheme corresponded to illumination of a 25-centimeter hydrogen chamber, described in ([8]). Pho-

Figure 3

Figure 3: Figure 3

Figure 1

Figure 4: Figure 1

tography was carried out with camera Φ from a distance of ≈ 50 cm, having an objective with focal length 53 mm and relative aperture 1 : 20, on sensitive photographic film with a resolving power of 70 lines/mm. To attenuate the excess light, a combination of an interference filter IF at $\lambda = 694$ mμ with transmission 30% and a neutral filter NF with transmission 11% was used.

To the article by V. M. Gorbulov, V. V. Korobkin, and A. M. Leontovich, p. 75

Fig. 3. Photographs of tracks modeled by air bubbles in a bubble test, under illumination by a ruby generator (indicated by arrows). The vertical and concentric bands are images of the edges of the bubble test and of the frame of the illuminating mirror.

To the article by A. A. Baranov, K. P. Bunin, and E. D. Glebova, p. 84

Fig. 1. Change in the structure of spheroidal graphite in cast iron B during thermal cycling.
a –initial, 200×; *b* –30 cycles under the regime 870° ⇄ 680°, etched with chromic anhydride, 200×; *v* –1 heating to 1000° in vacuum, 250×.

Fig. 2. Layered inclusions of graphite in thermally cycled cast iron B.
a –regime: 1000° –normalization, 680° –graphitization, 800×; *b* –regime: 1100° ⇄ 870°, furnace cooling, 800×.

The bubble test was illuminated and photographed 5 times on unrewound film with successive rotations of the camera through a small angle. Figure 3 gives an example of such a photograph. It shows (indicated by arrows *1* and *2*) a strongly overexposed track from a bubble 1.4 mm in diameter and a normally exposed track from a bubble 0.7 mm in diameter, which corresponds to a bubble in hydrogen 0.3 mm in diameter.

The photographs obtained show that with the given illumination system, without an attenuating filter, it is possible to record bubbles in hydrogen down to a diameter of 0.06 mm. Recording bubbles of the indicated and smaller diameters in larger chambers is readily achievable by increasing the generation energy. On the other hand, the exposure margin makes it possible to photograph on less

Figure 2

Figure 5: Figure 2

sensitive but higher-resolution photographic emulsions, whose use is desirable for increasing contrast and improving the accuracy of measurements ([1]).

Obviously, the ruby generator can also be used to illuminate a Wilson chamber. It need only be borne in mind that, because of the smaller sizes of drops and other angles of photography (at 90°), in this case greater light energy is required.

The authors express their deep gratitude to M. D. Galanin for his constant attention and discussion of the work, and to M. N. Smirnova for assistance in the work.

P. N. Lebedev Physical Institute Academy of Sciences of the USSR Moscow Institute of Physics and Technology

Received 15 I 1965

REFERENCES

1. Yu. A. Aleksandrov, G. S. Voronov et al., *Bubble Chamber*, 1963.
2. B. A. Lenguel, *Lasers*, N. Y., 1962; B. A. Lengyel, *Lasers*, Moscow, 1964.
3. F. J. McClung, R. W. Hellwarth, Proc. IEEE, **51**, 46 (1963).
4. D. F. Nelson, R. J. Collins, Adv. in Quantum Electronics, N. Y., 1961, p. 79.
5. V. V. Korobkin, A. M. Leontovich, M. N. Smirnova, JETP, **48**, 79 (1965).
6. A. M. Leontovich, A. P. Veduta, JETP, **46**, 71 (1964).
7. V. M. Gorbunkov, *Instruments and Experimental Techniques*, No. 6, 41 (1962).
8. T. D. Blokhintseva, A. T. Vasilenko et al., *Instruments and Experimental Techniques*, No. 5, 51 (1962).

Note: Figure translations are in progress. See original paper for figures.