Science, society and the Chelyabinsk meteor

Don Barrett
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Much media attention has been given to the spectacular and widely recorded explosion of a significant meteor over Chelyabinsk, Russia, on the morning of February 15. The resulting shock wave shattered most windows in the city, with debris injuring over 1,000 people.

This event marked the first conjunction of a frequent and natural occurrence—the collision of the Earth with debris left over from the formation of the solar system—with a modern metropolis. It also invites examination of a significant disconnect between the development of the productive forces of society and their allocation towards the mitigation and avoidance of future, potentially far worse encounters. It should be noted that small changes in the Chelyabinsk meteor's path and composition could have produced a much lower airburst centered on the city, leading to the potential deaths of tens or even hundreds of thousands.

The understanding of meteors themselves is a triumph of the late age of the enlightenment. The motions of the best-known bodies in the solar system—Mercury, Venus, Earth, Mars, Jupiter, Saturn, the Sun, and the Moon—motivated some of the first quantitative scientific work, leading to successively the increasingly rich theories of motion of Ptolemy, Copernicus, Kepler, and finally Newton. The widespread production of the first high-quality artisanal glass made possible the production of spectacle lenses and then Galileo's refracting telescope of 1609. Almost immediately, the solar system inventory increased by four bodies, the largest "Galilean" moons of Jupiter. With a more developed telescope, Christiaan Huygens would add to this the largest moon, Titan, of Saturn in 1655.

But these moons only indicated that planets may themselves have companions, not that additional planets themselves were awaiting discovery. Visible meteors were explained as phenomena of the atmosphere, not the solar system.

William Herschel, a working musician and amateur astronomer, would begin in 1779 the first undertaking to survey the entire northern sky with improved telescopes made possible by the growth of knowledge in metallurgy and optics. In the course of this survey, in 1781, he would discover Uranus, the first new planet to be added to the pantheon of antiquity.

Even by the late 1700s, the chemist Antoine Lavoisier would write, "A stone cannot fall from the sky—there *are* no stones in the sky," and conclude that increasing accounts of actual meteorite bodies associated with the appearance of some meteors were earth rocks struck by lightning. But the known complexity of the solar system continued to grow.

In 1801, Giuseppe Piazzi discovered the first asteroid, Ceres, in the region between Mars and Jupiter. The following year, Heinrich Olbers announced the discovery of another asteroid, Pallas. By 1807, four asteroids were known, with the promise of more. The appearance of a major meteor shower in 1799 with multiple meteors in the sky also forced acknowledgment that meteor showers appeared as streams apparently radiating from the same point in the sky. The perfection of the science of perspective and the revival of geometry during the Enlightenment immediately allowed this observation to demonstrate that meteor showers were a signature of coordinated debris lying outside the atmosphere.

In 1805, Thomas Jefferson wrote, regarding increasing evidence of large meteor appearances accompanying a fall of actual meteorites, "I do not know that this would be against the laws of nature and therefore I do not say it is impossible; but as it is so much unlike any operation of nature we have ever seen it requires testimony proportionately strong. The formation of hail in the atmosphere is entirely unaccountable, yet we have the evidence of our own senses to the fact and therefore we must believe it."

Two years later inhabitants of Weston, Connecticut would awake to a blazing fireball followed by loud explosions heard up to 40 miles away—a Chelyabinsk event in miniature. Some 350 pounds of unfamiliar stones were collected afterward in an investigation conducted by Yale professors Benjamin Silliman and James Kingsley. This first meteorite fall with extensive documentation marked the beginning of meteorite science in the United States. Professor Silliman, in fact, would go on to found the first major scientific journal, the *American Journal of Science*, in 1818, which remains in print.

In 1798, Benjamin Thomson would publish the first scientific account of frictional heating, and by 1845, James Prescott Joule would present a firm scientific theory of the equivalence of heat energy and kinetic energy. The high velocity of meteors had already been measured by simple geometry. The light and shock from meteors was now explained as a simple consequence of their high velocity. One kilogram of meteoritic matter traveling at 40 km/s relative to the Earth possesses the explosive power of 285 times its mass in TNT, simply on account of its motion.

A century would pass before the destructive possibility of meteors became apparent. In 1892, Grove Karl Gilbert would propose that the craters on the Moon were produced by impact rather than volcanism, and Daniel Barringer would postulate the same for what is now known as "Meteor Crater" in Arizona. The immense explosion over Tunguska, Siberia, on June 30, 1908, produced sound waves which were recorded thousands of miles away by tracing barometers throughout Europe. Distant accounts were published by newspapers in remote settlements, but 20 years would elapse before an expedition returned with direct observations of the centrally impacted area. The destruction, over tens of kilometers, would only find comparison with nuclear weapons decades in the future. Only slowly did an impact origin for this event become evident.

By 1900, 460 asteroids had been discovered. The number would grow to 9100 by 1980, to 15,000 by 1990, to 80,000 by 2000, and to 500,000 by 2010. The rapid development of automated telescopes, of computers to process and collate vast amounts of survey data, and of digital detectors to record light with exquisite sensitivity, has revolutionized solar system astronomy. It has also led to the discovery of a class of asteroids which move in orbits such that they eventually may strike the Earth.

Over the 20th century, accounts of significant meteor impacts or near-impacts also grew. A 1930 event over a remote region of Brazil may have produced an explosion with 10 percent the energy of the 1908 Tunguska blast, up to “megaton” atomic equivalent. A brilliant daytime meteor, widely photographed and imaged with movie film over the northwestern United States on August 10, 1972, was estimated to have resulted from the close passage of a body some tens of feet across, which descended to within 57 km (35 mi) but did not break up or strike the Earth, returning back into space.

Networks of infrasound detectors to monitor compliance with the Comprehensive Nuclear Test Ban Treaty entered operation beginning in 2001. Within months, some of the first detectors recorded the signature of an explosive event, presumably related to a meteor, on April 23, 2001 over a remote area of the Pacific Ocean. The energy inferred from the infrasound measurements was that of a small nuclear warhead, equivalent to detonation of several thousand tons of explosive – but with neither the sound signature nor radioactive release which would have marked an actual nuclear detonation.

A similar event, measuring roughly the energy of the Hiroshima nuclear weapon used by the US against Japan in World War II, took place 230 km (140 mi) north of Benghazi, Libya, over the Mediterranean Sea on June 6, 2002. This event was of particular note because it occurred during one of the heated standoffs between India and Pakistan, and would have taken place over that environment if the Earth's rotation had been somewhat offset. U.S. Air Force General Simon Worden wrote afterwards, “Had the bright flash, accompanied by a damaging shock wave, occurred over India or Pakistan, the resulting panic could have sparked a nuclear war.” Worden advocated survey programs to detect potential meteorite impacts in advance, purely along the lines of geopolitical interest, to deter unnecessary military reprisals.

It is now known that impacts with the equivalent energy of atomic bombs are not infrequent, occurring every year at some point on the globe. Larger impacts, with the energy of hydrogen bombs, occur less frequently, every few decades. Many of these impacts produce explosions high in the atmosphere, distributing, as at Chelyabinsk, the energy over a very wide area but without great devastation at any one point. Others, in which the impacting body is strongly cohesive, as with the rare nickel-iron meteorites, may survive to impact the Earth itself, producing craters and vast localized destructive potential – as with the Barringer Meteor Crater in Arizona. Very large impacting bodies, as with the presumed 10-kilometer body which struck the Earth near the Yucatan peninsula 65 million years ago, can produce enormous impact craters and devastate ecosystems across the entire planet, producing mass extinctions.

In only a few decades, the productive forces of mankind have produced technology that simultaneously reveals this threat, but they also have developed technology with the potential to mitigate it.

Asteroid surveys can now predict the number of devastating potentially impacting bodies (over a kilometer in size) as about 1,000 objects. Over 90 percent are thought to be now cataloged. But 20,000 asteroids exist whose potential impact could deliver still crippling, city-destroying blows. A much smaller proportion of these have been cataloged. Only one small impacting body has in fact been detected before striking the Earth—a roughly 4 meter (12 feet) body weighing about 80 tons which was detected a mere 20 hours before exploding over a remote area of the Sudan on October 7, 2008. The energy released was equivalent to a small atomic bomb, but breakup fortunately occurred high enough in the atmosphere to minimize any serious effects to the ground underneath.

The annual budget towards asteroid “civil defense” is in the mere tens of millions of US dollars worldwide. Far more, upwards of $10 billion, is spent annually on military space programs. The budget allocated to detection of nuclear explosions alone far exceeds that allocated towards global asteroid self-defense.

By far, the dominant threat of asteroid impacts arises from bodies which remain in the vicinity of Earth’s orbit and can be cataloged and monitored over time. With the high precision of modern celestial mechanics, it would be possible in such a program to detect future disasters years, even decades or centuries away. The earlier the detection, the smaller the necessary deflection would be to prevent the encounter. For many bodies, with sufficiently distant warning, it may be possible to deflect encounters simply by painting a hemisphere of the impacting body so as to alter the minuscule force produced by radiation reflecting from or emanating from part of the object. But only technological scenarios have been developed – no actual hardware or plans exist in the event of such a discovery.

A space telescope capable of accelerating a survey of critical near-earth asteroids has been budgeted at under $1 billion. The technology and manpower exists to address such vital world issues. But under capitalism, it is directed towards the monitoring of state rivalries first, and the pittances directed to basic research are awarded on the basis of posturing for technological supremacy, not on the demands of the world population for knowledge, safety, and security.

Meanwhile, “private enterprise” charitable funding of such enterprises is promoted by NASA as a solution. Edward Lu, a former NASA astronaut, left NASA to join Google to direct what is essentially a vanity project involving eBay and Facebook corporations proposing a private survey of asteroids under the aegis of the B612 Foundation, claiming that only private groups can carry out “audacious projects that previously only governments could accomplish—and at lower cost.” In other words, they promise the more efficient pauperization of scientists in the service of burnishing the charitable veneer of the sponsoring billionaires. Money to launch a space telescope built by this effort would come not from the coffers of the fantastically wealthy executives, but from a subscription of individuals.

Others promote asteroid surveys for the primary goal of eventually mining, i.e. profiting from them.

Only through socialism can this inverted relationship be set right and science put back into the democratic service of the needs of humanity. Until then, events such as the explosion at Chelyabinsk will continue to be frightening natural disasters which appear with no warning and are looked at as potential spectacles for media exploitation, not as events which are comprehensible, predictable, and eventually, avoidable.