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ACCURATE CHARACTERIZATION OF METRE-SIZED IMPACTORS THROUGH CASUAL BOLIDE OBSERVATIONS – NOVO MESTO SUPERBOLIDE AS EVIDENCE FOR A NEW CLASS OF HIGH-RISK OBJECTS

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ABSTRACT

The Chelyabinsk superbolide was caused by the largest asteroid entering the Earth's atmosphere since the 1908 Tunguska event, and the only confirmed airburst in history known to have caused human injuries. The Chelyabinsk event was also the first superbolide to have been well documented by ground-based casual video cameras. These data formed the basis to accurately model the asteroid's physical properties

and structure, which were further refined from recovered meteorites. Compared to space-based sensors, which with presently available data only measure brightness with time (and hence energy deposition), ground-based cameras have the advantage of providing a measurement of entry dynamics, a crucial constraint for entry models. To date, only half a dozen meter-sized or larger impactors have been instrumentally observed by dedicated fireball cameras. With the widespread use of high-resolution dashcams and security cameras, it is now also possible to record details of fragmentation and bolide wake - features not visible in data derived from space-based sensors.

In this work, we present a novel method of calibrating daytime observations of superbolides using casual videos which provides measurements of bolide trajectory, dynamics, and light curve of comparable quality to dedicated instrumental systems. We present open-source software with the implementation of the method and a fireball entry model.

We apply these tools to analyze the Novo Mesto superbolide, which occurred on February 28th, 2020, over Slovenia and resulted in the fall of several L5 meteorites. The ~1 m asteroid produced a 0.3 kT airburst which was felt on the ground as a minor earthquake. In contrast to other meter-sized impactors, >80% of the mass loss experienced by the impactor occurred in a single fragmentation point (Figure 1) at a dynamic pressure of 3.5 MPa (at an altitude of 35 km). The observed increase in atmospheric energy deposition is best explained by a massive release of mm-sized dust, evidenced by a bright luminous trail visible for several seconds. Only ~30 kg of the initial body survived the peak dynamic pressure of ~10 MPa.

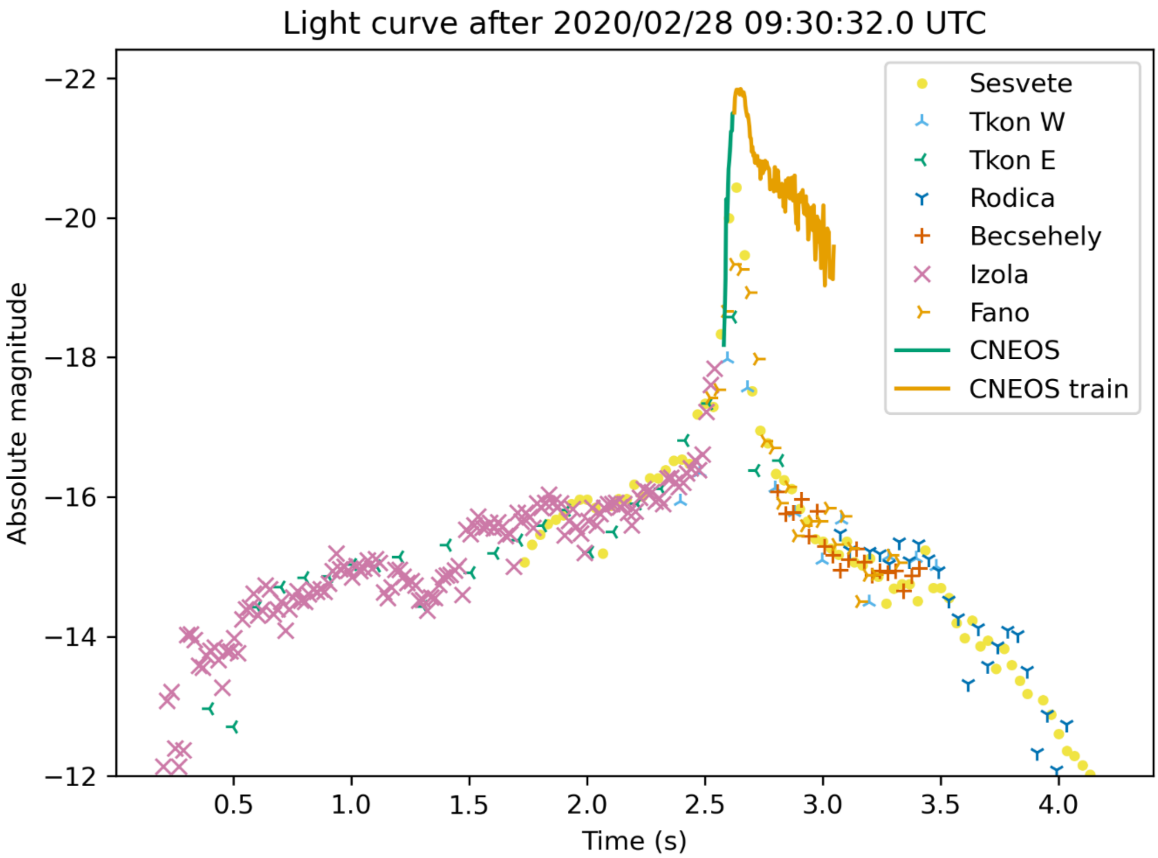

Figure 1: Light curve of the Novo Mesto fireball reconstructed from independently calibrated ground-based casual video records and US government sensors (CNEOS).

This object, together with one other similar case, provides evidence for a special class of Near-Earth Objects (NEOs) which catastrophically disrupt into small fragments and deposit most of their energy in a single point rather than in a prolonged cascade of fragmentations. This contrasts with classical assumptions of a Weibull strength distribution which assumes a more gradual fragmentation at lower pressures. Such objects present a higher risk as small impactors can create outsized airbursts.

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Comments:

(Alternative session: NEO Characterization; Oral preferred - attractive video materials will be shown)