Unidentified Aerial Phenomena. Overview of Observations and Characterization Estimation

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Unidentified Aerial Phenomena. Overview of Observations and Characterization Estimation

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ABSTRACT We use high-tech observations of Unidentified Aerial Phenomena (UAP) class objects to evaluate their characteristics. We present data in five cases. (1) Bright UAPs over Kyiv and San Diego. (2) Dark objects over Kyiv and New York. (3) Space UAPs. (4) Analysis of objects near the Moon. (5) Analysis of the object recorded in the combat zone. Two-side observations of bright UAPs showed tropospheric objects at altitudes of several kilometers, size is about 10 m and speed of several Mach or more. Two-side space UAP observations showed objects at altitudes of more than 1000 km that exhibit unprecedentedly high linear velocities of hundreds of km/s and sizes of several kilometers. UAP observations over Kiev and New York revealed objects of large linear size, one about 150 meters and the other about 100 meters, with unprecedentedly high speeds, about 120 km/s and the other about 13 km/s. The motion of the objects does not cause atmospheric disturbances. We report sightings of objects of enormous size. They resemble a large floating island in the sky, similar to Laputa, described in Swift's novel "Gulliver". The albedo of these objects is a few percent, making their detection a challenge.

Key words: methods: observational; object: UAP; techniques: imaging

1 Introduction

The Main Astronomical Observatory of NAS of Ukraine conducts an independent study of Unidentified Aerial Phenomena (UAP) in the atmosphere.

Unidentified anomalous, air, and space objects are deeply concealed phenomena. The main feature of the UAP is its high speed. Ordinary photo and video recordings will not capture the UAP. To detect UAP, we need to fine-tune (tuning) the equipment: shutter speed, frame rate, and dynamic range.

According to our data, there are two types of UAP, which we conventionally call: (1) Cosmics, and (2) Phantoms. We note that Cosmics are luminous objects, brighter than the background of the sky. Phantoms are dark objects, with a contrast, according to our data, to several per cent. Both types of UAPs exhibit high movement speeds. Their detection is a difficult experimental problem.

The results of previous UAP study are published in [2], [3], [4]. Here we present our recent results and present an overview of works on the identification of UAPs and evaluation of their characteristics.

2 Bright UAPs over Kyiv and San Diego

For UAP observations, we used a meteor station installed in Kyiv. The station has an ASI 294 Pro camera and lens with a focal length of 28 mm. ASI 294 Pro camera has a field-of-view (FOV) of up to 9.7 deg, a pixel size of 34.1 arc second, and a frame rate of up to 120 fps. The ASI 174 MM camera has a FOV of 4.08 deg, a pixel size of 24.2 arc second, actual frame rate more of than 200 fps. The SharpCap 4.0 program was used for data recording. Observations of objects were carried out in the daytime sky. Frames were recorded in the .ser format with 14 bits.

For San Diego observations, two modern smartphones were used, the Samsung s23 Ultra and the Pixel 6 Pro. The Samsung was used for high-speed single-camera video captures with a maximum rate of 960 frames per second. The spatial resolution of the smartphone is 1080 x 1920 in precise 8-bit color per pixel and a FOV of up to 85 x 48 deg . Video observations were made in Escondido California, with a clear sky view. Observations were made during daylight. We recorded with two smartphone cameras (Samsung and Google) simultaneously at 240 fps [5].

Figs 1, 3 and 5 show object over Kyiv on February 12, 2023 with 59.4 frames per second. Fig. 5 show the objects flash for no more than two-hundredth of a second at an average of 20 times per second. The special feature of the objects is the intensity of the glow drops to almost zero. It is natural to assume that a bright object shines by reflected sunlight. But this is not compatible with the intensity drop to zero.

Figs. 2, 4 and 6 show the UAP observed over San Diego on April 04, 2023. The object demonstrates strong variations of intensity (Fig. 6). The object flashes for no more than three-hundredths of a second. The next feature of the object is the intensity of the glow drops to zero. Notably, the objects light curve shows a repeating signal.

The object in Fig. 2 crosses a frame of 38 degrees for 135 sec with 30 frames per second. It demonstrates a speed of 0.3 degrees per second and periodicity with a frequency of about 0.104 Hz (Fig. 6). The objects size is about 60 arc minutes (two sizes of the Moon).

The San Diego object (Fig. 4) has almost identical characteristics to the Kyiv object (Fig. 3). Its angular size is four times greater than the size of the Kyiv objects. This may be due to the distance to the object.

We can inform about discovering a new type of UAP, which we conventionally call "blinkers". A feature of this object is regular flashes with a duration of hundredths of a second. In addition, the intensity of their glow drops to almost zero. The waveform of blinkers can be characterized by a duty cycle, i.e. the percentage of the ratio of pulse duration, or pulse width to the total period of the waveform. Its duty cycle ranges from about 1 to 10 per cent. This means that blinkers can be invisible ninety-nine per cent of the time.

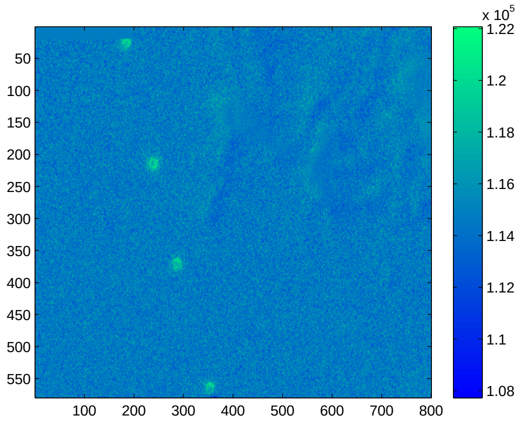

Fig. 1: UAP track (Kyiv 2023).

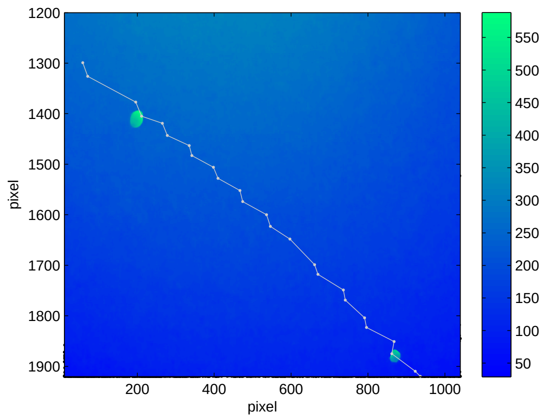

Fig. 2: UAP track on April 4, 2023, (San Diego).

Analysis of object over Vinarivka

Two-side observations are required to characterize the UAP. The objects taken synchronously by two cameras giving a parallax, distance to the object as well as an angular velocity, a linear velocity and the altitude of the object.

For two-side observations of UAP, it is necessary to synchronize two cameras with an accuracy of one millisecond. Shots at a rate of at least 50 frames per second in a field of view of 5 degrees at a base of 40 m allowing us to detect objects at a distance above $\simeq$ 950 m.

In Fig. 7 and 8 show the UAP observed by two cameras simultaneously over Vinarovka on August 04, 2023. Fig. 7 shows the light curves coincident on the two cameras for 0.3 sec. Figure 8 shows the tracks of the object. The coincidence of light curves, vectors, and velocity is obvious. They indicate that the two cameras are observing the same object.

Figure 9 shows images of the object in pseudo colors. The object has the shape of a toroid with a size of about 10 angular minutes. The object periodically disappears from the field of view.

The two-side observations yield the following characteristics of UAP.

- Parallax 0.86 degree.

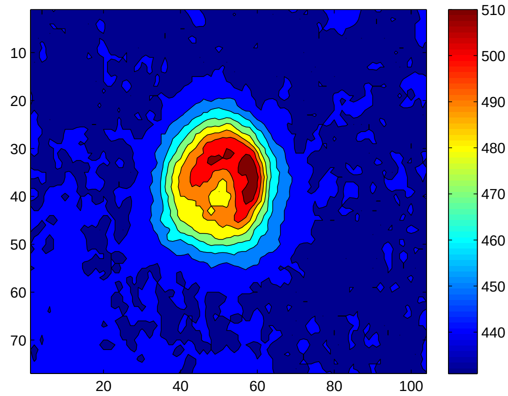

Fig. 3: The image of UAP on February 12, 2023, Kyiv.

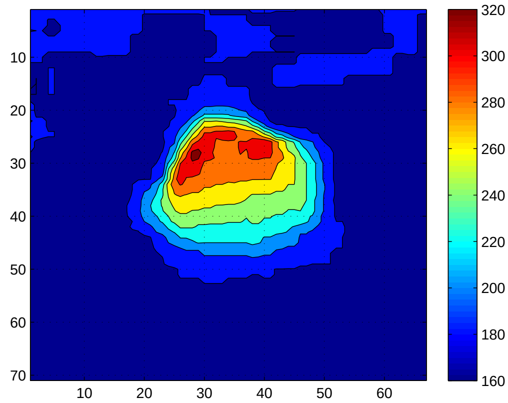

Fig. 4: UAP image on April 4, 2023, (San Diego).

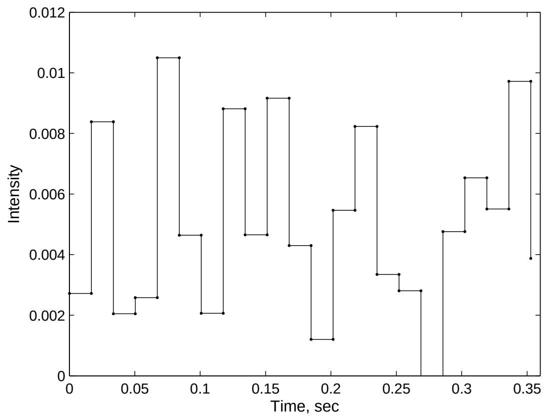

Fig. 5: The light curve of the UAP on February 12, 2023, Kyiv, in magnitude scale.

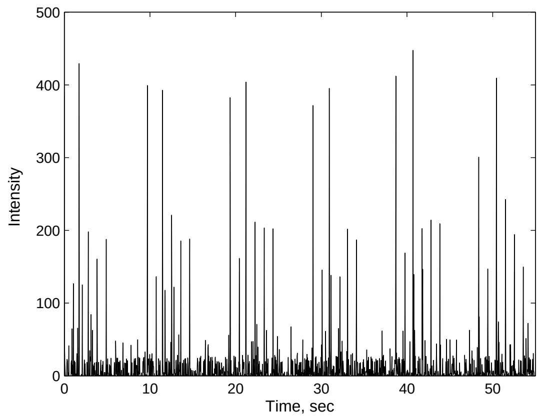

Fig. 6: UAP light curve on April 4, 2023, (San Diego).

- Distance 2.7 km.
- Speed 19 deg/sec.
- Velocity 0.930 km/sec ($\sim$ 3M).
- Size 8 m

High-speed IR video recordings of the sky were made during recording sessions between 1 - 5 January, 2024. Recordings were made at the location Riverside Park, New York City [12].

Videos were recorded using a Panasonic Lumix GH6, comprising a 5776 x 4336 array of 3.0 μm square pixels. The camera can record 24-bit, 4K video (4096 x 2160 pixels) at a frame-rate of 119.88 fps.

Five frames of video Fig. 10 show an elongated UAP passing near, or perhaps through, clouds. The National Weather Service (NWS) reported two cloud layers at the time of the recording, at an altitude of 1.7 km and 2.1 km. Both cloud layers can be seen in the video (Fig. 10).

Time stamps and image sizes using an altitude of 1.7 km and 2.1 km allow us to determine a lower bound on the size and velocity of the UAP. The object over New York has a size of about 4 meters and a speed of 48 km/sec.

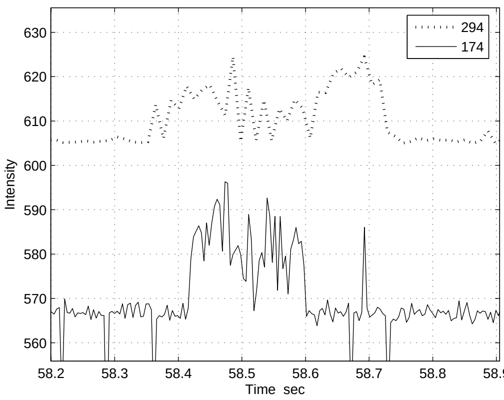

Fig. 7: The light curves on the two cameras for 0.3 sec.

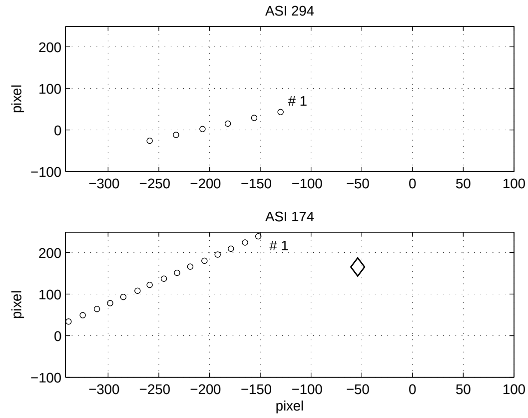

Fig. 8: The tracks of the object on the two cameras.

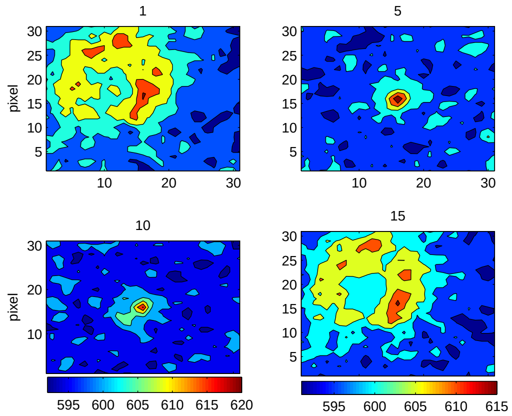

Fig. 9: Images of the object in pseudo colors.

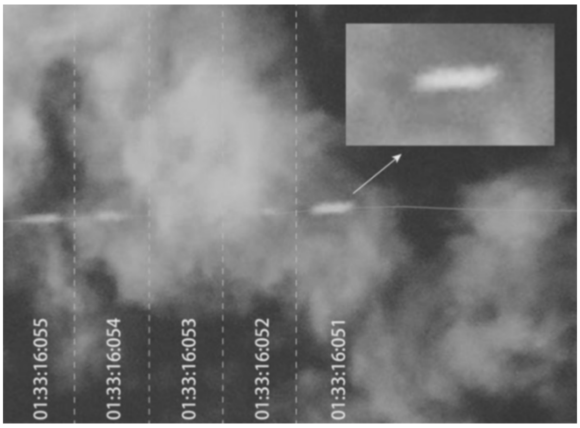

Fig. 10: The object over New York has a size of about 4 meters and a speed of 48 km/sec.

Results

Two-side observations of bright UAPs show that (1) they are tropospheric objects at altitudes of several kilometers; (2) their size is about 10 m; (3) their velocities can be several Mach or more.

3 Dark objects over Kyiv and New York

Here we present observations of objects of the Unidentified Aerial Phenomena (UAP) class in Kyiv and New York. Both events are short-lived, 0.17 and 1.028 seconds. Both objects have large linear dimensions, about 150 meters, and the other is about 100 meters. Both objects have an unprecedentedly high speed, about 120 km/s and the other is about 13 km/s.

3.1 Dark object over Kyiv

A multi-color DSLR camera was used in Kyiv. The camera with a full-scale sensor allows shooting in the field of view (FOV) 90 degrees at a rate of 30 frames per second.

Object (Fig. 11) was detected during the sky monitoring on August 24, 2018, at about 9 am. The clear sky was monitored in video mode with the Canon 5D Mark III camera in the Goloseevo district of Kyiv. Note that at 11:18 - 11:38 am a military equipment parade was held in connection with the anniversary of Ukraine's Independence. The processing of observational data made it possible to establish the following characteristics of the object provided below.

Figure 11 shows the shooting of a phantom object (as we will call dark objects further) at a speed of 30 frames per second. Their color scheme is shown in Fig. 13 and 14. Color diagrams allow us to estimate the distance to objects.

The extinction in the object in Fig. 13 and 14 is normalized to the intensity of the sky background in the vicinity of the object. The first conclusion is that the residual intensity in RGB filters is the same. This means that the colors of the object and the background are the same, that the object does not have its radiation and, most importantly, does not reflect solar radiation. It is theoretically possible that it reflects equally in all wavelengths, i.e. the object is a completely grey body, which is unlikely.

Determination of distance to an object by colorimetry methods

The colors of the object and the background of the sky make it possible to determine the distance using colorimetric methods. The necessary conditions are (1) Rayleigh scattering as the main source of atmospheric radiation; (2) and the estimated value of the object's albedo. The scattered radiation intensity has the form:

$$I = I_0 \cdot e^{-\sigma \cdot s} \tag{1}$$

Here s is the current distance, σ is the Rayleigh scattering coefficient, and I_0 is the value of the intensity observed at sea level. The linear Rayleigh scattering coefficient σ has the form [1]:

$$\sigma = 3 \cdot 10^{18} \cdot \delta \cdot (n-1)^2 / \lambda^4 / N \tag{2}$$

Here n is the refractive index of air, λ is the wavelength of light in microns, δ is the depolarization coefficient equal to 0.97 for the Earth's atmosphere, and N is the number of molecules in 1 cm^3 (Loshmidt number). Expression (1) can be written for both sky background and object. Expression (1) can be represented in stellar magnitudes as:

$$\Delta m = 1.086 \cdot \sigma \cdot (S - s_{obj}) \tag{3}$$

In the approximation of a homogeneous atmosphere with a height of 10 km, $S = 10/\sin(h)$, h is the height of the object above the horizon, s_{obj} is the distance to the object from the observer.

Expression (1) can be integrated overall RGB wavelengths λ of the system. In doing so, the distance can be determined using formula (3) for the average value of the linear Rayleigh scattering coefficient σ. Its value is close to the maximum sensitivity of the G band ($\lambda = 0.55$ mkm) and, according to equation (3), is equal to 0.19 km^{-1}.

Using the approximation of a homogeneous atmosphere instead of a real atmosphere with an exponential density distribution gives some error at small distances. For distance $s_{obj} = 0$, the magnitude difference $\Delta m = 2.1$ and residual intensity equals 0.145. This gives a contrast equal to 85% instead of 100%.

According to equation (3), the distance from the observer can also be determined from the value of the residual intensity from the graph given in Fig. 16.

Fig. 12 represents the sample RGB data for the object and sky background at the flight path. The first conclusion is that the colors of the object and the background are the same (Figs. 13 and 14). But the object has less brightness compared to the sky background. The object does not reflect or emit sunlight. It becomes visible because it shields the scattered light of the sky behind it.

Figs. 13 and 14 show photometric sections of the trace in RGB rays along the path. The second conclusion is that the residual intensity varies along the trajectory. This means that the air mass separating the object from the observer is different. Moreover, it is directly proportional to the distance to the object. This provides a way to measure distance using colourimetry methods.

Restoring a distorted image of an object

To eliminate the image motion blur caused by the rapid movement of the object, we construct a distorting point spread function for the case of motion blur PSF(L,θ), where L is the length, and θ is the angle of the image motion. Motion blur is the convolution of an image of an object with a

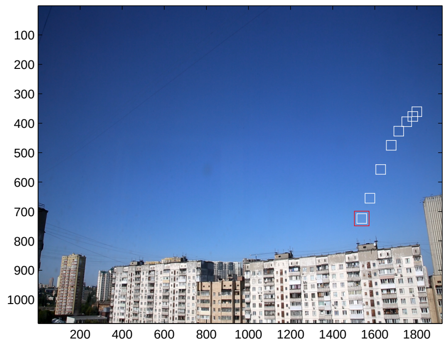

Fig. 11: Trace of the dark object.

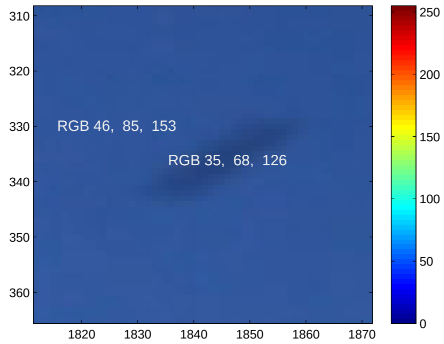

Fig. 12: Image of the dark object.

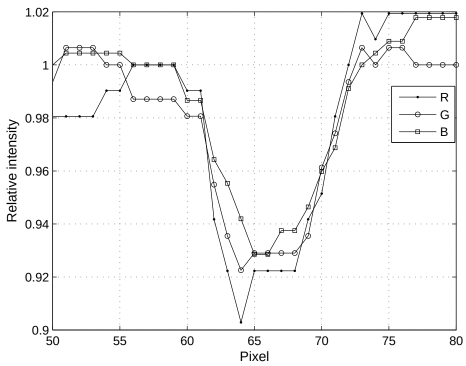

Fig. 13: The photometric sections in the RGB rays. Beginning.

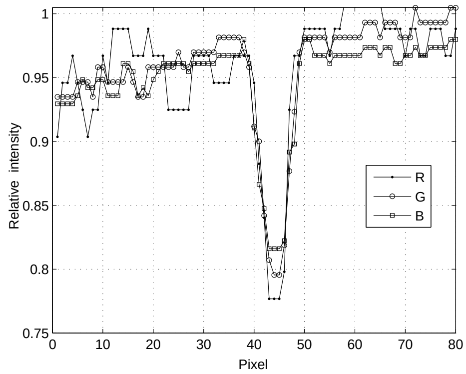

Fig. 14: The photometric sections in the RGB rays. End.

distorting function. The operation inverse to convolution is called deconvolution. As a result, we get an oval-shaped undistorted image of the object in pseudo-colors (Fig. 15).

To restore a distorted image of an object, we use inverted filtering using the Wiener filter. The kernel (hardcore) of the restored image is an ellipse measuring 5x10 pixels.

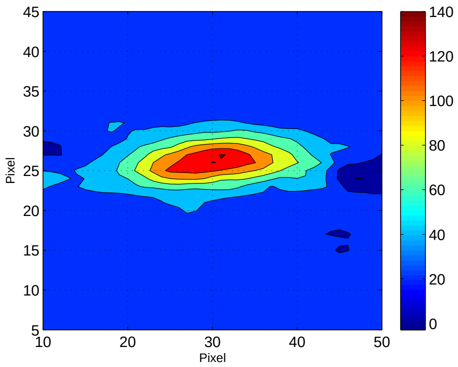

Fig. 15: Undistorted image of the object in pseudo-colors.

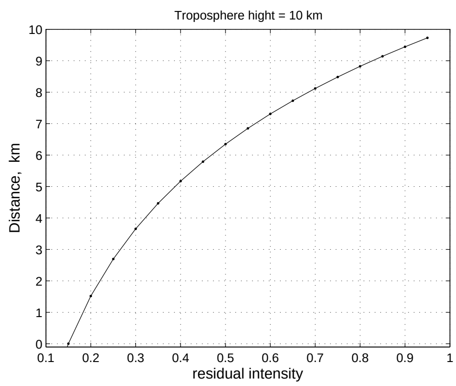

Fig. 16: Distance to the object vs residual intensity.

Figs. 17 and 18 show intrusion diagrams, the dependence of distances on azimuth. The diagram in

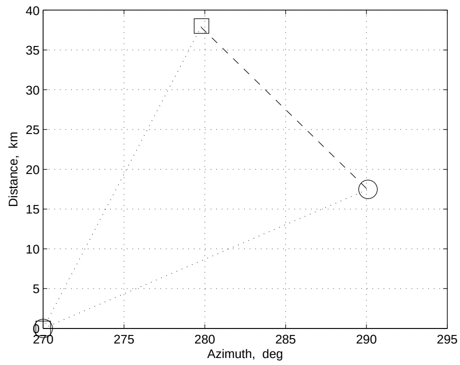

Fig. 17: Diagram of the invasion in Kyiv.

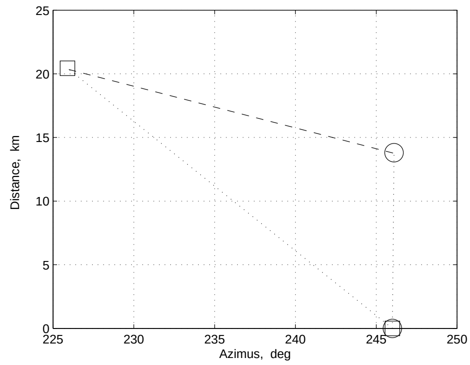

Fig. 18: Diagram of the invasion in New York.

Fig. 17 shows that the object has moved 10 degrees in azimuth. The height h of the object above the horizon at the beginning and end are 15 and 32.5 deg (Fig. 11). The color charts in Figs. 13 and 14 allow us to estimate the distance. Its distance was at first 38.3 ± 0.9 km, at the end 17.4 ± 0.6 km and altitudes of 10 ± 0.3 km. The speed of the object can be estimated as 59 deg/sec.

If we know the distance, we determine the size and speed of an object. The width of the object in Figs. 12 and 14 is about 30 arc minutes. This gives the size about 150 meters. The object crosses the path of 20.5 km in Fig. 17 in 0.17 sec with a linear speed of 120.8 km/s.

We establish the following characteristics of the object from observation data:

- The object was shot in the falling sunlight, but it looked like a dark spot on the background of a bright sunny day sky. The contrast with the sky background in RGB colors at different distances of the object varied from 8 to 20%.
- The moving object was observed for 0.17 seconds.
- The object moved at a speed of about 59 deg/sec.
- At the beginning of the observed trajectory, the object was at a distance of 38.3 ± 0.9 km, at an altitude of 10.0 ± 0.3 km.
- At the end of the observed trajectory, the object was at a distance of 17.4 ± 0.6 km, at an altitude of 10.0 ± 0.3 km and had angular dimensions comparable to the Moon. The size of the object is estimated to be about 150 meters.
- The diagram in Fig. 17 gives a path length of 20.5 km. The object crosses it in 0.17 seconds. This allows us to determine the linear speed of 120.8 km/s.

Note the object has an unprecedentedly high speed and large size. The movement of the object is not accompanied by atmospheric disturbances.

3.2 Dark object over New York

A second dark object was observed over Beacon, New York. Location: 41° 30′ 8”, N 73° 57′ 47”, Altitude: 126.7 ft, Facing: 246° SW [15].

Object (Fig. 19) was detected during the day sky monitoring on September 1, 2022, at 17:18:08.659 (begin), 17:18:09.682 (end) UTC. The time is 1.028 sec.

Observations were carried out with an ASI 178 MC camera and lens with a focal length of 2.5 mm at a rate of about 110 frames per second. The SharpCap 4.0 program was used for data recording. Frames were recorded in the .ser format with 8-bit.

Fig. 20 shows the contrast characteristic of the object. The conclusion is that the residual intensity differs at the trajectory's beginning and end. This means that the air mass separating the object from the observer is different.

Fig. 19: Trace of the dark object.

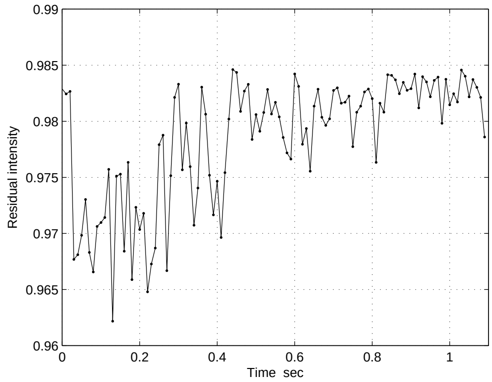

Fig. 20: Residual intensity vs time.

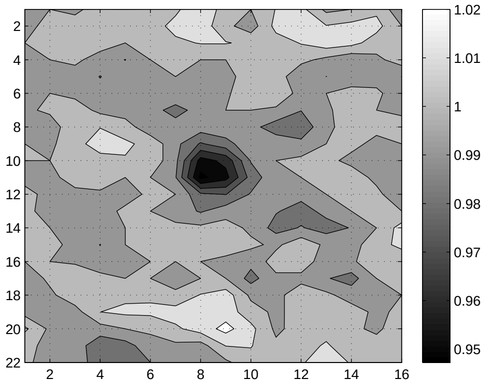

Fig. 21: Image of the dark object.

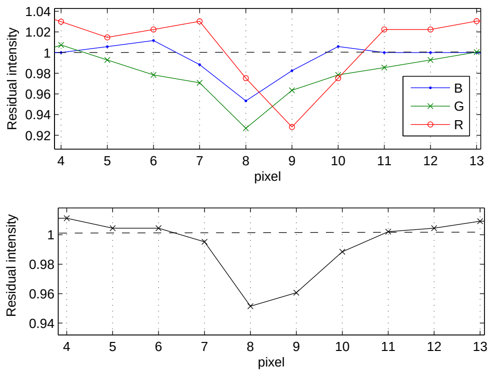

Fig. 22: The photometric sections of the object in the RGB rays (upper panel), in integral light (bottom panel).

Fig. 22 shows photometric sections of the trace in RGB rays (upper panel) and in integral light (lower panel). The conclusion is that the residual intensity in RGB filters is the same. This means that the colors of the object and the background are the same, that the object does not have its radiation and, does not reflect solar radiation. We can see that for a black body, residual intensity has the same values for RGB rays and integral light.

The diagram in Fig. 18 shows that the object has moved 20 degrees in azimuth. The height h of the object above the horizon at the beginning and end are 45 and 21 deg (Fig. 19). The residual intensities in Figs. 20 and 22 allow us to estimate the distance. Its distance was at first 13.8 ± 0.2 km, at the end 23.6 ± 0.6 km and altitudes of 8.9 and 9.4 ± 0.3 km. The speed of the object can be estimated as 19 deg/sec.

We establish the following characteristics of the object from observation data:

- The object was shot in the falling sunlight, but it looked like a dark spot on the background of a bright sunny day sky (Fig. 21). The contrast with the sky background in RGB colors at different distances of the object varied from 3 to 1.5% (Fig. 20).
- The moving object was observed for 1.028 seconds.
- At the beginning of the observed trajectory, the object was at a distance of 13.8 ± 0.2 km, at an altitude of 8.9 km.

- At the end of the observed trajectory, the object was at a distance of 23.6 ± 0.6 km, at an altitude of about 9.4 km and had angular dimensions of 10 arc minutes or one-third the size of the Moon.
- The object moved at a speed of about 19 deg/sec.
- The size of the object is estimated to be 107 ± 37 meters.
- The diagram in Fig. 18 gives a path length of 13.5 km. The object crosses it in 1.028 seconds. This allows us to determine the linear speed of 13.2 km/s or 40.6 Mach.

Note the object has an unprecedentedly high speed and large size. The movement of the object is not accompanied by atmospheric disturbances.

Results

Some considerations regarding birds should be considered. At a distance of 400 m, birds will look like point objects. At a shorter distance, birds will appear as structured objects. Taking the linear speed of the bird to be 10 meters per second, we obtain an angular speed of no more than two degrees per second. From this, it is easy to conclude that birds cannot be phantoms.

The work [3] presents data from observations of birds and insects, potential interference when observing phantoms. The work shows that the speed and color characteristics of these objects lead to the conclusion that they cannot imitate the characteristics of phantoms.

Both events are short-lived, 0.17 and 1.028 seconds.

Both objects exhibit blackbody characteristics. Both do not have radiation and, most importantly, do not reflect solar radiation.

Both objects have finite sizes. One is the size of the Moon, and the other is one-third the size of the Moon.

Both objects have large linear dimensions, about 150 meters, and the other is about 100 meters.

Both objects have an unprecedentedly high speed, about 120 km/s and the other is about 13 km/s.

The movement of objects does not cause atmospheric disturbances.

4 Space UAP

4.1 Analysis of object over Kyiv

For UAP observations of the objects, we used two meteor stations installed in Kyiv and in the Vinarivka village in the south of the Kyiv region at a base of 120 km. The Vinarivka station has an ASI 294 MC Pro camera and lens with a focal length of 50 mm. ASI 294 MC Pro camera has a FOV (field of view) of up to 9.7 deg, a pixel size of 34.1 arc second, and a frame rate of up to 120 fps.

The ASI 174 MM camera in Kyiv has an FOV of 4.08 deg, a pixel size of 24.2 arc second, actual frame rate more of than 200 fps. From simple trigonometry, it is easy to determine that objects at a distance of more than 995 km will fall into the field of view of the cameras at a base of 120 km.

The SharpCap 4.0 program was used for data recording. Observations of objects were carried out in the daytime sky. Frames were recorded in the .ser format with 14 bits.

Figures 23 and 24 show an image with the object taken synchronously by two cameras in UTC: 17/10/2022, 08:58:08.136 with time precision of one millisecond.

A parallax of 0.0464 rad (2.66 degrees) gives a distance to the object of 2600 km. For an hight of 26 degrees (Stellarium, UTC: 17/10/2022, 08:58:08) we estimate the altitude of the object at 1130 km. Vinarivka with 6 shots gives an angular velocity of 1.73 deg/s and a linear velocity of 78 km/s.

An image of the object can be seen in Fig. 25. Fig. 26 shows the color map of the object in RGB rays. The object size can be estimated to be 7 ± 1 pixels. The PSF (point spread function) of the camera is about 2 x 2 pixels. This gives reason to consider the object as a finite-size object, and estimate the size of the object to be 3.0 ± 0.4 km.

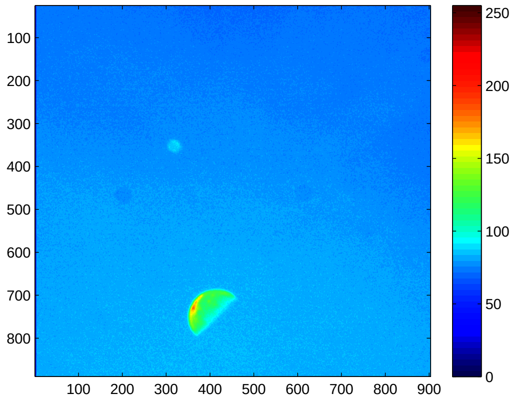

Fig. 23: UAP over Kyiv.

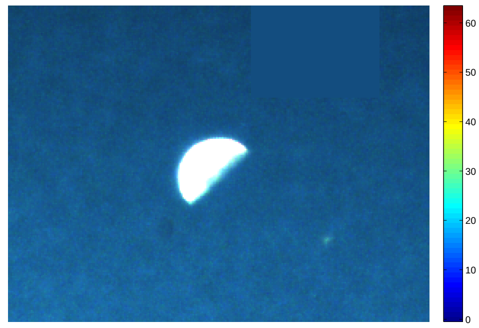

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Fig. 24: UAP over Vinarivka.

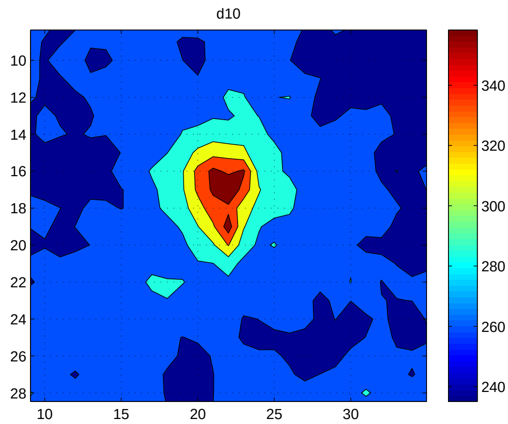

Fig. 25: Image of the object.

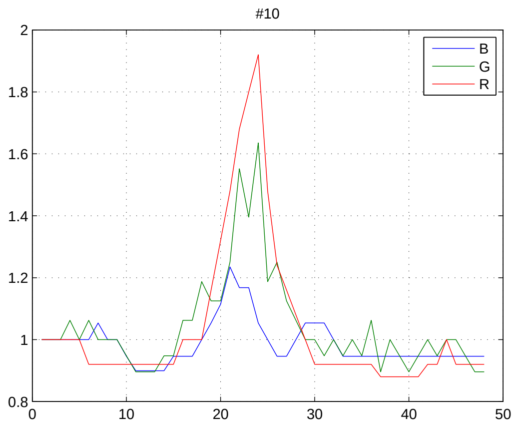

Fig. 26: Color map.

Evaluation of flying objects' properties

Observing UAPs, it becomes necessary to evaluate their characteristics. In particular, the sizes of bright objects can be determined if they shine with reflected sunlight. Practice shows that fireflies are visible only in the daytime sky. With the onset of twilight, their brightness decreases, and with the setting of the sun, they disappear from view. If their distance is known from parallax measurements, and if their albedo value is assumed, then one can easily determine the size of the object without angular resolution.

For calculations, we need to know the brightness of the daytime sky near the object and the distribution of energy in the spectrum of the Sun. The generic analytical expression of the spectrum of a clear daylight sky is given in [13]. The brightness of a clear blue sky for a zenith distance of 45 deg depending on the wavelength λ and the distribution of energy in the spectrum of the Sun are given in [1]. In particular, a clear daylight sky brightness for $\lambda = 0.5$ μm $F_{sky} = 4.5 \; erg/(cm^2 \cdot s \cdot \text{Å} \cdot sr)$. The solar radiation flux $F_{sun} = 193 \; erg/(cm^2 \cdot s \cdot \text{Å})$.

We represent the light fluxes of the object and the sky background as:

$$I_{obj} = F_{sun} \cdot r^2/R^2 \cdot \alpha \tag{4}$$

$$I_{sky} = F_{sky} \cdot \Omega \tag{5}$$

$$I_{obj} = \beta \cdot I_{sky} \tag{6}$$

Here r is the size of the object, R is the distance to the object, α is the albedo, β is the ratio of the brightness of the object to the brightness of the sky background, and Ω is the solid angle of the pixel. This implies

$$r = R \cdot \sqrt{\beta \cdot F_{sky} \cdot \Omega/(F_{sun} \cdot \alpha)} \tag{7}$$

If the distance and the size of the object are known from parallax measurements, then one can easily determine the albedo value:

$$\alpha = \beta \cdot F_{sky} \cdot \Omega/F_{sun} \cdot (R/r)^2 \tag{8}$$

where Ω is the solid angle of the object.

Using the distance and size given above and β according to Fig. 26 equal to 2, one can to estimate the albedo of the object to be 0.037.

An image of the object can be seen in Figs. 25 and 26. Fig. 26 shows the color map of the object in RGB rays. The object size can be estimated to be 7 $\pm$ 1 pixels. The PSF (point spread function) of the camera is about 2 x 2 pixels. This gives reason to consider the object as a finite-size object, and estimate the size of the object to be 3.0 $\pm$ 0.4 km. In any case, we can state that the object has a very impressive size.

4.2 Two-side observation of UAP

Fig. 27 demonstrates two-side observations of UAP for the object in UTC: 23/07/2022, 07:23:10.831. For UAP observations of the object, we used two meteor stations installed in Kyiv and in the Vinarivka village. The distance between stations is 120 km. The stations are equipped with ASI 178 MC and ASI 294 MC Pro cameras, and lenses with a focal length of 6 mm and 37 mm. The FOV are 5.5 and 4.58 deg. The object cross frame of 5.5 degrees for 0.32 sec with 4.1 ms exposure. It demonstrates a speed of 17.1 degrees per second.

An object against the background of the Moon was detected at the zenith angle of 56 degrees. Parallax of about 5 degrees was evaluated. This allows us to evaluate a distance equal to 1524 km, an altitude of 1174 km, and a linear speed of 282 km/s.

The coincidence of 2-point light curves in Fig. 29 proves we observe the same object from two points. Fig. 30 shows the light curve at a sampling rate of 238 Hz. The object flashes for 16 milliseconds at about 20 times per second. Note that the object was observed for only 0.32 seconds.

The special feature of the object is the intensity of the glow drops to almost zero. It is natural to assume that a bright object shines by reflected sunlight. But this is not compatible with the intensity drop to zero.

Fig. 28 demonstrates the images with the Moon and bright object (top panel). The bottom panel shows the color RGB diagrams of the Moon and the bright object.

The PSF (point spread function) of the camera is about 2 x 2 pixels and is almost the same size as the object. This gives reason to consider the object as a point source.

The color RGB diagrams of the Moon and the bright object are almost identical within the error limits. It can be assumed that the albedo of the object is similar to the albedo of the Moon and has a value of 0.067 according to [1]. Then, using formula (7), we obtain the size of UAP equal to 1.0 $\pm$ 0.2 km.

5 Analysis of objects near the Moon

On March 26, 2020, a French astronomer Mark Carlotto used a telescope to capture a video showing the moon at night [6]. Dr. M. Carlotto is a specialist in digital video analysis of space objects [7]. The video shows three objects rising above the Moon's limb, flying across the lunar surface and disappearing in the Moon's shadow.

What is immediately evident is that the objects in the video are large enough and close enough to the moon to be able to cast noticeable shadows.

The fact that these objects are so clearly visible in the video immediately suggests that they are quite large. Using the large Endymion crater shown in the video as a benchmark, the sizes of the objects were determined. The size of a single object flying over Endymion is about 5 miles long and about 1 to 3 miles wide. The other two objects appear to be comparable in size.

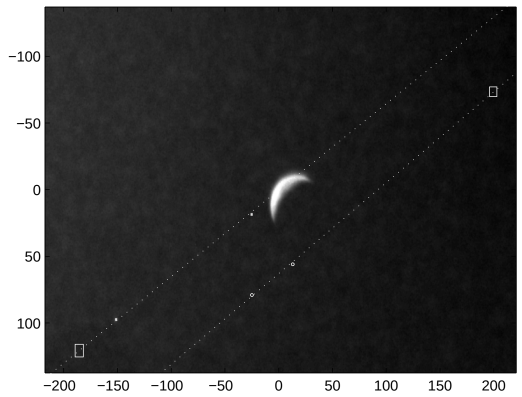

Fig. 27: A composite image of the bright object with two-side observations.

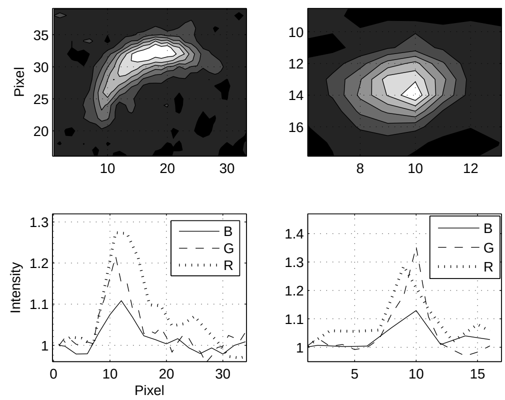

Fig. 28: The images with the Moon and bright object (top panel). The color RGB diagrams of the Moon and bright object (bottom panel).

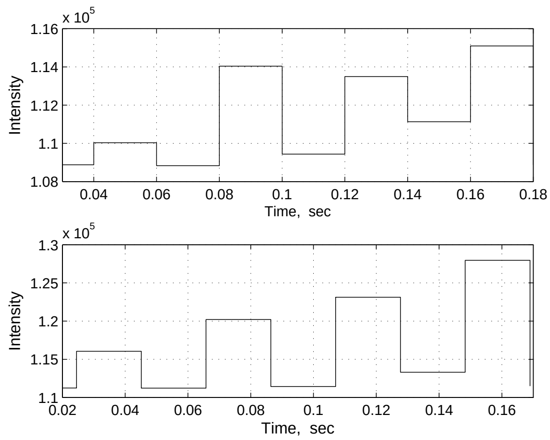

Fig. 29: Two-point object light curves.

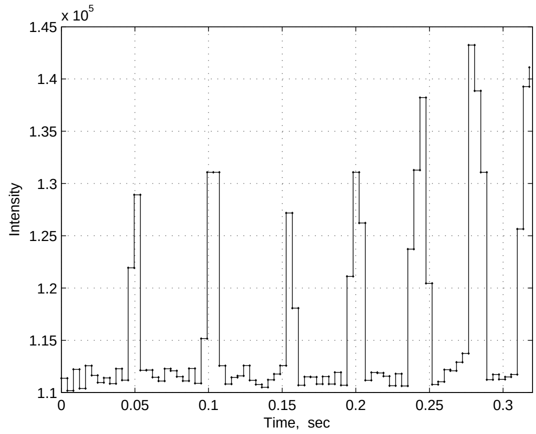

Fig. 30: The light curve at a sampling rate of 238 Hz.

By measuring the displacement of the object between frames of the video, it appears that the object is traveling at about 31 mps. It is traveling more than 30 times faster than if it were in lunar orbit.

A paper was recently published that attempts to prove that the original video is a fake. We have analyzed the video and made calculations that confirm the originality of the video.

We performed a colorimetric analysis of the surface of the Moon (Endymion crater) and the object in Fig. 31. We represent the light fluxes of the object and the moon background as:

$$I_{obj} = F_{sun} \cdot \alpha_{obj}$$

and

$$I_{moon} = F_{sun} \cdot \alpha_{moon}$$

We took RGB intensity estimates of the crater and object points. Ratio of intensities in white light $\beta = I_{moon}/I_{obj} = \alpha_{moon}/\alpha_{obj} = 2.65$. The Moon's albedo α_{moon} is 0.067 [1]. This gives us an estimate of the object's albedo α_{obj} of 0.025.

The size of Endymion crater in Fig. 31 (bottom panel) is 59 miles. This gives a pixel size estimate of 0.151 miles. The size of an object flying in Fig. 32 can be estimated to be about 4.3 miles long and about 2.2 miles wide or 6.8 and 3.5 km, respectively.

The size of an object flying in Fig. 31 (bottom panel) is 12 pixels or about 1.8 miles or about 3.0 km.

The distance of the object flying over the surface of the Moon in Fig. 32 is 36 pixels. The object's height above the Moon's surface is 5.4 miles, or 8.7 kilometers.

The color diagram of the object in RGB rays is shown in Fig. 33.

We can argue that our object estimates and Carlotto's estimates agree within measurement error.

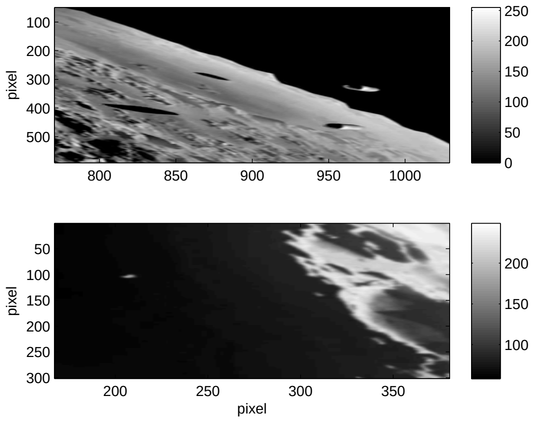

Fig. 31: Frame from original video.

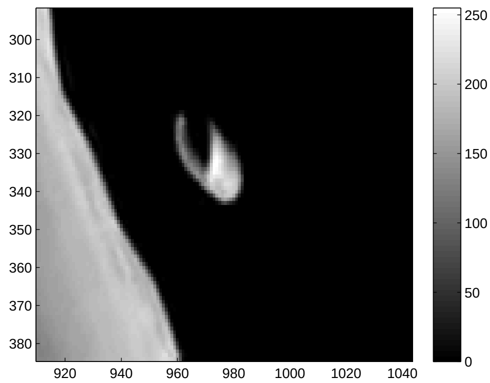

Fig. 32: Frame from original video.

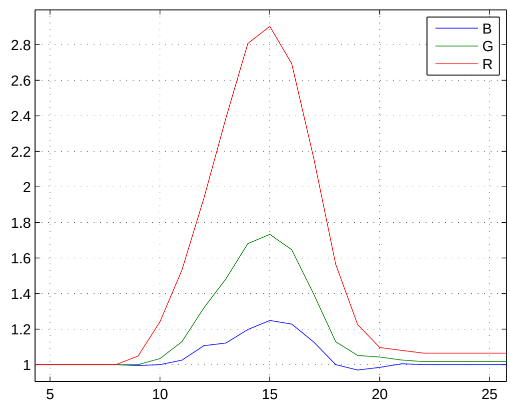

Fig. 33: The color diagram of the object in the RGB Bayer filters.

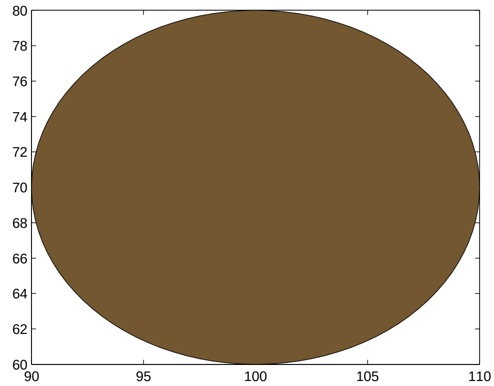

Fig. 34: The restored image of the object.

Color properties of flying objects

Fig. 33 shows the color diagram of the object in the RGB Bayer filters. Object colors can be converted to the Johnson BVR astronomical color system using the color corrections published in [10]. Semi-empirical relations are as follows:

$$(B - V)_J = 1.47 \cdot (B - G) + 0.12 \tag{9}$$

$$(V - R)_J = (G - R) + 0.23 \tag{10}$$

According to Fig. 33 the color index $(B - G)$ is 0.38. Hence $(B - V)_J$ is 0.68. Similarly $(V - R)_J$ is 0.77. Visually, such an object is perceived as very dark.

For control, we use the formulae (6, 7) to determine the color index $(B-V)_J$ in the Moon. The calculated color index $(B-V)_J$ is equal 0.72. According to [11], the measured color index $(B-V)_J$ is 0.75 ± 0.01.

Using the color chart in Fig. 33, we can restore the color image of the object in the Bayer RGB filters. We use a triple of row vectors $[rgb]$ as indexes to specify the color. Note that the RGB intensity depends on the extinction correction known in [1]: [0.91 0.82 0.73]. We have colotmap as $[rgb] = [1/0.91\ 0.61/0.82\ 0.43/0.73] \cdot albedo$. The restored image is shown in Fig. 34.

6 Analysis of the object recorded by the Ukrainian armed forces in the combat zone

Source of nighttime UAP observations: Instagram account [8]. The date of the video upload is 24-2-2024. Video title: "Exclusive footage sent in by a military unit. The 406th battalion of the UAF captured some kind of UAP on its drone while observing the front line".

Later (27-2-2024), the British newspaper Daily Mail wrote about the sighting, also referring to the 406th Battalion video, under the headline "Ukrainian Armed Forces record UFO in a combat zone. EXCLUSIVE: Disk-shaped UFO filmed by Ukrainian military in combat zone."

The video was taken from a DJI Mavic 3T drone with a thermographic camera. The characteristics are given in [9].

DJI Mavic 3T specifications: (1) sensor - uncooled Vox microbolometer, (2) 12 μm pixel, (3) 30 Hz frame rate, (4) MP4 video format, (5) infrared wavelength 8 to 14 μm.

The video is 17 seconds long. A typical frame of the video is shown in Fig. 35.

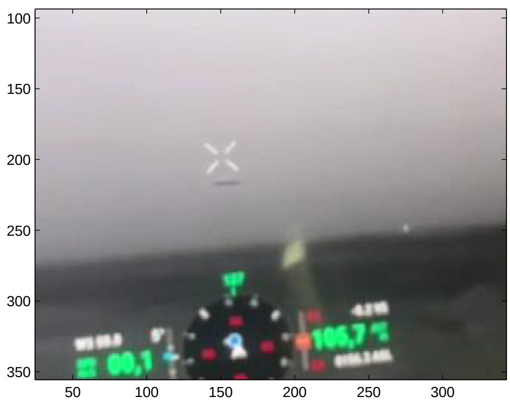

Fig. 35: A typical frame of the video.

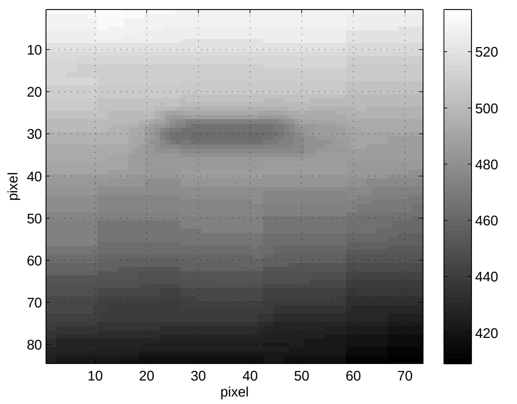

Fig. 36: The object in the video is a dark, elongated body.

The object in the video (Figs. 35 and 36) is a dark, elongated body, slightly irregular in shape, with a blurred edge.

The Daily Mail article states that "While the size, altitude, and shape of the object remain a mystery, the drone's own altitude indicates that the apparent object could be a large craft over 30 miles away." That is, the expert estimate of the distance is more than 48 km.

Fig. 36 shows a dark object at the end of the observation. It can be stated that the object does not emit and has the characteristics of a completely black body. The low contrast of the image (about 7% at the beginning of the observation) makes it difficult to detect the object.

The object's brightness and the sky's background allow us to determine the distance by colorimetric methods. A prerequisite is scattering as the main source of atmospheric radiation. The distance can be determined from the residual intensity on the contrast map according to the graph in Fig. 37.

In the approximation of a homogeneous atmosphere with an altitude of 10 km, the distance $S = 10/sin(h) \cdot r$, where h is the height of the object above the horizon, r is the residual intensity on the contrast map shown in Fig. 37. Using the approximation of a homogeneous atmosphere instead of a real atmosphere with an exponential density distribution gives an error of no more than 6% [1].

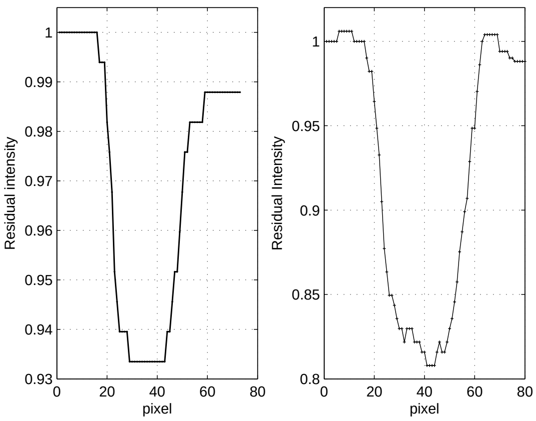

Fig. 37: Contrast map at the beginning of the observation (left panel) and at the end (right panel).

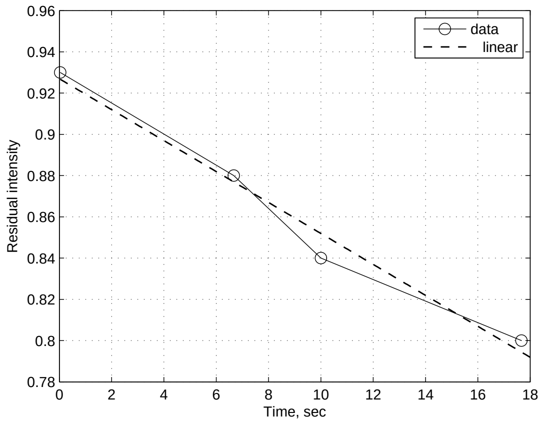

Fig. 38: Linear variations of residual intensity along the trajectory.

The height of the object above the horizon at the beginning of the observation is 6.1 degrees. The contrast map of the dark object in the IR wavelength range in Fig. 37 estimates the distance to the object to be 88 km at the beginning and 75 km at the end. The height of the object can be estimated at 8 km.

Fig. 38 shows linear changes of the residual intensity along the trajectory. This indicates that the velocity of the object is constant. Its radial velocity will be about 806 m/s (about 2.5 M).

The angular size of the object can be estimated at 40 pixels and its height at 10 pixels (Figure 36). It can be assumed that the object has a width of about 6 km and a height of about 1.5 km.

Results

The object was discovered by chance during a nighttime drone inspection at 6.1 degrees above the horizon. It was initially located 88 km away, at an altitude of 8 km. During an observation time of 17 seconds, it flew 14 km at a speed of 803 m/s (Mach 2.5).

The object is Disk-shaped and of tremendous size. It resembles a large floating island in the sky Laputa inhabited by scientists and philosophers in Swift's novel about Gulliver.

7 Discussion

Two-side observations of bright UAPs show that (1) they are tropospheric objects at altitudes of several kilometers; (2) their size is about 10 m; and (3) their velocity can be several Mach or more.

Dark objects in the troposphere over Kiev and New York demonstrate large linear dimensions, one about 150 meters and the other about 100 meters. Both objects have unprecedentedly high velocity: one is about 120 km/s, the other about 13 km/s. The motion of the objects does not cause atmospheric disturbances.

The size of the object seen in the vicinity of the Moon is estimated to be about 6.8 km long and about 3.5 km wide.

The object, recorded in the war zone, was discovered by chance during a nighttime drone survey at an altitude of 6.1 degrees above the horizon. It was initially located at a distance of 88 km, at an altitude of 8 km. During the time of observation (17 seconds) it flew 14 km at a speed of 803 m/s (Mach 2.5). The object is disk-shaped and enormous in size.

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