ON THE INTERSTELLAR ORIGIN OF THE 20140108 CNEOS/USG SUPERBOLIDE. P. Brown[1,2] and J. Borovička[3], [1]Department of Physics and Astronomy, University of Western Ontario, London, Ontario, N6A 3K7, CANADA, [2] Institute of Earth and Space Exploration, Western University, [3]Astronomical Institute of the Czech Academy of Sciences, Fričova298, CZ-25165 Ondřejov, Czech Republic

Introduction: Several recent works [1,2,3] have claimed that a meter-sized impactor recorded by US Government (USG) sensors in 2014 may be of interstellar origin. The interstellar origin of this event is based on its measured speed and radiant which produce a highly unbound orbit. Prior surveys at smaller meteoroid sizes, where interstellar particles should be more abundant, have failed to produce convincing interstellar detections [4,5,6]. Experience from these past surveys which have attempted to isolate interstellar meteoroids have emphasized the need for careful estimates of uncertainty [7], values for which are not available for USG data. However, it is possible to place this event in context with other USG data by examining the dataset as a whole as we will discuss. In particular, ground-based fireballs also detected by USG provide a useful means of calibrating the global USG accuracy [8]. For example, as of early April, 2023, six USG events have measured hyperbolic orbits, among a dataset of 288, representing a 2% interstellar fraction. This is similar to the percentage found in ground-based optical surveys where errors push orbits to be nominally hyperbolic [5].

Methods and Data: The data available for USG 20140108 from USG sensors include the time (170534 UT), speed at peak brightness (44.8 km/s), height of peak brightness (18.7 km), latitude/longitude (-1.3, 147.6) and apparent radiant (α_r=90.1º, δ_r=13.3º). The light curve of the fireball has also been released, from which we measure a radiated energy of 3.2×10^{10} J, assuming a 6000K blackbody. Using the relation from [9] results in a total source energy of 0.11 kT TNT equivalent. The infrasonic signal from the fireball was also detected at several infrasound stations, including I39 PW at a range of 1750 km and several in Australia. Preliminary analysis of those signals suggests a lower source energy than the USG estimate as will be discussed in this talk.

Ablation and Fragmentation Modelling: Using a semi-empirical ablation model [10] which has been applied successfully to several meteorite-producing fireballs, we explored ablation behavior which can match the observed light curve (Figure 1). The light curve is notable for showing four flares, three of which are very short and close together in time. For models using typical stony-meteoroid parameters, the light curve is substantially overestimated prior to the flares using the reported velocity. No normal combination of parameters could reproduce the light curve. To reproduce the first flare with the reported speed, we had to decrease ΓA to 0.2. This "exotic model" would correspond to a very aerodynamic body with low drag and low cross-section relative to the mass. But even the exotic model had problems to reproduce the light curve well. The brightness was too high between the first and the second flare (see Fig. 1). The fragment masses in this model were 0.1 kg. The dynamic pressure was also very high of order 190 MPa. Assuming a lower speed instead of the reported high speed, we could fit the model with conventional stony meteoroid parameters and the dynamic pressure approaches the upper limit of the hardest components in typical fireballs.

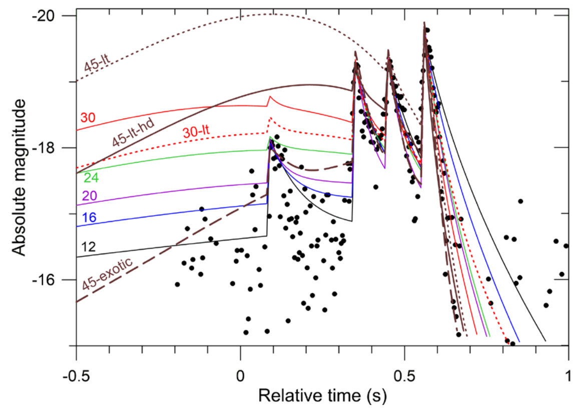

Figure 1. Ablation models of various speeds in km/s (colored curves) compared to observations (black dots).

Conclusions: The interstellar origin of CNEOS 20140108 remains controversial. In the absence of the original metric data used to measure the orbit a definitive conclusion as to its origin is not possible. However, we have shown that the ablation behavior can be consistent with a normal stony meteoroid, assuming a lower velocity than measured. Such a lower velocity would also suggest a non-interstellar origin for the object.

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