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Observation of ball lightning on the river Voronezh

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Recently because of wide spread of digital video-cameras the possibilities of obtaining of information on ball lightning features were significantly improved. Analysis of video-films made in 2010 in Dolgoprudny [1] and in 2015 in Mitino [2] lets to determine ball lightning features, which usually are lost at visual observation of ball lightning. A sufficiently exact definition of ball lightning size and distance to it may be fulfilled by processing the results of the shooting, made by different observers. The analysis of this event becomes possible if one manages to define the coordinates of each observer and synchronize various cameras. Fortunately, there are a large enough number of cases when distance and size of ball lightning can be found by studying a sole photo of ball lightning. Such photo is shown in Fig. 1 [3].

FIGURE 1. A photo of ball lightning, observed in the autumn of 2015 on the river Voronezh [3].

On Sunday night of September, 27th, 2015 a 57-year-old inhabitant of Lipetsk Victor Barkov together with friends arrived for fishing on the river Voronezh at a place located seven kilometres upstream from the village Karamyshevo in the Grjazinsk district of the Lipetsk region. At five o'clock in the morning, in almost complete darkness, he started to pump up a rubber boat. Suddenly a right bank of the river was illuminated by a fiery ball. Its light was much brighter than the moon, and it illuminated only a plot of the opposite bank of the river. And farther there was darkness. There was no cloud in the sky, and nothing foretold a thunder-storm. This object was at low altitude. The fiery ball was observed during 5 minutes. Then it began to fade, turned to a shining cloudlet, and then totally dissolved in the predawn sky. Let us look at a picture made by Barkov (see Fig. 1). One can see in the photo the shining ball and its reflection in water. Besides, one can see in water the reflections of trees, growing on opposite bank of the river. If to accept a height of a tree top above the water equal to 20 m, then the ball height above the trees can be defined as 15.5 m. If to look at a ball reflection on a water surface, it is possible to notice, that it is raised over tops of the reflected trees only by 11 m. This distinction allows finding the size of ball and distance to it.

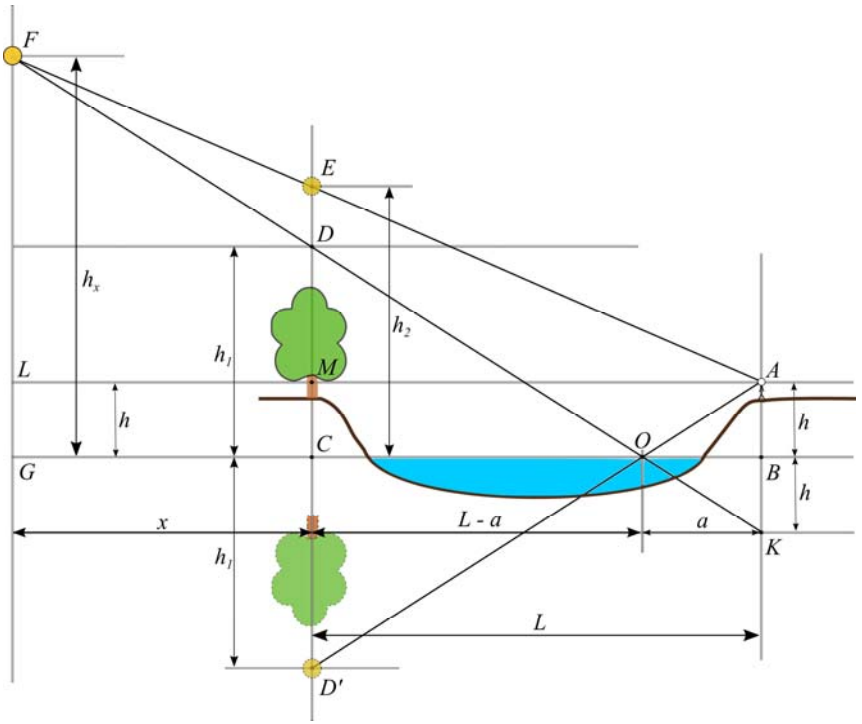

FIGURE 2. The scheme of paths of rays at taking of a photograph of a shining object, reflecting in water.

In Fig. 2 a path of rays at taking of the photo is shown. In this drawing a point *A* is a camera position, $AB = BK \equiv h$ is a camera height above water level, *O*

is a point of light of object F reflection from a water surface, $OB \equiv a$. Let us designate a distance $AM = BC$ from a point of shooting A to a plane of trees CD on the opposite bank by a letter L, a height CE of a light source above water by a letter h_2, and a height of its reflection above water $CD' = CD$ by a letter h_1. Let a distance of object F to a plane of trees CD in horizontal plane is $CG \equiv x$, and its true height above water is $GF \equiv h_x$. From a condition of equality of angles DOC and AOB follows:

$$a = LH/(h+h_1). \tag{1}$$

From triangles OGF and OBK it is found

$$h_x = h\,(x+L-a)/a. \tag{2}$$

From similarity of triangles FLA and EMA follows:

$$\frac{FL}{LA} = \frac{h_2 - h}{L} = \frac{h_x - h}{x + L}. \tag{3}$$

Substituting expressions (1) and (2) in the formula (3), we find:

$$x = \frac{L(h_2 - h_1)}{2h + h_1 - h_2}. \tag{4}$$

Substituting (4) in (2), we have:

$$h_x = \frac{hh_2 + hh_1}{2h + h_1 - h_2}. \tag{5}$$

Knowing $FL = h_x - h$ and $AL = L + x$, it is possible to find from triangle FLA a distance to object F: $L_x \equiv AF = (FL^2 + AL^2)^{1/2} = [(h_x - h)^2 - (L + x)^2]^{1/2}$. Using expressions (4) and (5), we find:

$$L_x = \frac{2h[(h_2 - h)^2 + L^2]^{1/2}}{2h + h_1 - h_2}. \tag{6}$$

Thus, one can define a distance L_x to ball lightning, knowing L (horizontal distance from a place of shooting to trees on the opposite bank of the river), h (camera height above water), h_2 (height of object visible position above water) and h_1 (height of object reflection above water). Unfortunately, we do not know exact values of these parameters. Therefore let us use for estimations their most probable values. The width of the river Voronezh in the region of village Krutogor'e is about 80-100 meters [4]. Assuming that the photographer and trees on the opposite bank

were 5 m from water, we find L = 100 m. Let the banks on both sides of the river were elevated 3 m above water, then a height of a shooting point above water is h = 5 m, and the tree-top is raised above water by 20 m. As we estimated above, a height of ball image above water is h_2 = 20+15.5 = 35.5 m, and a distance of ball reflection from a water surface is h_1 = 20+11 = 31 m. Substituting these values into the formula (6), we find: L_x = 182 m. Comparing a ball size with typical height of a tree (17 m), it is possible to consider, that if the ball was located precisely above trees, its diameter would be equal to D_a = 3 m. As the ball is farther than trees, its true size is D_i = 3 m×(182/100) = 5.5 m. If we had more exact data on the sizes of the used reference points, definition of distance to ball lightning and its size could be more exact.

1. A.I. Nikitin, T.F. Nikitina and A.M. Velichko. *Analysis of video-film, shot 3 June 2009 in Dolgoprudny*. In: Proc. 10 Intern. Conf. "Wave electro-hydrodynamics of conducting liquid. Long-lived plasma objects and pour-investigated forms of natural electric discharges in atmosphere". Yaroslavl, 2013. pp. 150-165 (in Russian).
2. A.I. Nikitin, A.M. Velichko, T.F. Nikitina and I.G. Stepanov. *Ball lightning observation in Mitino, the northwest district of Moscow* (this issue).
3. Ball lightning on the river Voronezh, http://www.lipetskmedia.ru/news/view/58327-NLO_nablyudali.htmail.
4. Google Maps, https://www.google.ru/maps/@52.3876148,39.4650701,10426m/data=!3m1!1e3?hl=ru.