What is a supernova?

How dangerous are they to life on Earth?

How would the universe be different without supernovae?
RECENT HEADLINES

Astronomer predicts that a red supergiant star nearby could go supernova very soon

Betelgeuse’s Brightening Raises Hopes for a Supernova Spectacle

Is the puzzling star Betelgeuse going to explode in our lifetime after all?
A hundred years ago, we believed we lived in a quiet, safe universe . . .
Today we know the universe is filled with powerful cosmic radiation our eyes cannot see:

- Gamma-rays
- X-Rays
- Fast-moving atomic particles ("Cosmic Rays")

Much of which originates from monstrous black holes in the centers of galaxies and from . . .
Today we know the universe is filled with powerful cosmic radiation our eyes cannot see:

- Gamma-rays
- X-Rays
- Fast-moving atomic particles (“Cosmic Rays”)

... neutron stars with powerful magnetic fields and more commonly from ...
Supernova!
Types of Supernova

• Type Ia – White dwarf experiencing thermal runaway after absorbing material from a companion star
• Type Ib – White dwarf experiencing core collapse after absorbing material from a companion star
• Type II – Supermassive star undergoing core collapse
The progenitor of a Type Ia supernova

Two normal stars are in a binary pair.

The more massive star becomes a giant...

...which spills gas onto the secondary star, causing it to expand and become engulfed.

The secondary, lighter star and the core of the giant star spiral toward within a common envelope.

The common envelope is ejected, while the separation between the core and the secondary star decreases.

The remaining core of the giant collapses and becomes a white dwarf.

The aging companion star starts swelling, spilling gas onto the white dwarf.

The white dwarf's mass increases until it reaches a critical mass and explodes...

...causing the companion star to be ejected away.
Life of a Sun-like Star

- Sun-like Star
- Protostars
- Star-Forming Nebula
- Red Giant
- Planetary Nebula
- White Dwarf
Life of a Massive Star

- Protostars
- Massive Star
- Red Supergiant
- Star-Forming Nebula
- Supernova
- Neutron Star
- Black Hole

Diagram showing the life cycle of a massive star, from protostars to supernova and beyond.
Is radiation from supernovae and GRB sources dangerous to Earth?

How close would they have to be?
Radiation from exploding stars
Impact of Exploding Stars?!
How close would a Supernova have to be dangerous?
How close would a Supernova have to be dangerous?
How close would a Supernova have to be to be dangerous?

Supernova: within 30 light years

Location of Solar System

Nearest Supernova Candidate IK Pegasi: over 150 light years away!
Gamma-Ray Burst (GRB)!

Formed from the collapse of a supernova into a black hole
How close would a Gamma-Ray Burst (GRB) have to be to be dangerous?
How close would a Gamma-Ray Burst (GRB) have to be to be dangerous?

GRB Danger Zone: within 8,000 light years

Location of Solar System
How close is the nearest Gamma-Ray Burst (GRB) source?

Nearest detected GRB source: over a Billion light years away!

Our galaxy is about 100,000 light years across.

Location of Solar System

GRB Danger Zone
There may be some closer

But you must in line with this narrow jet to be impacted by it
Earth’s Atmosphere & Magnetic Field

Protect Earth from most high-energy radiation . . .
But prevent us from detecting it here on Earth
The high view: getting a better look

XMM-Newton

Suzaku

Swift

GLAST

X-rays

Gamma-rays
Scientists have discovered that most of the heavy elements in the universe are dispersed from stars that go supernova.
Life from Exploding Stars!

Silicon
Life from Exploding Stars!
Life from Exploding Stars!
Life from Exploding Stars!

Without supernovae to disperse elements made in stars, there would be no planets, no life as we know it!
How are elements produced?
Fusion Sequence within Stars
# Formation of the Elements

<table>
<thead>
<tr>
<th>Element</th>
<th>Process</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>Big Bang fusion</td>
<td>No stable isotopes</td>
</tr>
<tr>
<td>Li</td>
<td>Dying low-mass stars</td>
<td>Merging neutron stars</td>
</tr>
<tr>
<td>Na</td>
<td>Cosmic ray fission</td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>Exploding massive stars</td>
<td>Exploding white dwarfs</td>
</tr>
<tr>
<td>Al</td>
<td>Human synthesis</td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>Ca</td>
<td>Sc</td>
</tr>
<tr>
<td>Ti</td>
<td>V</td>
<td>Cr</td>
</tr>
<tr>
<td>Zr</td>
<td>Nb</td>
<td>Mo</td>
</tr>
<tr>
<td>Cs</td>
<td>Ba</td>
<td></td>
</tr>
<tr>
<td>Fr</td>
<td>Rb</td>
<td>Sr</td>
</tr>
<tr>
<td>La</td>
<td>Ce</td>
<td>Pr</td>
</tr>
<tr>
<td>Ac</td>
<td>Th</td>
<td>Pa</td>
</tr>
<tr>
<td>Ce</td>
<td>Pr</td>
<td>Nd</td>
</tr>
<tr>
<td>Nd</td>
<td>Pm</td>
<td>Sm</td>
</tr>
<tr>
<td>Sm</td>
<td>Eu</td>
<td>Gd</td>
</tr>
<tr>
<td>Eu</td>
<td>Gd</td>
<td>Tb</td>
</tr>
<tr>
<td>Gd</td>
<td>Tb</td>
<td>Dy</td>
</tr>
<tr>
<td>Tb</td>
<td>Dy</td>
<td>Ho</td>
</tr>
<tr>
<td>Dy</td>
<td>Ho</td>
<td>Er</td>
</tr>
<tr>
<td>Ho</td>
<td>Er</td>
<td>Tm</td>
</tr>
<tr>
<td>Er</td>
<td>Tm</td>
<td>Yb</td>
</tr>
<tr>
<td>Tm</td>
<td>Yb</td>
<td>Lu</td>
</tr>
<tr>
<td>Yb</td>
<td>Lu</td>
<td></td>
</tr>
<tr>
<td>Lu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
So aren’t you glad we live in a universe where stars explode?

Which stars?

Orion’s stars likely to go supernova!
Betelgeuse is 650 light years away

The last naked eye supernova in our galaxy was in Kepler’s Supernova in 1604

Messier 1, the Crab Nebula, is a supernova remnant that was observed by Chinese astronomers in the year 1054 (6500 ly away)