The Universe in my pocket

Cosmic threats

TUIMP
No. 21
THE UNIVERSE IN MY POCKET

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The first forests appeared in the Devonian period, about 400 million years ago (at left, a picture of a present-day jungle).

'The Birth of Venus' by Botticelli (1485). This work shows what the painter considered to be the most precious aspect of nature:: power of sea, firmness of ground, lightness of air, splendor of birth.

An example of what a cosmic threat can do to us: the destruction of a Siberian forest by the Tunguska meteorite in 1908.

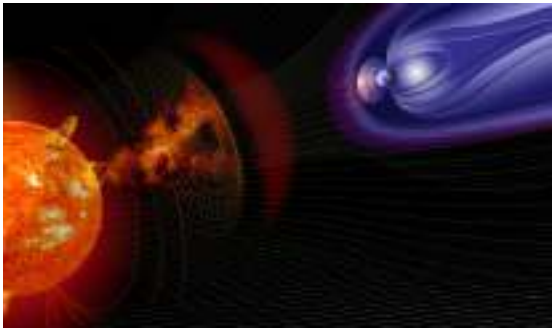
Is the Earth in danger?

The Earth was formed about 4.5 billion years ago, at the same time as the Sun and the other planets of the Solar System. The first traces of life appeared about a billion years later. In the 3.5 billion years since then, no cosmic catastrophe has been destructive enough to eradicate all life on our planet! But can we rule out any threat? The answer is no!

In this booklet, we will discuss the cosmic dangers that threaten us, from the most frequent to the most hypothetical. But we will only talk about the dangers identified in our current state of knowledge, hoping that there are no others...

Artist's representation of particle showers due to cosmic rays (high energy particles travelling between stars and galaxies).

Some of these particles have enough energy to penetrate our atmosphere and hit the air molecules creating secondary particle showers that reach the ground. These cascades of particles are not visible to the naked eye.



During a solar flare, a large number of electrically charged atomic particles are emitted. Some of these particles propagate towards the Earth, which is fortunately protected by its magnetic field.

When these solar particles reach the atmosphere, they can cause aurorae borealis and australis.

Cosmic rays and solar emissions

The so-called vacuum of space is not an absolute vacuum. In fact, space is permeated by a steady stream of particles of all kinds (protons, electrons, etc.) coming from other stars and galaxies. We are continually bombarded by a shower of particles (often secondary particles, see opposite page). When cosmic rays are very energetic, they can cause genetic mutations. This is the most common cosmic threat to which life on Earth has adapted.

The particles emitted by the Sun during its eruptions do not affect our bodies, but they can disrupt telecommunications, endanger high-altitude aircraft and cause damage to satellites.

Asteroid 433 Eros photographed by the NEAR Shoemaker spacecraft. This near-Earth object, about 17 km in size, passed relatively close to the Earth in 2012, at a distance 70 times the distance to the Moon.

Footprint of the 10 km diameter meteorite believed to be responsible for the extinction of the dinosaurs. It crashed in Chicxulub (Gulf of Mexico) creating a crater 140 km in diameter and 30 km deep.

The Meteor Crater in Arizona, USA (1 km in diameter) caused by an asteroid only 30m in diameter.

Earth-grazing asteroids (EGAs) and comets

The formation of planets around our star has also produced a large number of 'small' remnant bodies: comets and millions of asteroids of all sizes, from simple rocks to bodies tens of kilometres in size that orbit the Sun (see TUIMP 4). Some of the larger ones that pass close to the Earth are EGAs and they present a very serious threat. One of them probably caused the extinction of the dinosaurs about 65 million years ago.

To protect us from such a risk, several organisations in the USA and Europe (DART mission) have set up warning systems and are considering ways of deflecting these bodies from their trajectory.

In about 6 billion years, the Sun will evolve into a **red giant** and grow to encompass Venus (indicated by the red arrow). The small black dot in the centre represents the current size of the Sun. In this drawing the size of the planets has been greatly exaggerated.

Artist's representation of the Sun at the beginning of its expansion phase as seen from the Earth, by then a scorching desert, in 5-6 billion years. It will then fill almost **the entire sky**!

The evolution of the Sun

Astrophysicists calculate the evolution of stars with great accuracy. The Sun is currently in the middle of a fairly stable period that will last for about 5 billion years. However, its luminosity will increase by 10% over the next billion years, which will begin to eliminate liquid water and life on the Earth's surface. After this stable period, the Sun's evolution will become catastrophic. It will become a red giant and will be 100 times larger in diameter. It will encompass the planets Mercury and Venus, and the Earth will be a glowing desert.

But on a human timescale, the evolution of the Sun is not dangerous and is not the cause of the current global warming.

Right: a Type Ia supernova is caused by the accretion of matter onto a white dwarf from the companion star...

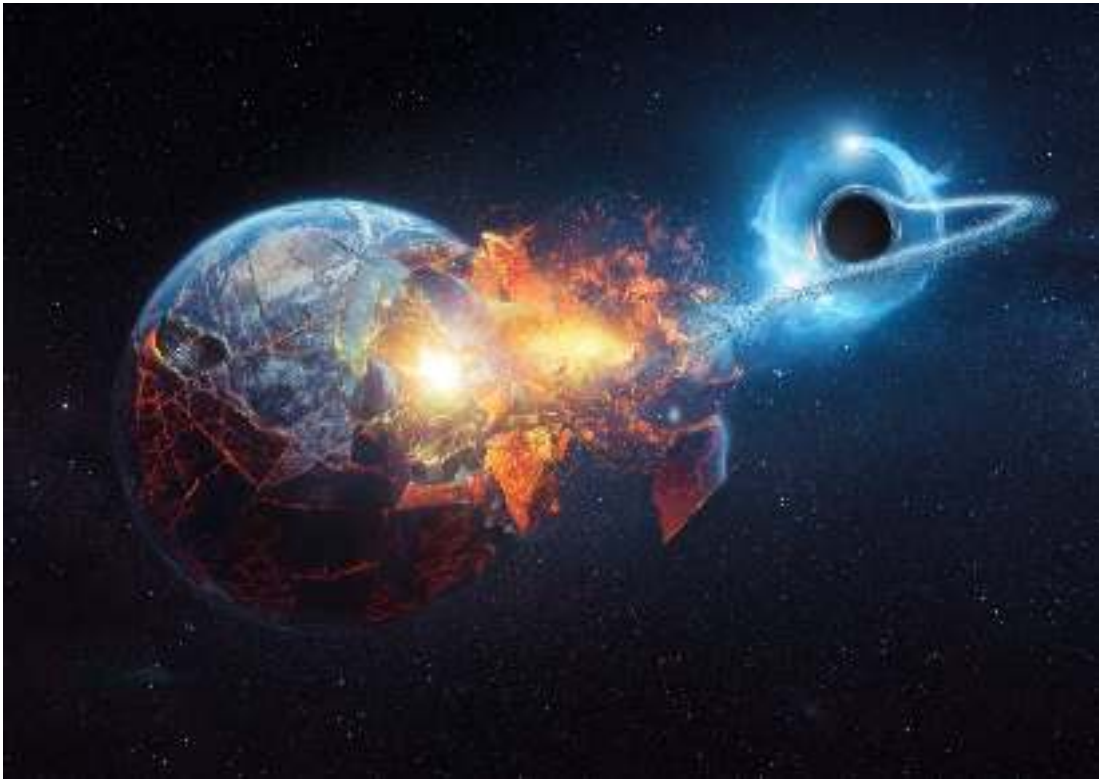
Left: ...then the white dwarf explosion lights up the whole galaxy! (Artists' drawings)

Below: A visual representation of the effect on Earth of a supernova exploding at a distance of less than a few light years.

The nearest star likely to go supernova (type II) appears to be Betelgeuse at a distance of about 500 light years.

Supernovae

A supernova (SN) explosion is one of the most energetic processes in the Universe (see TUIMP 9). It is a relatively rare phenomenon, with only 1 to 3 supernovae per century in our Galaxy. Our Galaxy is about 120,000 light years (l.y.) in diameter, and a supernova has to be closer than about 10 l.y. to be dangerous, so the probability of such an event threatening the Earth is low, even if such a risk cannot be ruled out. However, no star near the Earth is known to be a potential supernova. Note that a star does not go supernova by accident: it is a normal stage of evolution for stars of more than 8 solar masses (type II supernova). Some highly evolved lower-mass stars (not the Sun!) can also go supernova (type Ia) provided they have a companion star.



Artist's impression of what a near collision of the Earth with a black hole might look like. Close to the black hole, the tidal effects are so strong that the planet breaks apart and its material forms a disc around the black hole before falling into it. In this drawing, the black hole is relatively massive (a few tens of thousands of solar masses). A black hole with the mass of the Sun would have a horizon (represented by the black disc) of only 3 km.

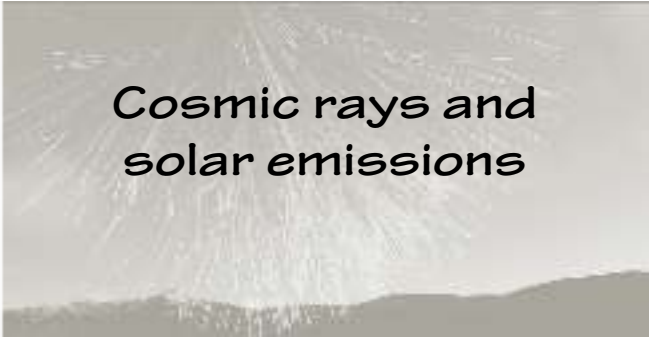
‘Exotic’ threats

For an encounter with a black hole to be truly fatal, the Earth would have to collide almost head-on with it. This is highly unlikely, as both the Earth and the most common black holes (resulting from the collapse of a star) have very small diameters. The most likely outcome of an approaching black hole would be that the Earth would orbit the black hole at a safe distance. But even without immediate destruction, such an event would create a major gravitational imbalance in the Solar System. The danger would be much greater with a super-massive black hole, but there are very few of these, they are mainly in the centres of galaxies. Equally unlikely is a collision with a star, because the number of stars near the Solar System is small.

Quiz

What is the most life-threatening cosmic event on Earth?

Answer on the back



Answer

An EGA encounter is the most serious cosmic threat.

But human activity can generate other threats.

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This booklet was written in 2021 by Georges Alecian and reviewed by Jean Schneider. Both are from the Paris Observatory and the CNRS (France).

Cover image: An asteroid colliding with the Earth as imagined by D. Hardy (© 2015 AstroArt by David A. Hardy)

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