PRELIMINARY MODELING OF POTENTIAL INTERSTELLAR BOLIDE (08 JAN 2014) SUGGESTS FURTHER EXAMINATION IS WORTHWHILE.

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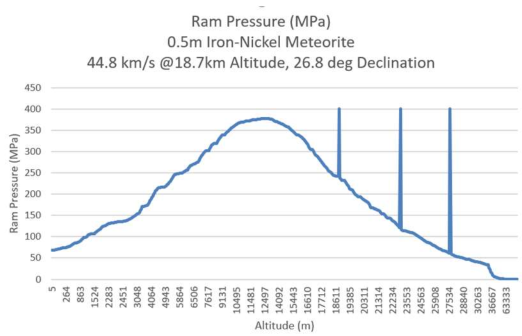
Introduction: The purpose of this abstract is to share data from preliminary modeling of meteor dynamics of the 08 Jan 2014 bolide which occurred north of Papua New Guinea as reported by US Department of Defense (DoD) sensors. A hypothesis has been proposed that this event was of interstellar origin [1]. DoD data indicate that this bolide was produced by a meteor moving 44.8 km/s at only 18.7 km altitude, which describes a velocity profile that is exceptional in velocity, much less at such a low altitude. The Jörmungandr model developed by the author for dark flight modeling was adapted to estimate the luminous flight profile of this body. While this model has significant limits in use for luminous flight and all results must be viewed as preliminary, analysis indicates there is a compelling need for further investigation. Calculation of ram pressure by this object indicate that an iron or iron-rich meteorite 0.5m in diameter is a possible explanation for the reported DoD data.

Methods: The Jörmungandr dark flight model was developed for calculating strewn fields from meteorites detected in weather radar data. It uses stepwise modeling of falling meteorites using 3D vector-based assessment of aerodynamic deceleration from winds and atmospheric pressure as meteorites fall to the ground. Wind direction, speed, and temperature data are provided with respect to altitude by radiosondes ("weather balloons"). This model has been validated on over two dozen recovered meteorite falls to date, but Jörmungandr is designed for "dark flight" at weather-radar altitudes and does not factor in mass loss through fragmentation or ablation. However, it is not resource-intensive and was used here for an initial assessment of possible solutions for the DoD data.

Results: *Velocity:* DoD reports a velocity of 44.8 km/s at 18.7 km altitude, indicating that the pre-atmospheric velocity was higher. Jörmungandr was used to estimate the velocity profile up to 85 km altitude (Fig.1). Results indicate an estimated pre-atmospheric velocity of ~49 km/s, higher than the 44.8 km/s used in [1] to assert an interstellar origin for this body. Orbital modeling should be revisited using this value. Jörmungandr does not account for mass loss which would decrease velocity at 18.7 km, so the estimated pre-atmospheric velocity of ~49 km/s is a lower bound which requires refinement.



Ram Pressure: The light curve from the 2014 event shows three major fragmentation events occurred, with the most luminous at 18.7 km. Ram pressure was calculated to assess the mechanical strength of the body (Figure 1). Jörmungandr indicates that fragmentation events at 18.7 km altitude and 0.1 and 0.2s prior fragmented under ram pressures of 247, 122, and 62 Mpa, respectively (vertical spikes added to Figure 1). Jörmungandr does not consider mass loss so actual velocity would be lower and these values are an upper bound. Since chondritic meteorites fragment at 0.5-5 MPa [2 and refs therein] and icy bodies are significantly weaker, they can be excluded from this event as they would not have survived below ≥45 km altitude. Iron meteorites exhibit compressive strength values of 424±143 MPa [3 and refs therein] and probably feature lesser size-vs-strength scaling behavior seen in chondritic meteorites, so these preliminary results suggest that an iron meteorite is within logical reach of explaining the observed DoD data. Pallasites exhibit similar strength [3].

Discussion: Multiple hypotheses must be examined. One, the DoD data is in error. Since the dataset is classified no peer-reviewed assessment is possible in open literature and this hypothesis remains valid at present. Two, the reported values of 44.8 km/s at 18.7 km altitude are correct, in which case Jörmungandr suggests that only an interstellar iron or iron-rich meteorite could explain the DoD data. These calculations are presented with the significant caveat that Jörmungandr was not designed for luminous flight and does not compute mass loss. Community input is needed to more adequately test this hypothesis, especially in the form of modeling with dedicated luminous-flight meteor models. Baldwin and Schaeffer [4] show that survival rate of an iron meteorite with this velocity would be on the order of 1e-7 to 1e-6, leaving only 0.05-0.5g of original 478 kg mass unmelted. Based on this it is reasonable to expect the entire mass was melted or vaporized. This complicates any potential recovery efforts, although recovery of melted micrometeorites from the seafloor has been demonstrated [5-7].

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