Threats from Space: Asteroid Impacts and Solar Storms

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“Have you ever wondered what would happen if a giant hairball were to slam into the earth?”

What *would* happen if a giant hairball, or asteroid, or comet were to slam into the earth?

That depends on the size of the object striking the Earth.
A **small** space rock (a meteoroid) strikes the Earth:
Chelyabinsk, Siberia, February 2013
Chelyabinsk meteoroid:
speed = 40,000 mph (Mach 60)
diameter = 20 yards
mass = 10,000 tons
breakup altitude = 18 miles
energy released = 0.5 megatons

Most damage was done by its sonic boom.  
1500 people were badly injured (mainly from flying glass).  
Several thousand buildings were damaged.
A **mid-sized** space rock (an asteroid) or iceball (a comet) strikes the Earth: Tunguska, Siberia, January 1908

Part of the 800 square miles of flattened forest.

Lake Cheko: a possible impact crater, half a mile across.
Tunguska asteroid:

- Speed = 40,000 mph (Mach 60)
- Diameter = 100 yards
- Mass = 1 million tons
- Breakup altitude = 4 miles
- Energy released = 12 megatons

80 million trees were flattened.  
A thousand reindeer were killed. 
People were knocked down 300 miles away.
A **REALLY BIG** asteroid or comet strikes the Earth: Chicxulub, Mexico, 65 million years ago.

Chicxulub crater:
64.98 million years old
110 miles across
Chicxulub asteroid:

speed = 40,000 mph (Mach 60)
diameter = 6 miles
mass = 1 trillion tons
energy released = 100 million megatons
An asteroid struck the Earth 65 million years ago.

Mass extinction of dinosaurs (and many other organisms) took place 65 million years ago.

**COINCIDENCE?**
Indirectly, a large impact can cause mass extinctions.

Collision ejects dust into atmosphere.
   Months of darkness and cold.
       Death of plants.
       Death of herbivores.
       Death of carnivores.

Tsunami
Firestorms
Acid rain
Small impacts (Chelyabinsk) occur once per decade.

Medium impacts (Tunguska) occur once per century.

Really big impacts (Chicxulub) occur once per 100 million years.
What to do?

Small: Step away from the window.

Mid-size: Monitor the sky with wide-angle telescopes. We can detect a Tunguska-sized object a day in advance. Evacuate.

Really big: Monitor the sky with wide-angle telescopes. We can detect a Chicxulub-sized object months in advance. What then?
Do **not** send Bruce Willis to blow it up.

Send an unmanned rocket to *gently* nudge it, and change its orbit.
Worst recorded **solar storm**: The Carrington Event, September 1859

Richard Carrington, a British astronomer, saw two patches of intensely bright light in a sunspot.
Carrington’s bright solar flares were followed 18 hours later by disturbances to Earth’s magnetic field and flamboyant auroras.

Magnetic field measured at Kew Gardens, near London.

Frederic Edwin Church, *Aurora Borealis*, 1865
Conclusion: Earth’s magnetic field was being pummeled by fast-moving protons and electrons ejected by the Sun.
Earth’s changing magnetic field severely damaged the telegraph network in September 1859.

First transatlantic telegraph cable (1858)

Telegraph room in the Houses of Parliament (1859)
What caused the damage? A changing magnetic field creates an **induction current** in a closed loop of wire.

Induction currents in the telegraph wires were greater than they were designed to carry.
21\textsuperscript{st} century society is far more “wired” than the Victorians were.

High voltage power transmission lines are particularly vulnerable to induction currents.
Fast-moving protons & electrons also damage the electronics of satellites & high-flying airplanes.
What to do?

**Monitor the Sun:** 18 hour window between arrival of light and arrival of protons and electrons.

**Prepare the power grid:** Disconnect transformers, isolate subsections of the power grid.

**Kiss orbiting satellites goodbye:** Shielding satellites requires a huge mass of heavy metal. It’s easier to launch replacement satellites.
Additional resources:

Asteroid impacts:
NASA’s Center for Near-Earth Object Studies
(cneos.jpl.nasa.gov)

Solar storms:
NOAA’s Space Weather Prediction Center
(swpc.noaa.gov)

Random astronomical stuff:
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