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Features of image colouring in a projection microscope based on a copper vapour laser with an unstable resonator and a Glan prism

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***Abstract*. The effect of properties of metal surfaces on the colour of their images obtained with a 510.6/578.2-nm copper vapour laser projection microscope is studied. The metal surfaces were exposed to laser radiation polarised by 99 % in the horizontal plane. Radiation used for surface imaging is predominantly polarised in the vertical plane and is coupled out of the resonator in the direction perpendicular to its optical axis. It is found that the ratio of laser radiation powers at wavelengths 510.6 and 578.2 nm determining the image colour is dependent on the total reflection coefficients, the curvature, and statistical characteristics of the surface roughness.**

Keywords: *projection microscope, copper vapour laser, unstable resonator, polariser, surface, reflection coefficient, curvature, roughness.*

1. Introduction

A laser projection microscope (LPM) based on a copper vapour laser with an unstable resonator and a Glan prism emitting the green 510.6-nm and yellow 578.2-nm lines was studied in Refs [1, 2]. One of the specific features of the LPM was that an object observed in the microscope was exposed to radiation polarised by 99 % in the horizontal plane, while the object imaging was performed by radiation polarised predominantly in the vertical plane. This radiation was coupled out of the resonator using the Glan prism, which served as a polarisation beamsplitter in the direction perpendicular to the optical axis of the unstable resonator.

It was found in experiments [1, 2] that, first, the LPM, as a conventional projection microscope (see, for example, Ref. [3]), allows the imaging of microobjects (for example, lines of a measuring ruler, caverns on its surface, etc.). Second, it was found that the image of surfaces scattering light diffusively (lines and caverns on the ruler surface) had green colour, whereas the images of polished metal (specular) and plane dielectric surfaces had yellow colour. The image colour was independent of the curvature of metal surfaces. Figure 1 shows the image of the fragment of a measuring steel ruler with a polished surface, which demonstrates some characteristic details visible to the human eye.

Taking into account that the average power of the green line of a copper vapour laser is greater than that of the yellow line, one can assume that, if the conditions of reflection for these lines from the ruler surface are identical, the ruler image should be predominantly green. However, different parts of the ruler-fragment image in Fig. 1 have different colour. Between boundary *1* and bright region *2* of the image, green colour dominates. Bright region *2* is coloured yellow. Small dark inclusions observed in region *2*, representing the images of caverns, are green. In region *2*, lines are distinctly observed, which are also coloured green. Inside circle *4*, which is coloured yellow, the green lines of the ruler are also noticeable, although they are less distinct. Inside circle *5*, which is also coloured yellow, the green lines of the ruler are barely noticeable. Bright spots of light *6* are yellow.

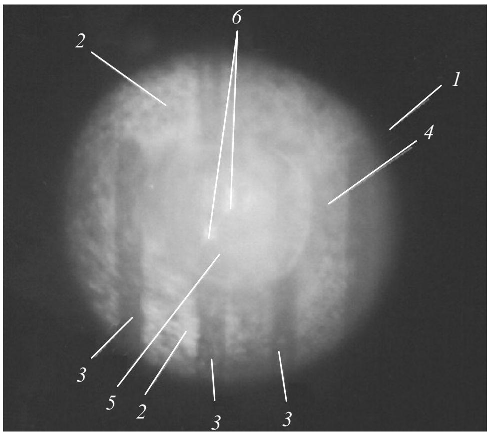

Figure 1. Image of a fragment of a metal measuring ruler obtained in the LPM [1, 2]: (*1*) boundary of the object image formed by a limiting aperture; (*2*) bright region produced due to reflection of laser radiation from the polished ruler surface; (*3*) dark lines on the ruler; (*4*) bright circle devoid of a segment at the upper part (the segment is absent because the Glan prism mounting cuts off the upper part of the laser beam propagating between small and large resonator mirrors); (*5*) weakly discernible bright circle located inside circle (*4*) and representing the image of the output resonator mirror; (*6*) bright spots inside circle (*5*).

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Because the images of specular surfaces (surfaces of a polished ruler and of the output mirror of the resonator) were predominantly yellow, whereas the images of rough surfaces (lines, figures, and caverns on the ruler surface) were predominantly coloured green, it was assumed in Ref. [1] that a rough surface depolarises radiation, and the dependence of the image colour on the surface roughness observed in Ref. [1] is explained by different depolarising properties of individual sites of the measuring ruler for the yellow and green lines. It was proposed in Refs [1, 2] to use the LPM to control the surface roughness of various materials by the colour of their images or, in other words, by the relation between the intensities of yellow and green colours in each of the images. The properties of surfaces determining the colour of their images have not been investigated in Refs [1, 2].

The aim of this paper was to verify the existence of dependence of the surface image colour on the surface roughness observed in the LPM and also to search for other properties of surfaces affecting the colour of their images.

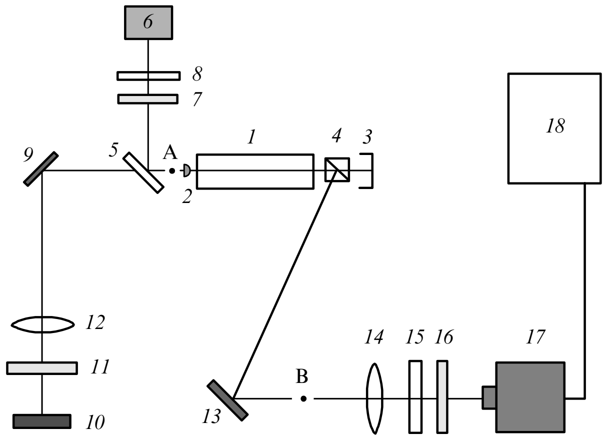

Figure 2. Scheme of the experimental setup: (*1*) active element of a copper vapour laser; (*2, 3, 9, 13*) mirrors; (*4*) Glan prism; (*5*) plane glass plate; (*6*) calorimetric power meter; (*7*) optical filters; (*8, 16*) polaroids; (*10*) sample; (*11, 15*) neutral filters; (*12, 14*) lenses; (*17*) spectrophotometer; (*18*) computer; A is the point of radiation splitting; B is the point of power recalculation.

2. Experimental

The experiment performed in this paper differs from experiments [1, 2] in two substantial respects. First, we used samples of rough surfaces with the known statistics. Second, no imaging of the observed surface was performed in this paper.

We studied four steel rough samples (1 – 4) having a plane base rectangular surface of size 20×30 mm, and also plane and convex spherical (with the radius of curvature $R_{\rm curv} \simeq 3$ cm) aluminium mirrors.

Surfaces of steel samples 1 and 3 had approximately one-dimensional microroughness distribution, while this distribution for samples 2 and 4 was isotropic. The surface of sample 1 was obtained by finishing, while that of samples 2 and 3 by polishing. The finishing and polishing of samples 1 and 3 were performed along a larger side. The rough surface of sample 4 was obtained by sandblasting. The root-mean-square deviation σ of the rough surface profile from the average line and the autocorrelation functions $B(\tau)$ of surfaces of steel samples were measured with a Talysurf profilometer with the needle tip of radius 2 μm. The root-mean-square deviation σ was 0.009 μm (sample 1), 0.06 μm (sample 2), 1.84 μm (sample 3), and 2.3 μm (sample 4). The shape of autocorrelation functions was close to exponential for all the samples. The correlation length ρ of microscopic irregularities for samples 1 – 4 was 1.0, 1.6, 26, and 20 μm, respectively.

The large-scale roughness of the surface of sample 1, which was processed by hand, was observed visually. This roughness led to the formation of a light halo located around the central part of a light strip caused by reflection of the laser beam due to the unidirectional distribution of microscopic irregularities on the surface of sample 1.

The colour of radiation coupled out of the resonator by the Glan prism of size 25×25 mm was determined by measuring the relative intensities of the yellow and green lines. The scheme of the experiment is shown in Fig 2. As in papers [1, 2], we used a commercial ILG-201 copper vapour laser (*1*) with the active element of length 800 mm and diameter 20 mm, the unstable resonator with mirrors (*2*) and (*3*) separated by 1500 mm and having the magnification 200, and Glan prism (*4*). The laser emitted 12-W, 25-ns pulses with a pulse repetition rate of 8 kHz.

The active medium was excited using the scheme with a capacitive voltage doubling and a magnetic compression section [4]. The capacitance of each of the two storage capacitors was 1000 pF. The power consumed from a rectifier was 3.3 kW.

To measure the relative intensities of the green and yellow laser lines, a small part of laser radiation was deflected (at point A in Fig. 2) by glass plate (*5*) to a measuring system consisting of calorimetric power meter (*6*) and optical filters (*7*) providing filtering of one of the laser lines. The polarisation properties of radiation were analysed by polaroid (*2*).

Laser radiation was directed by mirror (*9*) through lens (*12*) with the focal distance 150 mm to sample (*10*) with the different roughness of the reflecting surface. The sample surface was located at a distance of about 130 mm from the lens, and the diameter of a focused laser spot was ~ 3 mm. Lens (*12*) collected a part of radiation reflected by the sample and directed it back to the active medium. The radiation incident on the sample was attenuated using neutral NS filters (*11*). Vertically polarised laser radiation reflected from the sample and amplified in the active medium was coupled out of the resonator by Glan prism (*4*). This radiation was directed with the help of mirror (*13*) and lens (*14*) through neutral filters (*15*) (NS glasses) to Hohner Corporation 4885 spectrophotometer (*17*) to detect the relative time-averaged powers of the green ($P'_{\rm sp}$) and yellow ($P''_{\rm sp}$) lines. The output signal of the spectrophotometer was processed with computer (*18*). Powers $P'_{\rm sp}$ and $P''_{\rm sp}$ were recalculated to powers $P'_{\rm B}$ and $P''_{\rm B}$ at the point B (Fig. 2) using the known transmission coefficients $K_{\rm tr}$ of attenuators (*15*). In some cases, the polarisation properties of radiation were analysed with polaroid (*16*).

We measured for some samples the ratios of the intensities of reflected laser radiation for the yellow and green lines. In this case, the reflected beam was directed to spectrophotometer (*17*) without passing through the active medium.

Table 1. Output powers of the green and yellow lines coupled out of the resonator by a Glan prism and their ratios measured on the setup in Fig. 2.

Experiment number	Sample and direction of lines	E_y component						E_x component				P'_{A1}/P''_{A1}	P'_{A2}/P''_{A2}	δ
		P'_{sp} (arb. units)	P''_{sp} (arb. units)	K_{tr}	P'_B (arb. units)	P''_B (arb. units)	P''_B/P'_B	P'_{sp} (P'_B) (arb. units)	P''_{sp} (P''_B) (arb. units)	K_{tr}	P''_B/P'_B			
1	Absent	0.68	0.117	1.5×10^{-3}	453	78	0.172					2.4		0
2	4 (polaroid was used)	0.399	0.182	1.2×10^{-3}	332.5	151.7	0.456	0.343 (13.72)	0.196 (7.84)	0.025	0.571	2.4	2.28	0.05
3	4	0.618	0.211	1×10^{-3}	618	211	0.341					2.44	2.33	0.045
4	3, vertical	0.36	0.36	2.1×10^{-4}	1714.3	1714.3	1.0					2.41	2.28	0.054
5	3, horizontal	0.52	0.555	2×10^{-4}	2600	2775	1.07					2.4	2.28	0.05
6	2	0.743	0.529	4×10^{-4}	1857.5	1322.5	0.712					2.33	2.15	0.077
7	1, vertical	0.526	0.868	2.2×10^{-4}	2390.9	3945.5	1.65					2.35	2.1	0.106
8	Plane mirror	0.368	0.524	1.4×10^{-4}	2628.6	3742.9	1.42					2.36	2.0	0.153
9	Plane mirror (polaroid was used)	0.391	0.461	4×10^{-4}	977.5	1152.5	1.18	0.332 (37.94)	0.239 (27.31)	8.75×10^{-3}	0.72	2.36	2.0	0.153
10	1*, vertical	0.401	0.391	1.4×10^{-4}	2864.3	2792.9	0.975					2.32	2.21	0.047
11	Convex mirror	0.25	0.618	7.2×10^{-5}	3472.2	8583.3	2.47					2.4	1.96	0.18

*Note: NS6 neutral filter (*11*) was used ($K_{tr} = 0.65$).

The distances between basic elements of the setup were 3400 mm between sample (*10*) and the nearest end of active element (*1*), 250 mm between Glan prism (*4*) and the nearest end of the active element, and ~ 6000 mm between the Glan prism and spectrophotometer (*17*). All the optical elements used for radiation transport (lenses and mirrors) and its attenuation (optical filters) were mounted so that the radiation reflected from them was not incident on the active medium of the laser.

In the absence of sample (*10*), laser radiation at the point A is almost completely polarised in the horizontal plane (the electric field vector $\boldsymbol{E}_x$). The horizontally polarised component of both laser lines contains 99 % of the total output power, whereas the vertically polarised component (the electric field vector $\boldsymbol{E}_y$) contains only ~ 1 %. In this case, the ratio of the average output power in the green line to that in the yellow line $R_1 = P'_{A1}/P''_{A1}$ at the point A (Fig. 2) for the horizontally polarised component R_{1x} was 2.27 – 2.44, and this ratio for the vertically polarised component R_{1y} was 1.6. Variations in the values of R_{1x} are caused by the long-term instability of the parameters of the output laser radiation. In the absence of sample (*10*), background radiation was observed at the point B, which was predominantly (about 90 %) polarised in the vertical plane. In the presence of a sample, the radiation power at the point B drastically increased.

3. Experimental results and discussion

The results of measurements of the relative radiation powers P'_B and P''_B at the point B and P'_A and P''_A at the point A performed for steel samples and aluminium mirrors are summarised in Table 1*. Because no samples were used in experiment No. 1, the values of P'_B and P''_B presented in Table 1 characterise in this case the power of vertically polarised background radiation at the point B (Fig. 2). In experiments No. 4, 7, 10, lines on the surface of steel samples were vertical, whereas in experiment No. 5 they were horizontal. In experiments No. 8 and 9, a plane aluminium mirror was used, in experiments No. 2 and 9, we used polaroid (*16*), and in experiment No. 10 – neutral filter (*11*) (see Table 1). In experiment No. 11, we employed a convex aluminium mirror.

The random error of the relative measurements of P'_B and P''_B did not exceed 10 %, and that of P'_{A1}, P''_{A1} and P'_{A2}, P''_{A2} was a few percent. Variations in the ratio P'_{A1}/P''_{A1} caused by the long-term instability of the output power did not affect the accuracy of measuring these parameters.

Before analysing the experimental results, we specify the terminology used in the paper to describe the reflecting properties of surfaces. The total reflection coefficient k_f is the coefficient of reflection within the solid angle 2π steradian. The reflected radiation pattern characterises the intensity distribution within a given solid angle. The reflected radiation pattern for a plane scattering surface coincides with that for light scattered by microscopic irregularities of the surface. The reflected radiation pattern for a curved specular surface coincides with the specular reflected radiation pattern, which is determined by the surface curvature. In the case of a curved scattering surface, the reflection pattern is determined by a set of radiation scattering and specular reflection patterns. The specular reflection coefficient k_s characterises a fraction of radiation reflected from the surface in the direction coinciding with the direction of specular reflection of incident radiation. This coefficient depends on the total reflection coefficient and the shape of the reflected radiation pattern. In the experiments performed in this paper, the angles of incidence of radiation on the sample surface and reflection from it were close to zero.

It is reasonable to analyse factors affecting the ratio P''_B/P'_B (the colour of the surface image) beginning with the study of the wavelength dependence of the total reflection coefficients k_t of samples. Taking into account that k_t almost coincides with k_s for specular surfaces, we estimate

*Note that we decided to measure the ratios P'_A/P''_A and P''_B/P'_B presented in Table 1 for the following reasons. Because the ratio P'_A/P''_A is conventionally used as one of the parameters of the output radiation of copper vapour lasers, which shows whether the active medium is insufficiently heated, overheated or normally heated, it is this ratio that we used here to characterise the output radiation. We employed the inverse ratio for radiation coupled out of the resonator by the Glan prism because during the visual control of the colour of this radiation the green colour was used as a 'reference' colour with respect to which the brightness of yellow colour was measured. Therefore, in our opinion, it is more convenient to use the ratio P''_B/P'_B to characterise radiation coupled out of the resonator by the Glan prism because this ratio reflects more clearly the dynamics of variation of the radiation colour.

the values of k_t for aluminium mirrors and steel samples using the values of specular reflection coefficients for specular aluminium and steel surfaces. According to Ref. [5], the values of k_s for aluminium at wavelengths 510.5 and 578.2 nm are 0.9174 and 0.9127, respectively, i.e., the coefficient k_t decreases by 0.5 % on passing from the former wavelength to the latter. This is far smaller than the error of measuring of the ratios P''_B/P'_B, P''_{A2}/P'_{A2}, and cannot noticeably affect the results of measurements.

The coefficients k_s for steel samples measured with a Shimadzu spectrophotometer were 0.474 for the green line and 0.492 for the yellow line. Therefore, the change in k_t for steel samples on passing from the green to yellow line has the opposite sign compared to the change in k_t for aluminium and, being equal to 3.8 %, is greater almost by a factor of eight. Therefore, we can expect in principle that for steel samples the difference in k_t for the green and yellow laser lines will affect to some extent the ratio P''_B/P'_B.

Because the radiation imaging a surface in a projection microscope is initiated by the part of radiation reflected from the surface that returns back to the active medium of a laser, the ratio P''_B/P'_B can also depend on the wavelength dependence of k_s.

Special studies of the reflection parameters of steel samples and analysis of these measurements, taking data [5 – 7] into account, showed that among numerous parameters characterising microscopic irregularities of the surface, the statistical characteristics of microscopic surface irregularities can substantially affect the ratio P''_B/P'_B. The calculations showed that this influence should be most prominent for samples 1 and 2.

The depolarising properties of rough surfaces were verified for samples 1 and 3. We measured the power ratios for the vertically and horizontally polarised components of laser radiation incident on the samples and reflected from them. The measured ratios were almost identical. Therefore, the rough surfaces studied here did not depolarise laser radiation, as in Refs [8, 9], so that depolarisation could not affect the value of P''_B/P'_B (image colour).

Analysis of the data presented in Table 1 shows that the presence of a sample affects the power ratio of horizontally polarised radiation in the green and yellow lines at the point A (see Fig. 2). In this case, as for radiation at the point B, the relative intensity of the yellow line increases. This suggests that the colour of the surface image observed in the LPM is also determined by the fact that the surface not only reflects incident laser radiation but also serves as the third mirror (element) of the unstable resonator. This assumption is confirmed by the results obtained in Refs [10 – 13]. It was shown in experiments with a CO_2 laser [10] that laser radiation entering the resonator after reflection from the irradiated target can substantially affect the radiation divergence, resulting in the distortion of the regular intensity distribution in the focal plane. It was shown theoretically in Ref. [11] that the reflection of radiation of a laser with the unstable resonator from a target affects the width of the angular distribution of this radiation.

The authors of Refs [12, 13] studied the processing of a graphite sample with the help of a copper vapour oscillator-amplifier and found that the surface of the graphite sample substantially affected the operation of the oscillator and the system as a whole. The author of paper [13] observed relatively stable plasma regions over the graphite surface, which reflected laser radiation and had, according to the author's interpretation, the electron concentration achieving 10^{20} cm^{-3}. However, taking into account that the relaxation time of charged particles at such high concentrations, which is determined by the rate of three-body recombination, is extremely short compared to the time interval (125 μs) between laser pulses, we should assume that a stable reproducibility of the regions strongly scattering laser radiation at the same site of the sample surface is caused by the difference in the reflecting properties of different microscopic regions of the graphite surface. Or, in other words, the regions with the increased electron concentrations are formed over microscopic regions of the target that have the relatively large coefficient k_s.

Thus, taking into account the influence of samples on the value of the ratio P'_{A2}/P''_{A2} (see Table 1) and results [10 – 13], we can conclude that the surface of samples studied in the LPM in this paper plays the role of the third mirror (element) of the resonator. The presence of such an element, which is characterised, for example, by the inhomogeneous distribution of the total reflection coefficient over its surface, should result in the spatial redistribution of laser radiation both on the surface of the element itself (object under study) and inside the resonator. This conclusion allows us to explain the appearance of bright spots of light (*6*) [1, 2] on the surface of output mirror (*2*) (see Fig. 1) by the inhomogeneity of the reflection properties of the ruler surface, which serves as the third element of the resonator.

We begin a search for the factors affecting the value of the ratio P''_B/P'_B (the surface image colour) from a comparison of the results of experiments No. 7 and 10. Because the presence of a neutral attenuator is equivalent to a decrease in the value of k_s for the sample surface, the results of these experiments demonstrate that this coefficient is one of the factors affecting the value of P''_B/P'_B. An increase in k_s leads to an increase in the ration P''_B/P'_B, or an increase in the yellow colour intensity in the surface image.

Another factor affecting the ratio P''_B/P'_B is the surface curvature (specular reflection pattern). This is confirmed by a comparison of the results of experiments No. 8, 9, and 11. This comparison shows that the ratio P''_B/P'_B for a convex aluminium mirror (experiment No. 11) is far greater than that for a plane mirror (experiments No. 8, 9). Taking into account the above-established dependence of the ratio P''_B/P'_B on k_s, i.e., on the laser power returned to the active medium, we can conclude that the convex aluminium mirror provides a greater amount of reflected laser radiation entering the active medium compared to the plane mirror. Therefore, the curvature of the object surface, which forms the scattering pattern for reflected light, also affects the ratio P''_B/P'_B.

Unfortunately, the possibility of a direct comparison of the results of different experiments for determining the factors affecting the ratio P''_B/P'_B is exhausted by comparing experiments No. 7 and 10 and No. 8, 9, and 11. For example, a comparison of experiments with aluminium mirrors and steel samples for determining the influence of the surface roughness on the ratio is incorrect because this ratio depends on the specular reflection coefficient, which is determined not only by the shape of he reflection pattern but also by the total reflection coefficients, which are different for aluminium mirrors and steel samples. A comparison of experiments with samples 1 and 3, and 2 and 4 is also incorrect because on passing from sample 1 to 3 or from sample 2 to 4, not only the root-mean-square deviation σ increases but also the ratio of the specular reflection coefficients for the yellow and green lines changes substantially. In addition, by estimating the influence of the surface roughness for sample 1 on the ratio $P''_{\rm B}/P'_{\rm B}$, it is necessary take into account that this ratio also depends on the large-scale inhomogeneity of the sample surface, which produces a light halo, as mentioned above.

We attempted to analyse the type of interrelation between the parameters discussed in order to classify the data presented in Table 1. Figure 3 shows the dependences of the ratio $P''_{\rm B}/P'_{\rm B}$ on the parameter $\delta = [1-(P'_{\rm A2}/P''_{\rm A2})/(P'_{\rm A1}/P''_{\rm A1})]$. The parameter δ seems preferable compared to the parameter $P'_{\rm A2}/P''_{\rm A2}$ because it takes into account variations in the ratios $P'_{\rm A2}/P''_{\rm A2}$ and $P'_{\rm A1}/P''_{\rm A1}$ in passing from one experiment to another (see Table 1). Note that the results of double experiments (for example, 2 and 3) are represented in Fig. 3 by the average values of $P''_{\rm B}/P'_{\rm B}$ and δ.

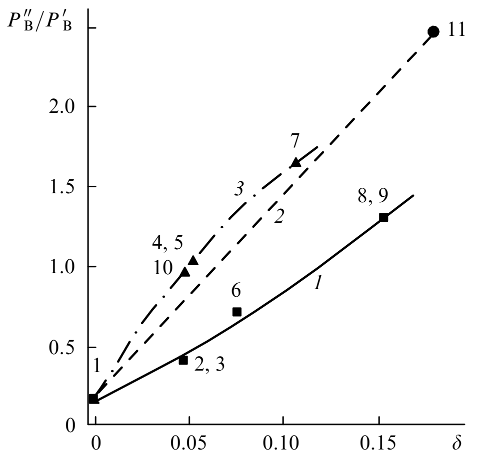

Figure 3. Dependences of the ratio $P''_{\rm B}/P'_{\rm B}$ for vertically polarised radiation on the parameter δ. The figures at triangles, squares, and a circle correspond to the numbers of experiments in Table 1. Three groups of experiments are denoted by curves (*1*–*3*).

One can see from Fig. 3 that the results of measurements can be divided into three groups, including experiments No. 1, 2, 3, 6, 8, 9 [dependence (*1*)], No. 1 and 11 [dependence (*2*)], and No. 1, 10, 4, 5, 7 [dependence (*3*)]. Note that the first group includes experiments performed with samples 2 and 4 and a plane aluminium mirror with the isotropic distribution of microscopic irregularities. It is obvious that a decrease in the modulus of the Fresnel coefficient for a specular surface and an increase in isotropic scattering for a scattering surface cause a decrease in the specular reflection coefficient. The dependence (*1*) suggests that the relation between parameters $P''_{\rm B}/P'_{\rm B}$ and δ in the case of isotropic distribution of microscopic irregularities is mainly determined by the specular reflection coefficient.

The dependence (*2*) passing through two points demonstrates the above-established effect of the object surface curvature on the ratio $P''_{\rm B}/P'_{\rm B}$.

The results of measurements of δ and $P''_{\rm B}/P'_{\rm B}$ for samples with approximately one-dimensional roughness form their own dependence (*3*), which again demonstrates a strong influence of the scattering pattern of reflected laser radiation on the ratio $P''_{\rm B}/P'_{\rm B}$ and parameter δ. A comparison of dependences (*1*) and (*3*) shows that the ratio $P''_{\rm B}/P'_{\rm B}$ for a plane aluminium mirror is smaller than for sample 1, for which the total reflection coefficient and, hence, the specular reflection coefficient is almost half that for the aluminium mirror. This is probably explained by the roughness of surface of sample 1, resulting in the appearance of a halo, which suggests that the large-scale inhomogeneity is equivalent to some extent to the curvature of the convex aluminium mirror.

Dependences (*1*) and (*3*) demonstrate that no substantial difference is observed between the specular reflection coefficients for the yellow and green laser lines both for sample 2 [dependence (*2*), experiment No. 6] and sample 1 [dependence (*2*), experiment No. 7 and 10]. We can assume that this effect is caused by saturation of the active medium by laser radiation, resulting in the levelling of the difference between radiation intensities in the yellow and green lines returned to the active medium after reflection from a sample. This means that the ratio $P''_{\rm B}/P'_{\rm B}$ and, most probably, the ratio $P'_{\rm A2}/P''_{\rm A2}$ are determined first of all by the radiation intensity incident on the active medium and by its distribution over the active-medium cross section.

Therefore, a passage to the coordinates δ and to $P''_{\rm B}/P'_{\rm B}$ allowed us to classify a part of experimental data and separate factors affecting the ratio $P''_{\rm B}/P'_{\rm B}$ (image colour). However, the mechanism of this effect remains unknown. Moreover, we should point out also the presence of at least several obscure results. For example, on passing from sample 4 (experiment No. 2) to the aluminium mirror (experiment No. 9), the power of vertically polarised radiation in the yellow and green lines at the point B increased by factors of 7.6 and 2.9, respectively. At the same time, the power of horizontally polarised radiation at this point increased by a factor of 3.5 for the yellow line and by a factor of 2.8 for the green line, i.e., taking into account the measurement error, the increase in the green – line power was the same as in the case of the green line with the vertical polarisation. In this case, the value of $P''_{\rm B}/P'_{\rm B}$ for vertically polarised radiation increased by a factor of 2.6 and that for horizontally polarised radiation – only by a factor of 1.26.

4. Conclusions

The study of the LPM performed in the paper allows us to list the characteristics of a surface determining the colour of its image obtained in the microscope. These characteristics are the total reflection coefficient, the reflected radiation pattern, which is determined, first, by the statistical parameters of the surface roughness and, second, by he surface curvature. Unfortunately, the experimental data obtained in the paper cannot explain the mechanism of effect of the reflection properties of the surface on the ratios $P''_{\rm B}/P'_{\rm B}$ and $P'_{\rm A2}/P''_{\rm A2}$. It seems that the difference between the influence of the reflection properties of the surface on the ratio $P''_{\rm B}/P'_{\rm B}$ for vertically and horizontally polarised radiations also cannot be explained. Therefore, to understand the operation of the LPM, further experimental and theoretical studies are required.

Such studies are also justified because they can lead to the development of an LPM allowing the control of parameters determining the reflection characteristics of surfaces of various materials.

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