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Bright sporadic fireball with an Asteroidal Origin and its Parent Body

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Abstract

An accurate astrometric analysis of a bright and slowly moving sporadic fireball observed over Tajikistan in the framework of a continuous meteor monitoring. The fireball had an absolute magnitude of -7.3 and was recorded on October 30, 1962. Because of its computed low terminal height and non-zero ending mass, this event falls into the category of meteorite-dropping meteoroids so deserves further study.

1. Introduction

Bright fireball events are produced by large meteoroids penetrating Earth's atmosphere from very diverse bodies [1-4]. By obtaining accurate trajectory and orbital information we try to better understand the origin of this dangerous projectiles between the big diversity of small bodies populating the Earth-region vicinity. Bright fireballs are produced by large meteoroids which are capable, under the right geometric conditions, of producing meteorites. The meteorites are free-delivered samples that can help us to understand the solar system genesis and the processes that occurred after the formation of asteroids, the parent bodies of most meteorites. Meteor recordings provide useful data for the determination of the velocity, radiant, orbit and luminosity data as well as the physical properties of meteoroids and creation a link between meteoroids, meteorites and their parent bodies. We present here the analysis of a slow moving sporadic fireball, photographed in the past over the Hissar astronomical observatory (HisAO) and meteor station Kipchak (Tajikistan). This event was recorded during a systematic long-term observational photographic program on October 30, 1962 and had a maximal brightness corresponding to an absolute magnitude of -7.3.

2. Instrumentation

Two Tajikistan observing stations (Table 1) imaged the fireball discussed in this contribution. Both stations operated a system of meteor small-cameras MK-25 equipped with Uranus-9 (D/f = 1/2.5, f = 250mm) lenses which take one exposure per hour. The photographic plates, originally 19×19 cm^2 in size consisted of panchromatic emulsions (see e.g. Fig. 1). For the definition of the meteor velocity six small-cameras were equipped with rotating shutter creating 25 breaks/sec located in front of the lens. Each of these small-cameras covered an area of the sky measuring approximately 40º×50º and recorded meteors brighter than +1 visual magnitude.

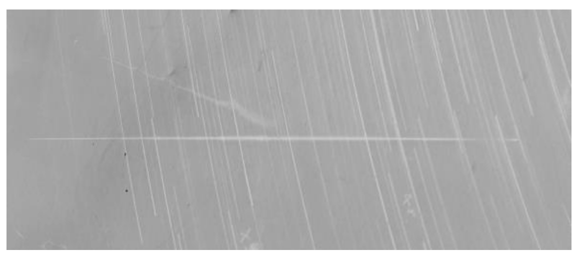

Figure 1. Image of the 062D3 (code 622215) fireball from the Hissar Astronomical Observatory station.

Table 1. Geographical coordinates of the meteor observing stations involved in this work.

Station name	Longitude (E)	Latitude (N)	Altitude (m)
HisAO	68º 29´ 22"	38º 29´22"	740
Kipchak	69º 01' 38"	38º 34' 53"	893

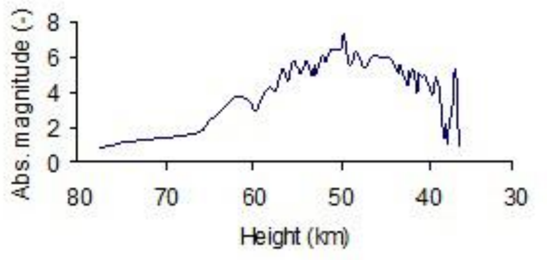

Figure 2. Light curve of the 062D3 fireball imaged from HisAO.

3. Observations and results

On October 30, 1962 at 17h 28m 10.5s UT, a bright fireball (abs. magnitude -7.3±0.2) was imaged by the Meteor Patrol of the Hissar Astronomical Observatory (Figure 1). The event was also recorded from meteor station Kipchak located 32 km from the Meteor Patrol. The parent meteoroid entered the atmosphere with a pre-atmospheric velocity V_∞=13.7±0.1 km/s. The fireball started its luminous path at a height of about 77.4±0.2 km, reached its maximum brightness when the bolide was located at a height of 49.4±0.2 km and ended at 36.2±0.2 km over the ground level. The geocentric radiant of the fireball was located at α=332.6±0.3º, δ=-12.3±0.2º. Atmospheric trajectory, radiant data and orbital elements are shown on Tables 2, 3 [5]. The orbital elements of the meteoroid confirmed the sporadic nature and asteroidal origin (T_j = 3.3) of this event. The fireball exhibited three strong flares including a very bright terminal flare which could point to sudden fragmentation of the body and numerous flickering in the second part of the trajectory. The light curve (Fig. 2) shows that maximal brightness was reached at an altitude of 49.5 km under an aerodynamic pressure of 0.2 MPa and terminal flare has occurred at about 37 km under an aerodynamic pressure of 0.3 MPa. This light curve has been used to infer the initial photometric mass of the meteoroid. A value of about 2.5 kg was obtained using the numerical value of luminous efficient provided by Ceplecha and McCrosky [6]. The terminal mass of the likely meteorite would vary from ~16 g (for a density d = 3.7 g/cm^3) to 47 g (for d = 2.2 g/cm^3).

Table 2: Radiant (J2000) and trajectory data.

HisAO Code	M_v	H_b (km)	H_e (km)	α_g (º)	δ_g (º)	V_∞ (km/s)	V_g (km/s)	V_h (km/s)
622215	-7.3 ±0.2	77.4 ±0.2	36.2 ±0.2	332.6 ±0.3	-12.3 ±0.2	13.7 ±0.1	8.0 ±0.1	37.6 ±0.1

Table 3: Orbital data (J2000).

HisAO Code	a (AU)	e	i (º)	Ω (º)	ω (º)	q (AU)	T_J
622215	2.36 ±0.04	0.583 ±0.006	0.29 ±0.15	36.66 ±0.014	15.47 ±0.3	0.984 ±0.002	3.3 ±0/015

In order to find a likely parent body for the meteoroid we have employed the ORAS software (ORbital Association Software) with the information contained in the NeoDys database. By using the Southworth and Hawkings D_{SH} dissimilarity criterion [7] the best match is obtained with the near-Earth object 2011SL189, with D_{SH}=0.05.

4. Summary and Conclusions

The event analyzed here fall within the fireball category. The calculated radiant and orbital data confirm the sporadic nature of this event and the likely asteroidal origin of the progenitor meteoroid. The derived value of the aerodynamic pressure at the heights of maximal brightness and terminal flare were used to estimate the bulk density of the meteoroid by using the graphical fit of the meteoroid bulk density versus the compressive strength shown in [8]. As result a value of about 1.2 g cm^{-3} is obtained and confirms the fragility of the meteoroid.

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