THE PHYSICS OF SPACE INTRUSIONS. COLORIMETRY OF METEORS

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For the analysis, we used the image of the Leonid-6230 meteor obtained by Mike Hankey in 2012 [4]. We applied a colorimetric approach [8-11]. It allows you to quantify the characteristics of meteors such as temperature, chemical composition and others. Photometry of a meteor trail shows changes in brightness with fluctuations along the path and across the direction of travel. Oscillation when moving in a direction perpendicular to the wake (Magnus effect [11]) had an amplitude of 2% and a frequency of 46 Hz; and the main fluctuations in brightness in the meteor trail are observed at a frequency of about 3 Hz with an amplitude of about 3%.

We use the “tuning technique” for program Impact 4A [2, 5] in conjunction with a simulated intrusion to characterize the meteor. It turned out that the progenitor of the meteor is an object weighing 900 kg at a speed of 36.5 km/s. The meteoroid reached a critical pressure at an altitude of about 29 km in a time of 4.6 s with a residual mass of 20 kg and a residual velocity of 28 km/s. The colorimetry of celestial objects in astronomy is based on Johnson's UBVR color system. Color diagrams U-B, B-V, V-R, allow you to determine the effective temperature of radiation sources, as well as the characteristics of the plasma. For meteors, colorimetry can determine the effective temperature in the case of optically thick plasma. In the BVR color systems, Johnson's B-V, V-R color diagrams are attached to the scale of the effective radiation temperature of a black body and main sequence stars in the range from 2650 K to 50,000 K [1, 6].

Using colorimetric data for the Johnson BVR bands and the Adobe BGR color system [12], one can easily switch from the RGB CMOS camera color system to the Johnson RVB system and determine the color characteristics of meteoric radiation, as well as identify the brightest spectral lines. To construct two-color diagrams, the color indices of the radiation of an absolutely black body were used [6]. Based on the data obtained, we determined the color indices of the meteor's own radiation. After some time, the meteor radiation is localized in the area close to the radiation of a black body. The bulk of our meteor track shows a blackbody spectrum with temperatures ranging from 4200 K at the beginning to 5500 K at the end of the path.

We found lines responsible for emissions of atmospheric oxygen O I (779 nm) and nitrogen N_2 (631 nm) in the meteor track, as well as a high-temperature component of the spectrum that emits like a black body. At the beginning of the trajectory, emission of magnesium Mg I 518 nm, nitrogen N2 631 nm, iron Fe I 373, 649 nm and the Balmer hydrogen line H_α 656 nm are observed. At the end of the trajectory, a global explosion and complete destruction of the meteor are observed. The cloud shone in the lines Ca II H, K 393, 397 nm, Fe I 382, 405 nm, Mg I 517 nm, Na I 589 nm, and O I 779 nm. Knowing the light curves of RGB filters at the emission line wavelengths, the absolute quantum efficiency (QE) of the receiver, we estimated the intensities of lines in the spectrum.

At the end of the light curves, the meteoroid reached a critical pressure on the surface, exceeding the strength of the material. At that moment, the meteoroid exploded and collapsed. To estimate the characteristics of the explosive cloud, we used the theory of a strong explosion in the atmosphere [3, 7]. As shown in [3], the gas motion in this case will be self-similar. The radius of the sphere of the shock wave depends on the energy of the explosion, the density of the atmosphere, and time. The self-similar nature of the motion is violated when the pressure at the front of the blast wave reaches the atmospheric value.

The simulation results made it possible to estimate the parameters of the meteor during the explosion: v = 28 km/s, m = 20 kg, E = 1010 J, air pressure – 0 .012 bar, sound speed – 315 m/s. Hence it follows: the radius of the explosion cloud is about 200 m, the cloud formation time is 0.64 s, the optical thickness of nitrogen in the cloud, depending on the temperature of the meteoroid at the moment of the explosion, was 0.1 at 4200 K, 1.0 at 4600 K and more than 60 at 5500 K.

Our colorimetric approach to quantifying the characteristics of meteors allowed us to estimate the temperature (at the beginning of flight 4200 K, at the end – 5500 K) for the Leonid-6230 meteor, the chemical composition and its spectrum, containing above mentioned emission lines.

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