Global Challenges Foundation

Black hole

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Will we survive the nearby formation of a black hole?
The night sky may appear to be a tranquil place, but, in reality, cataclysmic events occur continuously throughout the Cosmos. Among the most extreme of these are gamma-ray bursts (GRB) – created when old stars collapse to form black holes. The amount of energy released is prodigious. In no more than a few minutes, an amount of energy equivalent to that released by the Sun through-out its 10-billion-year lifetime is expelled in concentrated beams of high energy radiation called gamma-rays. What would happen to the Earth if it was hit by such a powerful beam of radiation?

Direct damage would be limited, as the Earth's protective atmosphere would greatly attenuate the GRB beam. A brief pulse of dangerous ultraviolet (UV) radiation would reach the Earth's surface, but its transient nature would prevent widespread damage. The GRB beam would, however, catastrophically damage the stratosphere, eventually resulting in surface-level devastation. The primary destructive effect is caused by gamma-rays ionising and dissociating nitrogen and oxygen molecules in the stratosphere, creating ozone-destroying nitrogen compounds. The ensuing demise of the ozone layer would result in elevated levels of solar UV radiation reaching the ground during a number of years. UV radiation damages DNA, resulting in destruction of lifeforms, e.g., through developmental abnormalities and cancer. Surface marine life, such as the plankton crucial to the food chain and global oxygen production, would also be threatened. A secondary factor is that the smog-like nitrous oxide gas produced in the stratosphere would reduce the amount of visible sunlight reaching the Earth's surface. Although the reduction is expected to be small (percent-level), and only last for a few years, an extinction-level global cooling episode may result if the climate system is already at a tipping-point.

What is the chance of a GRB threatening life on Earth?
All bursts observed thus far have occurred well outside of our galaxy. Consequently, the gamma-ray beam is weak and has little effect, if any, on the Earth's atmosphere. However, during the past 500 million years, it is likely that a bright GRB occurred as close as ten thousand light years from the Earth. It has

been proposed that such a GRB triggered the Ordovician mass extinction, which occurred 440 million years ago, resulting in the second largest loss of biodiversity in history. This is supported by the observation that deep sea life was less affected, presumably due to the UV absorbing properties of water. Moreover, the sudden ice age connected to the Ordovician period is a feasible consequence of the GRB-induced smog.

Understanding the risk posed by GRBs is made possible through curiosity-driven research, where a deeper understanding of the world is sought without a particular application in mind. Tantalisingly, this leads to an improved understanding of habitable zones in galaxies in general, informing searches for extra-terrestrial life. Only 10% of all galaxies might be hospitable to life. The low-density regions on the outskirts of galaxies are favoured, since conditions are not conducive for a GRB to form. Reassuringly, the solar system is located in just such an environment.