III IYNT 2015

Task №13
«Glowing Spheres»

Team *«MG 12»*

Statement of the Task

Some bright white discs (or spheres) may rather unexpectedly appear in photos taken with the help of a flash in the dark. Explain why these glowing spheres may appear in photos.

Glowing sphere. Photo taken at indoor light

Glowing sphere. Photo taken in the dark.

Hypothesis:

Small foreign particles contained in the atmosphere may cause light dispersion

Objective:

To explain the possibility for glowing spheres to occur in the photo.

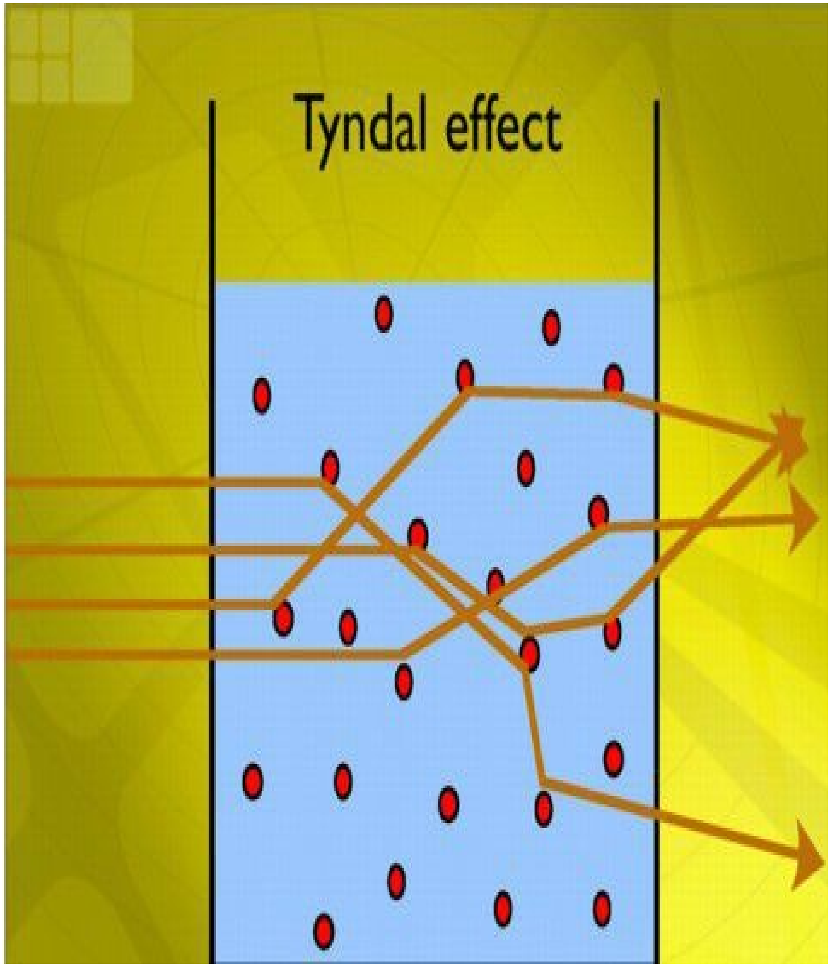
Research Problems

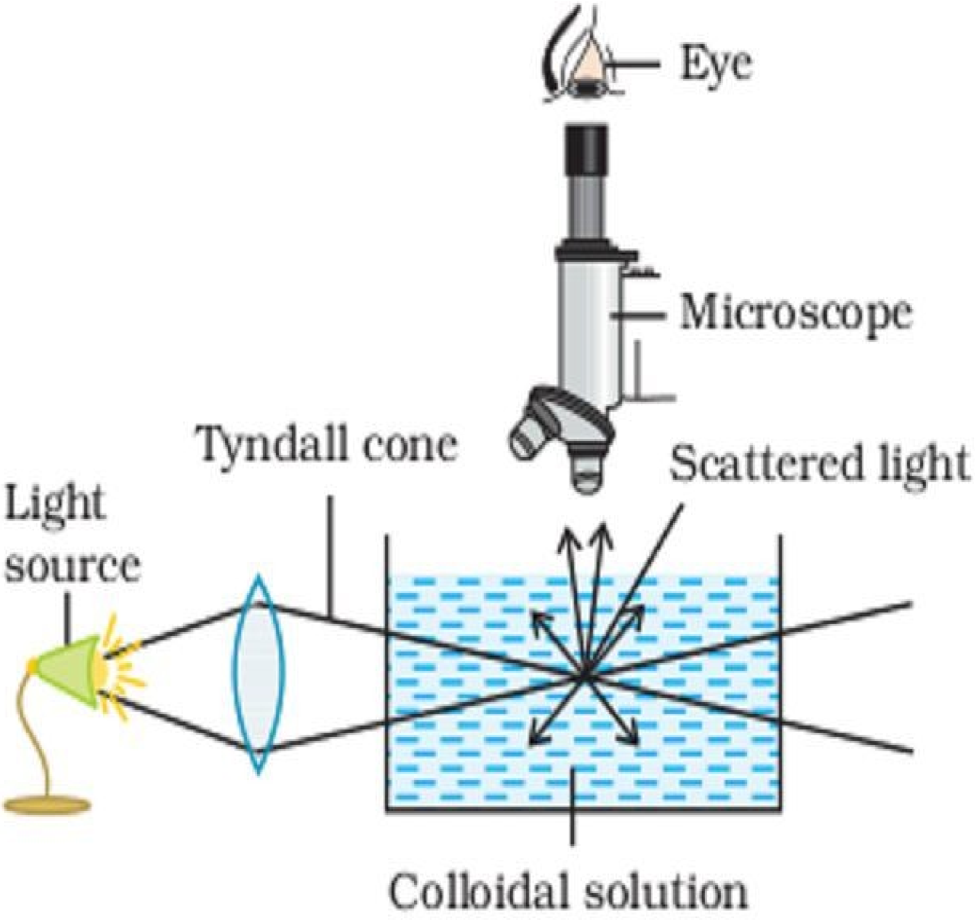
1. To study publications on the problem;
2. Photograph spheres, examine their structure;
3. To find conditions necessary for spheres to appear in photos.

Theoretical explanation for the observed phenomenon

Particles in the air, specks of dust and water droplets, disperse light beams of any colour. They disperse the white light.

Theoretical explanation for the observed phenomenon





Theoretical explanation for the observed phenomenon. The Rayleigh equation.

$$\frac{I_p}{I_o} = kc\frac{r^3}{\lambda^4},$$

I_0 – intensity of the incident light,

I_p – opalescence intensity,

I_0/I_p – turbidity of a system,

k – constant,

c – concentration (kg/m^3),

r – radius of a particle (m),

λ – the wave length of the incident light (m)

Assumptions:

- The particles are spherical;
- The size of the particles should not be more than 1/10 of λ;
- A large distance between particles (a diluted system).

Theoretical explanation for the observed phenomenon. The Rayleigh equation

Conclusions:

1. The smaller is the size of a particle much less is the dispersion (to the third power).

2. With colourless colloidal systems exposed to the white light, mostly short (blue) waves are dispersed as I_p is directly proportional to the 4th power of the wavelength. That's why when exposed to sidelight, colloidal systems have bluish colour. Whereas being exposed to passing light, they look reddish (additional to the blue colour).

3. Index k in the Rayleigh equation depends on the relation of indices of dispersed phase refraction (of particles) and dispersive medium. There is no light dispersion when they are the same, that's k=0.

The experimental part of the research

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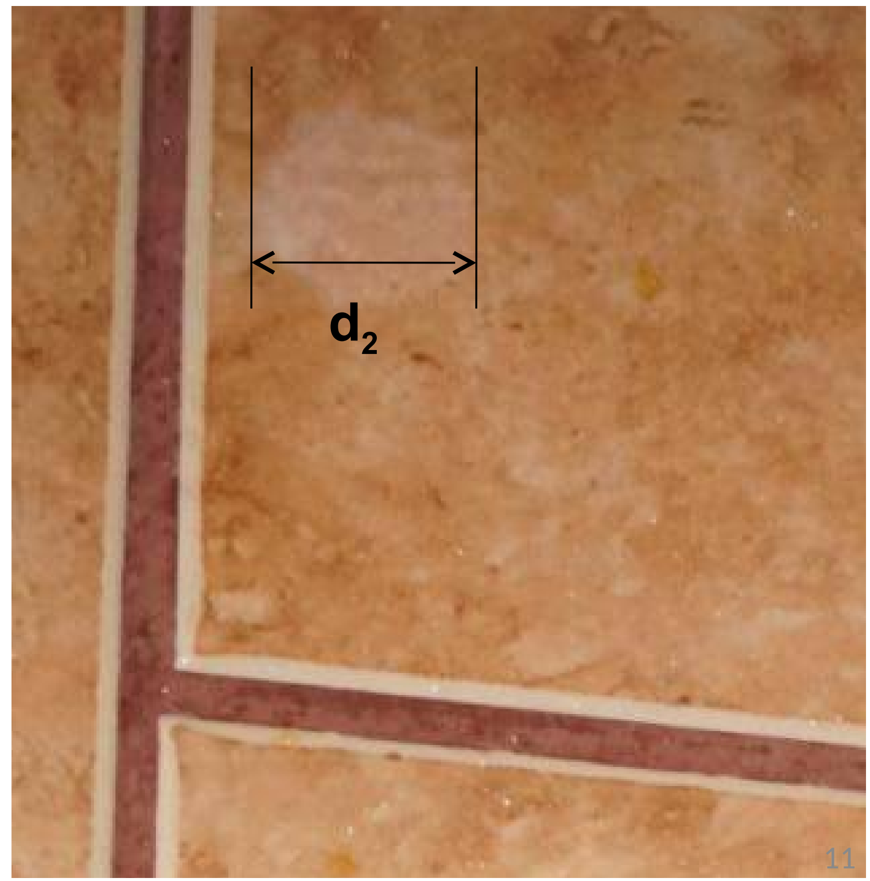
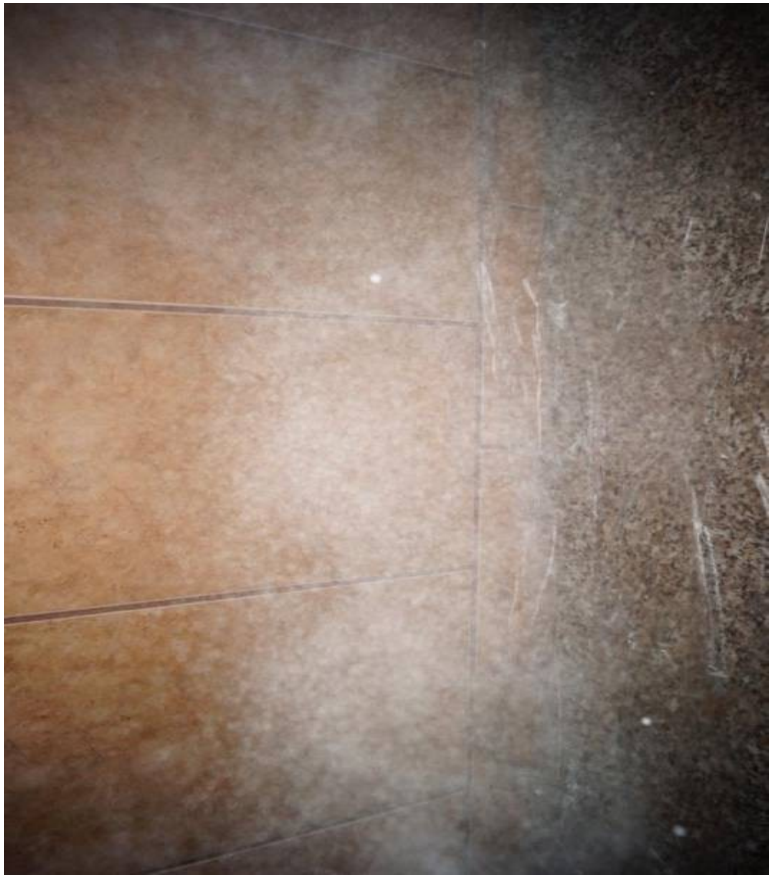
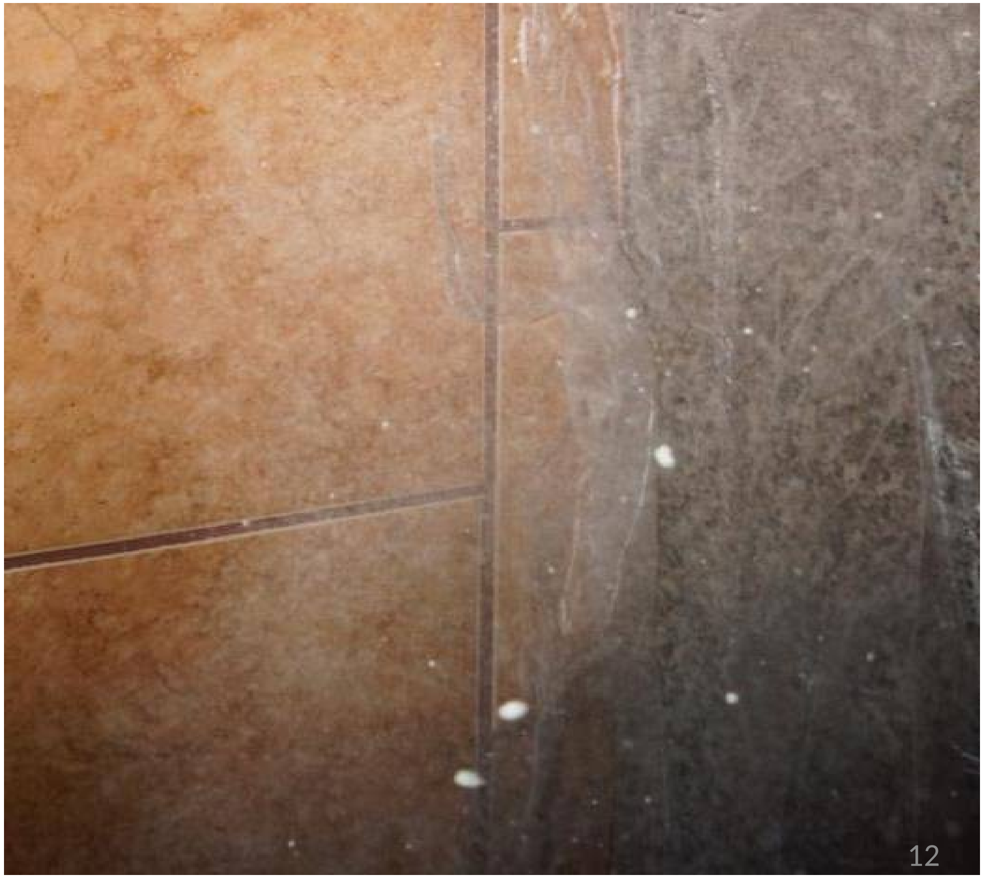
Light dispersion dependence on the size of a colloidal particle



The experimental part of the research

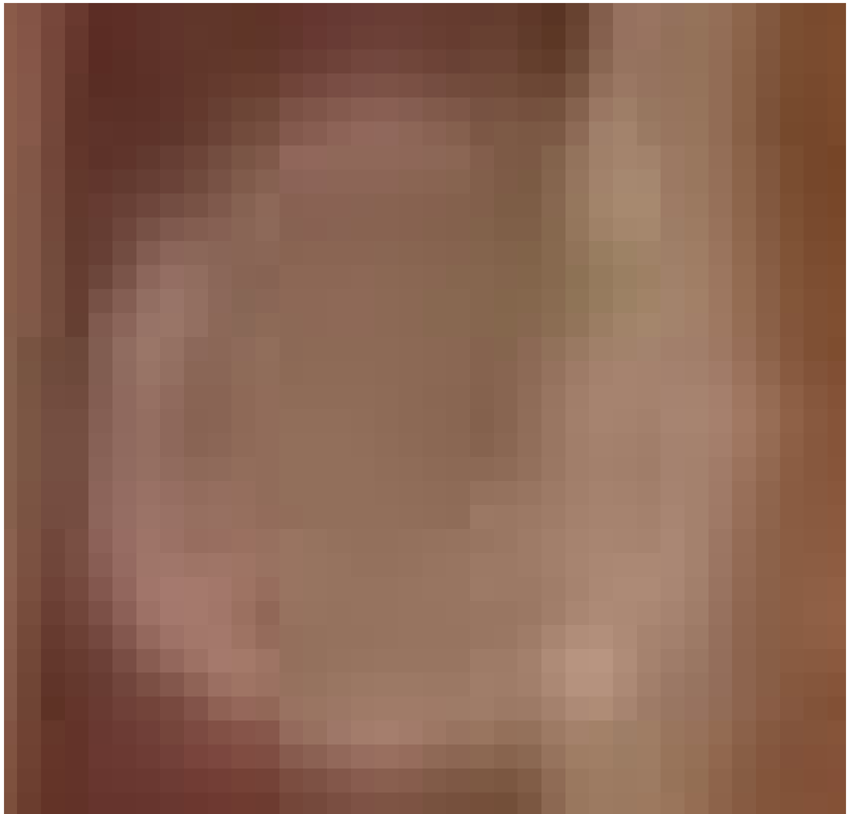
Light dispersion observed in the colloidal system with high dispersed phase concentration.

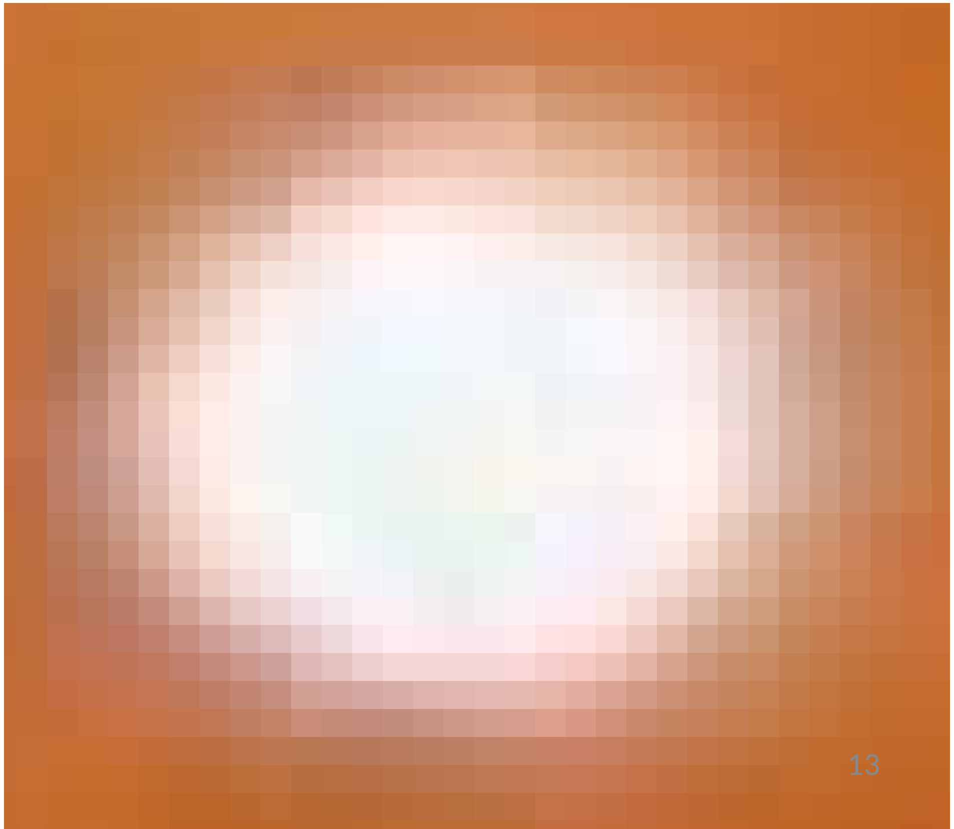




The experimental part of the research

Observing spherical light dispersion: the violet light is dispersed with colloidal particles in all directions





Conclusions

1. Glowing spheres in the photos can be explained by Rayleigh light dispersion with particles which sizes are not more than 1/10 of a wavelength of the incident light.
2. Opalescence intensity depends on the sizes of particles, their concentration, wavelength of the incident light, refraction index (of the particle and the medium).
3. In the photos the glowing spheres are located, as a rule, in front of the image, that’s at a distance shorter than the focus one of the optical system of our camera.

Information sources

- https://ru.wikipedia.org/
- The Rayleigh dispersion. The encyclopedia physical science.
- *Mitrofanov I. G.* The Rayleigh dispersion.
- http://chem21.info/info/715051/
- http://www.laserportal.ru/content_1032

Photos taken during the experimental part of the research