Interesting fireball invasion in the sky over Kiev. G. N. Dashkiev[1], B. E. Zhilyaev[2], A. F. Steklov[1, 2], A. P. Vidmachenko[2, 3], [1]Interregional Academy of Personnel Management, Frometivska Str., 2, Kyiv, 03039, Ukraine, [2]Main Astronomical Observatory of National Academy of Sciences of Ukraine, Ak. Zabolotnogo Str., 27, Kyiv, 03143, Ukraine, [3]National University of Life and Environmental Sciences of Ukraine, Heroyiv Oborony Str., 12, Kyiv, 03041, Ukraine, dashkiev@i.ua

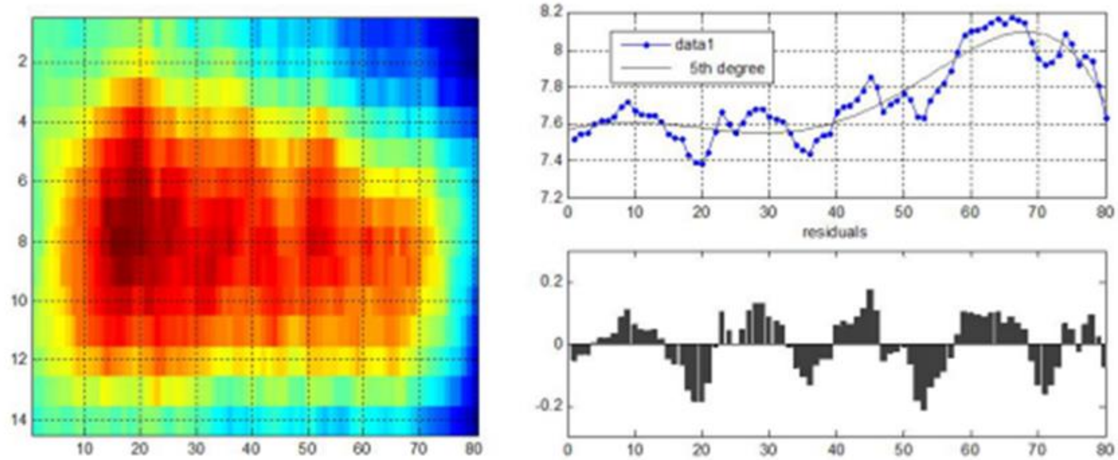

Fig. 3. The "trace" of the meteor ("light path") contains information about the variations in brightness and "bumpiness" of the meteor on the flight path.

Traces of fireballs are mainly composed of dust particles. Therefore, after a short flash, both during the daytime and at twilight, such a dusty trails are illuminated by the rays of the Sun and are visible in the form of bright stripes on a darker sky [1-5]. We observed such tracks from a few seconds to almost two hours, until they were destroyed by air flows [18]. Traces of space invasions are a mapping of their trajectories on the surface of the celestial sphere. From the geometrical point of view, the finding of the invasion trajectory is a Cauchy problem, which consists in finding an integral surface in space passing through a given spatial curve.

Fig. 1 present the obtained 10.28.2018 trace of the invasion. Fig. 2 shows a contour image of a trace with equidensites in the form of screw contour. It is a spatial curve obtained by moving a point that moves along the generatrix of a cylinder (or a cone), with uniform rotation around the axis. Horizontal projection of conic screw lines – is the Archimedes spiral, and the frontal projection – is a sinusoid with damped amplitude [17]. When moving in the atmosphere of a non-spherical object of irregular shape, a lifting force appears which will be perpendicular to the velocity vector of motion. It arises as a result of the asymmetric flow of such a body by a gas flow. And since the lifting force is perpendicular to the velocity vector of motion, that it is one of the reasons for the movement of the invading body along a helical path.

Fig. 1. The image of the trace of the invasion of the atmosphere.

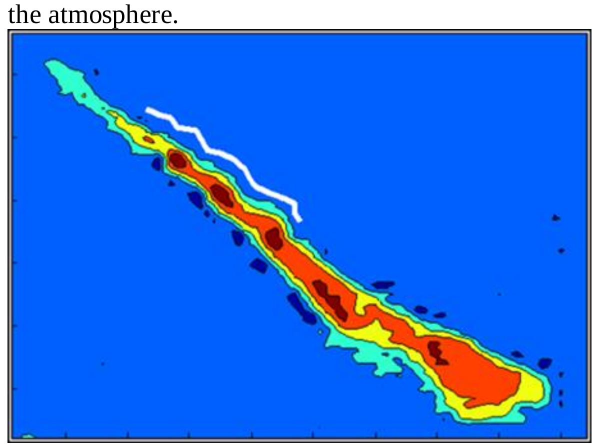

Fig. 2. Contour image of the track. Sine curve on the frontal projection of the image of the invasion (white).

Thus, if on the frontal projection of the image of the invasion we can construct a sinusoidal curve, then we can be sure that the trajectory of the invasion is screw line. Consideration of the motion of a meteoroid within the framework of the dynamics of a compressible gas shows that the motion of gas in the meteor trail is accompanied by an unsteady rarefaction wave. Our estimates allow us to conclude that almost all space invasions (meteoroids, fragments of space debris) are accompanied in the troposphere by the appearance of an inversion trace [8, 9]. Under favorable conditions, the inversion trail is formed almost instantly: a thousandths of a second. In the case of saturated steam, the trace can persist for a long time [10–15]. The processing of a number of bolide intrusions has shown that the trails of such intrusions usually is characterized by such factors: 1) around the object of the invasion, a kind of crown is observed, which indicates an intense warming of the surrounding air; 2) several flashes of light can be seen along the track; it indicates intense pulsation in such trace; 3) almost all invasions were ending the explosion of the object and the symmetric spread of its fragments; 4) often the invasions demonstrate a complex flight path of the "corkscrew" type.

In the spring of 2018, we observed the Lyrid meteor shower with a maximum at April 23 [6]. Morning and evening monitoring were carried out with using “Canon” DSLR cameras in modes of serial shooting and video registration (30 frames per 1 second). For each half-hour observation period, about 4 meteor events were recorded. According to the obtained images, we estimated such parameters: duration of the meteor track (fraction of a second), amplitude in white light up to 3.25^m relative to the sky background, speed of meteors up to 67.5 degrees/sec, width of the meteor trail reached 27 angular minutes, which is comparable with the size of the Moon.

From the data of colorimetry it was obtained that along the flight path the meteor changes its color significantly; this reflects the fact that the meteoroid is warming up. For example, for one of the events during the time of flight of 0.3 seconds, the temperature in meteor's trail changed from 6 to 11 thousand Kelvins. In addition, for light curves of meteor's tracks, it was possible to identify high-frequency oscillations (hundreds of Hertz), as well as “wobbling” with deviations of about 6% of meteor track width (Fig. 3).

References: [1] Churyumov K. I. et al. (2014) *ASR, 10(1),* 37-42. [2] Churyumov K. I. et al. (2015) *17ISCAS YS*, 84-85. [3] Churyumov K. I. et al. (2015) *ASR, 11(2)*, 99-102. [4] Churyumov K. I. at al. (2016) *AP 5ISC,* 33-37. [5] Churyumov K. I. et al. (2016) *ICoMeteoroids2016, ESTEC,* 63. [6] Kruchynenko V.G. et al. (2017) *19ISCAS YS*, 60-61. [7] Landau L. D. and Lifshits L. M. (1988) *Hydrodynamics*, *M Nauka, 736*. [8] Spurny P. and, Porubčan V. (2002) *ACM 2002, ESA-500,* 269-272. [9] Steklov A. F. et al.(1918) *18GamowSS*, 49. [10] Steklov A.F. et al. (2017*) 19ISCAS YS*, 73-75. [11] Steklov E.A. et al. (2017) *48LPSC*, *LPICo 964*, id.1327. [12] Vidmachenko A. P. (2015) *AAlm, 62*, 228-249. [13] Vidmachenko A. P. and Morozhenko O. V. (2014) *MAO NASU, NULESU, PHProfi*, 388. [14] Vidmachenko A. P. and Steklov A. F. (2013) *ASR, 9(2),* 146-148. [15] Vidmachenko A. P. and Vidmachenko H. A. (2007) *AAlm, 53,* 195-207. [16] Zhilyaev B. E. and Totochava A. G. (1996) *ASP CS*, 96, 97. [17] https://stuwood.ru/1635363/matematika_himiya_fizika/sinusoida. [18] http://www.astronet.ru/db/msg/1198013/04.html.