The Nature of Airbursts and their Contribution to the Impact Threat

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Ongoing simulations of low-altitude airbursts from hypervelocity asteroid impacts have led to a re-evaluation of the impact hazard that accounts for the enhanced damage potential relative to the standard point-source approximations. Computational models demonstrate that the altitude of maximum energy deposition is not a good estimate of the equivalent height of a point explosion, because the center of mass of an exploding projectile maintains a significant fraction of its initial momentum and is transported downward in the form of a high-temperature jet of expanding gas. This "fireball" descends to a depth well beneath the burst altitude before its velocity becomes subsonic. The time scale of this descent is similar to the time scale of the explosion itself, so the jet simultaneously couples both its translational and its radial kinetic energy to the atmosphere. Because of this downward flow, larger blast waves and stronger thermal radiation pulses are experienced at the surface than would be predicted for a nuclear explosion of the same yield at the same burst height. For impacts with a kinetic energy below some threshold value, the hot jet of vaporized projectile loses its momentum before it can make contact with the Earth's surface. The 1908 Tunguska explosion is the largest observed example of this first type of airburst. For impacts above the threshold, the fireball descends all the way to the ground, where it expands radially, driving supersonic winds and radiating thermal energy at temperatures that can melt silicate surface materials. The Libyan Desert Glass event, 29 million years ago, may be an example of this second, larger, and more destructive type of airburst. The kinetic energy threshold that demarcates these two airburst types depends on asteroid velocity, density, strength, and impact angle.

Airburst models, combined with a reexamination of the surface conditions at Tunguska in 1908, have revealed that several assumptions from the earlier analyses led to erroneous conclusions, resulting in an overestimate of the size of the Tunguska event. Because there is no evidence that the Tunguska fireball descended to the surface, the yield must have been about 5 megatons or lower. Better understanding of airbursts, combined with the diminishing number of undiscovered large asteroids, leads to the conclusion that airbursts represent a large and growing fraction of the total impact threat.

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