Preparing for cosmic collisions

BY BOB RIDDLE

Over time, we have been able to observe, track, and determine the orbits for many objects in direct orbits around the Sun, including comets, asteroids, planets, dwarf planets, and even a few Trans Neptunian Objects (TNO) and icy worlds in the Oort Cloud. On the other hand, unknown objects revolving around the Sun should be cause for some concern. For example, an asteroid can get off course as it passes by a more massive object and then possibly collide with Earth. Another source of cosmic collision concern is known as a "long period" comet, which takes between 200 hundred years to millions of years to orbit the Sun. Long-period comets typically have orbits that are steeply inclined to the plane of the *ecliptic* (Earth's orbit) and often approach Earth's orbit from random directions. These comets are believed to originate in the outer regions of the solar system in the Kuiper Belt and Oort Cloud. When a long-period comet is discovered, it could be passing the Earth and other planets toward their perihelion, closest to the Sun, or on the comet's outbound route coming from the Sun and heading toward the Earth and its *aphelion* (farthest distance from the Sun).

FIGURE 1: Initial calculations show the simulated Risk Corridor

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Short-period comets, however, have orbital periods that are inclined within about 30° from the plane of the ecliptic, and some have a short enough period to be seen twice during a person's life, such as Halley's Comet that can be viewed every 75 to 76 years. Scientists must study the timing between when the object, comet, or asteroid intersects the Earth's orbital path and when the Earth will be at the same point. So what would be done, or could be done, if we discovered an object heading for the Earth?

Simulating disasters

*The following information is based on simulations done by various space organizations. An asteroid is **not** expected to enter the Earth's atmosphere as described below.*

In 2009 scientists initially calculated that the orbit of an asteroid they discovered would travel around the Sun until reaching the Earth's orbit in 2019 or so. Since the discovery of the asteroid, astronomers realized that this asteroid fits within the potentially hazardous asteroid (PHA) category, meaning there was a good chance that it would intersect the Earth's orbit. The same calculations showed that the Earth will be at that same point in its orbit, thus putting the asteroid on a possible collision course with our planet.

Four years after its discovery, the asteroid was still too far away for an accurate determination of its size and mass based on the asteroid's brightness, known as its *absolute magnitude*. At that time, however, estimates put its absolute magnitude at around 20, which suggested the asteroid could be up to 0.5 km (1,700 ft.) in size. If the asteroid were to enter our atmosphere, astronomers thought it would break apart explosively above the ground and not reach the surface, much like

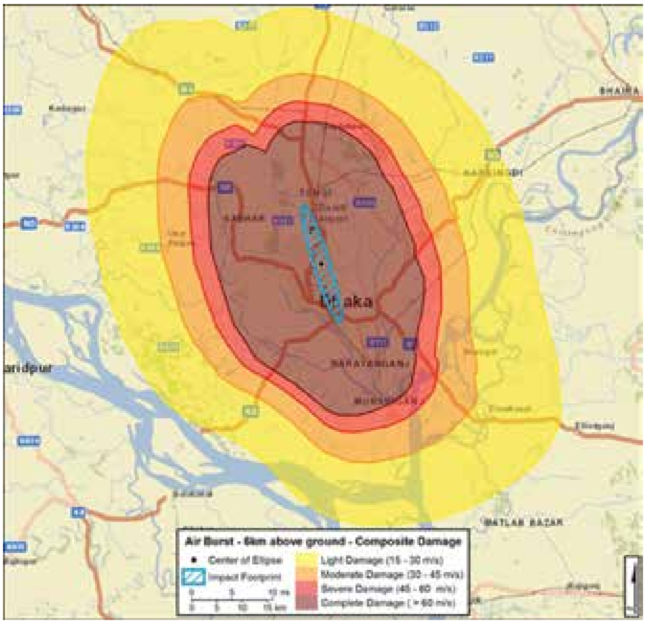
January

1 Moon at apogee: 404,600 km (251,407 mi.)
2 First quarter Moon
3 Quadrantids meteor shower
Lost city meteorite (1970)
5 The Sun is at perihelion: 147,084,626 km (91,394,150 mi.)
6 La Criolla meteorite (1985)
9 Moon at ascending node
10 Mercury at superior conjunction
Penumbral lunar eclipse
Full Moon
11 Waning gibbous Moon near M-44, the Beehive Open Star Cluster
13 Saturn conjunction
Moon at perigee: 366,000 km (227,422 mi.)
Discovery of Mars meteorite EETA 79001 (1980)
17 Last quarter Moon
Last quarter Moon near Spica
Mars passes Antares over the next week
18 Lorton meteorite (2010)
Tagish Lake meteorite shower (2000)
20 Waning crescent Moon near Mars and Antares
Buzz Aldrin's birthday
22 Moon at descending node
Thin waning crescent Moon near Jupiter
Vigarano Meteorite (1910)
24 New Moon
Discovery of Mars meteorite Dhofar 019 (2000)
25 Chinese New Year
27 Thin waxing crescent Moon, west of Venus
28 Thin waxing crescent Moon, east of Venus
29 Moon at apogee: 405,400 km (251,904 mi.)
31 Waxing crescent Moon near Uranus

February

1 First quarter Moon
4 Waxing gibbous Moon near Aldebaran
6 Moon at ascending node
7 Waxing gibbous Moon near Gemini Twins
8 Moon near Beehive Open Star Cluster
9 Full Moon
Moon near Regulus
10 Mercury at eastern elongation (18°E)
Moon at perigee: 360,463 km (223,981 mi.)
15 Last quarter Moon
Galileo Day
18 Waning crescent Moon near Mars
Moon at descending node
Neagari meteorite hits a car in Japan (1995)
19 Waning crescent Moon near Jupiter
20 Waning crescent Moon near Saturn
23 New Moon
25 Mercury at inferior conjunction
26 Moon at apogee: 406,276 km (252,448 mi.)
27 Waxing crescent Moon near Venus
29 Leap Day

FIGURE 2: The estimated damage "footprint"



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the 1908 Tunguska explosion (see Resources) or the Chelyabinsk Meteor in 2013 (see Resources). But the greatest questions and cause for concern are where on Earth would this impact occur, what damage would there be, and is there anything that could be done to avert this potential disaster?

In 2010, NASA and other space programs, including Russia, China, India, Japan, and Europe, launched a series of probes on a two-year voyage to the asteroid. The probes were designed to send back data about the asteroid. As a group, the four probes were placed in trajectory paths that would have them collide with the asteroid to alter the asteroid's path to avoid Earth. During the asteroid approach, the probes nudged the asteroid off its current trajectory and useful data were collected. How much of a change the nudge made was determined a few months later as scientists were able to more accurately calculate the trajectory of the asteroid.

When the asteroid was a few months from Earth, it became more certain that the asteroid's orbital path would take it across Earth's orbit. The probes did not provide enough force to alter the path. What is uncertain is the location of where the asteroid would enter the atmosphere and over or on what part of the Earth the asteroid would explosively break apart. Calculations initially create what is known as "risk corridor," the area of the Earth where the event may occur (Figure 1). In this situation, the risk corridor wraps about halfway around the globe. The asteroid is expected to explode in the atmosphere and not form an impact crater. Nonetheless, the effect of this will be devastating to the surface below. Anything within the risk corridor is a potential site for the impact. As time passed, the accuracy of the risk corridor steadily increased until scientists were confident of the event site.

As the date for the asteroid collision gets closer, calculations are finalized to the degree that not only is the date and time of atmospheric entry known, but also the location on the Earth above which the asteroid will explode is known. Based on estimates, the asteroid will explode between 6 km to 12 km (4 mi to 7 mi) above the Earth over a city in Bangladesh (see Figure 2). ●

For students

1. Read about the close flyby of asteroid Apophis in 2019 and how scientists planned for it (see Resources).
2. This column was based in part on a simulated asteroid impact scenario. For a more detailed chronology of the events including maps and NASA websites read the "2015 PDC Hypothetical Asteroid Impact Scenario" (see Resources).
3. Use the online Impact Earth or the Impact Earth Effects simulator (see Resources) to model simulated impacts by varying the "impact parameters."

RESOURCES

Alan Hills Meteorite—*www.lpi.usra.edu/lpi/meteorites/The_Meteorite.shtml*
Asteroid 2008 TC3—*http://*

astronomy.activeboard.com/t21306405/8ta9d69
Asteroid Apophis—*www.jpl.nasa.gov/news/news.php?feature=7390*
Asteroid Watch—*www.jpl.nasa.gov/asteroidwatch*
Best Asteroid, Comet, and Meteorite Books—*www.bookscrolling.com/the-best-asteroid-comet-and-meteor-books*
Buzz Aldrin—*http://buzzaldrin.com*
Buzz Aldrin's Rocket Experience Video—*http://youtu.be/YRI6BghJ1PU*
Calculating the age of solar system objects—*http://lco.global/education/activities/calculating-age-solar-system-objects*
Center for NEO Studies (CNEOS)—http://*cneos.jpl.nasa.gov/fireballs*
Dwarf planet Eris—*http://web.gps.caltech.edu/~mbrown/planetlila/index.html*
Fireball—*www.nasa.gov/feature/jpl/nasa-instruments-image-fireball-over-bering-sea*
Glossary-Potential Hazardous Asteroids (PHA)—*http://cneos.jpl.nasa.gov/glossary/PHA.html*
Hypothetical Asteroid Impact Scenario—*http://cneos.jpl.nasa.gov/pd/cs/pdc15*
Impact Earth Simulator—*www.purdue.edu/impactearth*
Earth Impacts Effects Program—*http://impact.ese.ic.ac.uk/ImpactEarth/ImpactEffects*
Killer Asteroids—*www.killerasteroids.org*
La Criolla Meteorite—*http://meteor-center.com/blog/project/la-criolla*
Lorton Meteorite—*www.foxnews.com/science/meteorite-crashes-through-virginia-doctors-office*
Lost City Meteorite—*http://meteorites.asu.edu/meteorites/lost-city*
Mars Meteorite EETA 79001—*http://en.wikipedia.org/wiki/EETA_79001*
Minor planet center—*http://minorplanetcenter.net*
Penumbral Lunar Eclipse—*www.timeanddate.com/eclipse/lunar/2020-january-10*
Potential Hazardous Asteroid—*http://cneos.jpl.nasa.gov/glossary/PHA.html*
Power of the Chelyabinsk Meteor 2013—*www.theguardian.com/science/2013/nov/06/chelyabinsk-meteor-russia*
Quadrantids Meteor Shower—*http://solarsystem.nasa.gov/asteroids-comets-and-meteors/meteors-and-meteorites/quadrantids/in-depth*
Quadrantids Meteor Shower—*www.amsmeteors.org/2018/12/viewing-the-2019-quadrantid-meteor-shower*
Tagish Lake Meteorite Shower—*http://en.wikipedia.org/wiki/Tagish_Lake_(meteorite)*
Tunguska Explosion 1908—*http://science.nasa.gov/science-news/science-at-nasa/2008/30jun_tunguska*
Vigarano Meteorite—*http://meteorites.asu.edu/meteorites/vigarano*

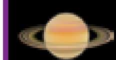
Visible planets

Mercury will move from superior conjunction, on the opposite side of the Sun, to become more visible as an evening planet at sunset local time, until mid-February when it moves into inferior conjunction, between the Earth and the Sun.

Venus will be visible over the western horizon at sunset.

Mars will rise before sunrise local time and will be visible over the eastern horizon.

Jupiter will slowly become more visible over the eastern horizon in the pre-dawn skies.



Saturn will be at solar conjunction, on the opposite side of the Sun, and will not be visible again until later next month as it becomes more visible over the eastern horizon in the pre-dawn skies.

Quadrantids Meteor Shower will reach its peak on the morning of January 4. This annual meteor shower will occur the last week of December through mid-January. It is a somewhat unusual meteor shower because the meteoroids entering our atmosphere come from Asteroid 2003 EH1 rather than from the debris left behind by a comet. It is thought that the asteroid may be the remnants of a comet that is no longer active as it orbits the Sun in 5.52 years.

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