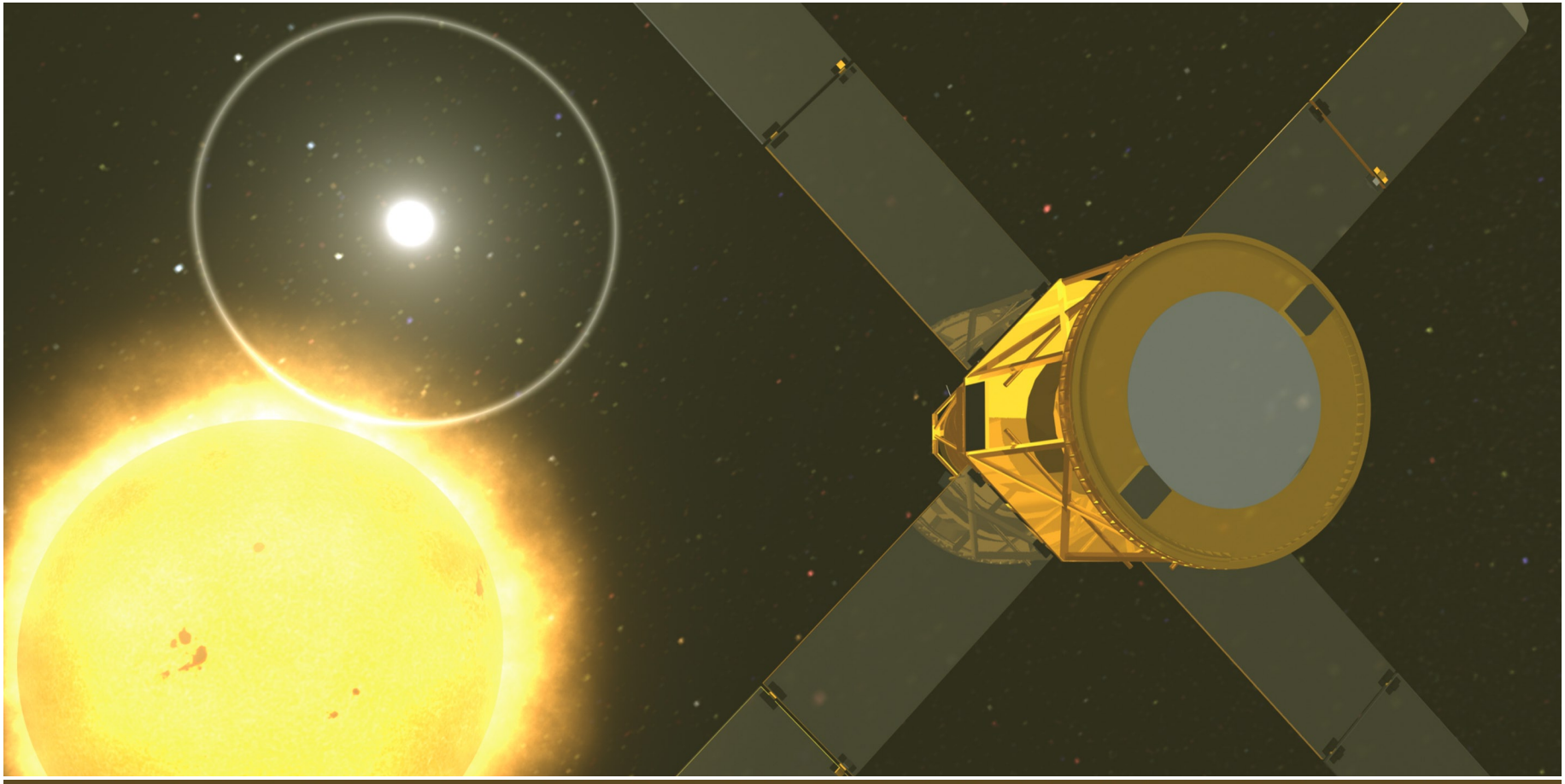
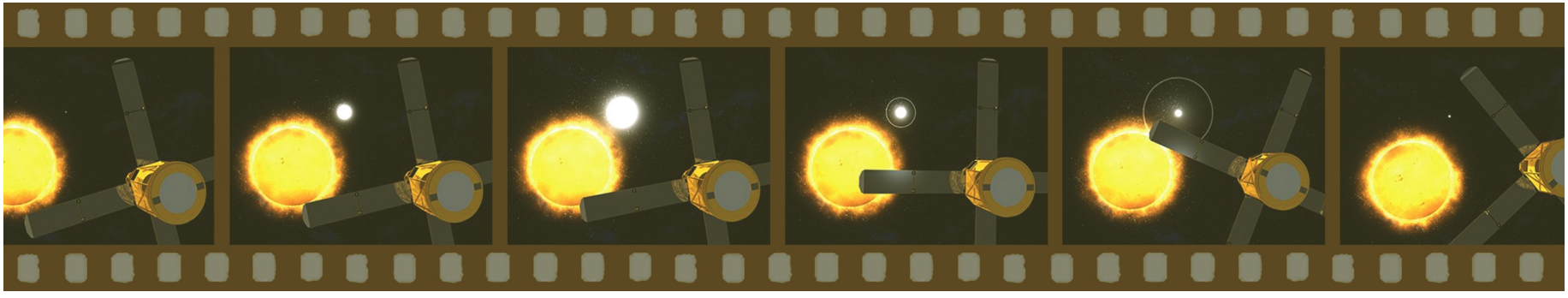
National Aeronautics and
Space Administration

Serendipity: RHESSI Spies a Gamma-Ray Burst





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Nature's Greatest Explosions

Almost once per day, an intense burst of gamma rays originating in deep space is recorded by space telescopes. These cosmic Gamma-Ray Bursts (GRBs) were first observed in the 1960s by military satellites monitoring Earth for nuclear weapons explosions in violation of a test ban treaty. Gamma-Ray Bursts can last anywhere from a few seconds to a few minutes, and when they go off are the brightest sources of gamma rays in the Universe. For decades, the origin of Gamma-Ray Bursts has been a mystery, but recent observations have revealed that some of them are the result of immense explosions occurring in distant galaxies. Because they are so bright (some afterglows of Gamma-Ray Bursts can be seen in visible light using just binoculars) and so distant, they must be the most energetic explosions in all the Universe.

The cause of these spectacular explosions is still uncertain, but astronomers now have strong evidence that at least some are the violent death throes of the most massive stars in the Universe. It has long been known that stars with masses more than eight times that of the Sun die in awesome explosions called *supernovae*. Now, astronomers think that the most massive stars, those with masses more than 30 times that of the Sun, perish in explosions of such stupendous magnitude that they are called *hypernovae*.

RHESSI's Chance Observation

On December 6, 2002, while observing the Sun, NASA's Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI) caught a serendipitous glimpse of a Gamma-Ray Burst. RHESSI studies the Sun, looking for X-rays and gamma rays from **solar flares**, which are the most energetic explosions in all the Solar System. Strong magnetic fields are thought to be responsible for solar flares and cause much of the electromagnetic radiation from them to become aligned, or **polarized**. RHESSI is the first instrument sensitive to such polarization, and its unique observation of this Gamma-Ray Burst has revealed some surprising new results in the study of these puzzling explosions. For the first time, it was discovered that emission from Gamma-Ray Bursts is highly polarized. This suggests that the driving force of the enormous explosions may be very strong magnetic fields.

Announcing the Birth of a Black Hole

One possible source of the exceptionally powerful magnetic field—that polarized the radiation from the Gamma-Ray Burst—could be the implosion of a supermassive star into a **black hole**. In a normal supernova, the core collapses down to a **neutron star**. In the hypernova death of a massive star, the star's core has so much mass that it implodes into a black hole. Neutron stars have been observed to have the strongest magnetic fields in the Universe. However, the strength of the magnetic field in the Gamma-Ray Burst seen by RHESSI was even greater than that of neutron stars.

Black holes themselves have no magnetic fields, but the magnetic field of surrounding matter can thread through a black hole. Like a string connected to a top, the magnetic field becomes tightly wound up as the black hole spins. Eventually, the magnetic field snaps, and releases an enormous amount of energy into a rapidly expanding fireball—one so hot that it produces enough gamma rays to be seen all the way across the Universe.

Remarkably, RHESSI's mission to understand solar flares and the role of magnetic fields in these greatest explosions in the Solar System, has now shed new light on the importance of magnetic fields in Gamma-Ray Bursts, the greatest explosions in the Universe.

Definitions

Solar Flare: A sudden and explosive release of energy in a localized region in the atmosphere of the Sun (called the *corona*). Solar flares occur when magnetic fields on the Sun's surface are stretched and twisted until they snap and accelerate charged gas to very high energies.

Polarization: Normally in light waves, electric and magnetic fields vibrate perpendicular to each other and to the direction of motion of the wave. From wave to wave the fields have random orientations. When light is polarized, the fields of all waves are aligned.

Black Hole: An object with so great a density that not even light can escape the gravitational force at its surface. Anything that falls beneath the surface of a black hole is trapped inside forever. Black holes may form when the core of a very massive star collapses under its own weight at the end of its life.

Neutron Star: A remnant of the supernova death of a massive star. A neutron star is the collapsed core of its progenitor, about 10 km across (the size of a city), containing between 1.4 and 3 times the mass of the Sun. These objects are called neutron stars because they are almost entirely composed of neutrons.

About the Image

An artistic conception of RHESSI's observation of a Gamma-Ray Burst. Image credit: Walt Feimer & Chris Meaney of the Conceptual Image Lab, NASA/GSFC.

Web Resources

1) RHESSI Education & Public Outreach Website: *http://cse.ssl.berkeley.edu/hessi_epo/*
2) Swift, a NASA mission to study GRBs: *http://swift.sonoma.edu/*
3) Space Science Education Resource Directory: *http://teachspacescience.org*