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De-Coding Starlight Activity:
From Pixels to Images

RECOLORING the UNIVERSE

The Scenario

You have just discovered a brilliant new supernova remnant using NASA's Chandra X-ray Observatory. The Director of NASA Deep Space Research has requested a report of your results in her office in 45 minutes. But, unfortunately, your computer crashed fatally while you were creating an image of the supernova remnant from the numerical data and you also lost a small amount of back up data. To fix the situation you will create, by hand, an image of the supernova remnant.

To do so, you will use raw (or unprocessed) data from the Chandra satellite. Additionally, you will prepare a written explanation of your discovery and answer a few of the Director's questions.

COMPLETE THE FOLLOWING TASKS:

1 Calculations

Turn the numbers into a picture. Before you can make the image, you will need to make some calculations.

The raw data for the destroyed "pixels" (grid squares containing a value and color) are listed in Table A. Before making the image, fill in the last column of Table 1 by calculating average X-ray intensity for each pixel.

After you have determined average pixel values for the destroyed pixels, write the numerical values in the proper box (pixel) of the attached grid. Many of the pixel values are already on the grid, but you must fill in the blank pixels. This is the grid in which you will draw the image.

Coloring the Image

Complete the following steps in coloring the image. Read all the instructions carefully before you start coloring.

You are allowed to use only five colors in drawing your image. Select 5 colors and fill them in the (B) color legend shown at the bottom of the page.

Using colored pencils or markers, shade in the grid at the right using the color legend you created. Match the value in the grid to the color range shown on the legend and color the grid squares according to the legend.

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A. PIXEL TABLE

NUMBER OF X-RAY PHOTONS DETECTED

Missing Grid Coordinate	Observation 1	Observation 2	Observation 3	Observation 4	Observation 5	Average Number of Photons
C3	50	54	52	50	54	
E8	214	210	210	210	214	
F6	148	135	missing	missing	130	
H10	73	83	missing	80	81	
I5	58	69	54	missing	65	

B. COLOR LEGEND

Average Number of Photons	<40	40-80	81-120	121-160	>160
Color					

Find more coding-related activities at http://chandra.si.edu/code

C. GRID

	A	B	C	D	E	F	G	H	I	J	K
1	0	1	1	1	1	1	1	1	1	1	1
2	2	5	35	42	48	48	50	51	46	18	7
3	23	36		35	30	27	21	31	38	13	0
4	41	43	24	8	216	155	126	120	54	21	3
5	36	58	37	44	36	20	33	105		23	4
6	32	60	34	106	12		18	96	24	50	17
7	24	65	32	141	41	17	12	126	64	67	21
8	18	69	36	237		146	155	114	22	74	6
9	16	75	38	34	26	12	14	21	77	37	4
10	8	71	63	54	42	23	64		31	16	2
11	3	3	2	1	0	0	2	0	1	0	0

3 Preparing the Presentation

Draw a picture of what the actual supernova remnant might look like. Include and label the neutron star, a fast outer shock wave, and a slower inner shock wave.

4 **Answer these questions:** Because your computer crashed, you had to draw the image by hand. In 2-3 sentences, explain why it would have been easier to use a computer. (Consider that the Chandra satellite sends millions of data from its observations, and how long it might take to process that much data by hand.)

In the table, some of the data were missing. In 2-3 sentences, describe how you handled the missing data in making your calculations and coloring your image.

WHAT'S THAT?! WORDS TO KNOW.

Light year: the distance that light, moving at a constant speed of 300,000 km/s, travels in one year. One light year is just under 10 trillion kilometers.

Neutron star: A dense stellar remnant produced by the collapse of the core of a massive star ending its life as a supernova. Neutron stars are composed almost entirely of neutrons, are about 20km in diameter, and about 1.5 times as massive as the Sun.

Supernova: an explosive death of a star, caused by the sudden onset of nuclear burning in a white dwarf star or the gravitational collapse of the core of a massive star followed by a shock wave that disrupts the star.

Supernova remnant: the expanding glowing remains from a supernova. A supernova is one of the most energetic events of the universe and may temporarily outshine the rest of the galaxy in which it resides.

GATHERING DATA

NASA's Chandra X-ray Observatory is a telescope designed to detect X-ray emission from very hot regions of the Universe such as exploded stars, clusters of galaxies, and matter around black holes. As the photons—individual packets of electromagnetic energy that make up electromagnetic radiation—coming from various cosmic sources strike Chandra's scientific instruments, the information is recorded.

Every 8 hours, Chandra downloads millions of pieces of information to Earth. Chandra's data arrive at the Chandra X-ray Center packaged in the form of 0's and 1's that only a computer could love. The flood of numbers must then be converted into images using scientific software. Scientists and programmers painstakingly calibrate and validate the processes to ensure that images being produced are accurate.

The process of making computer-generated images from X-ray data collected by Chandra involves the use of "representative color" (also sometimes called false color).
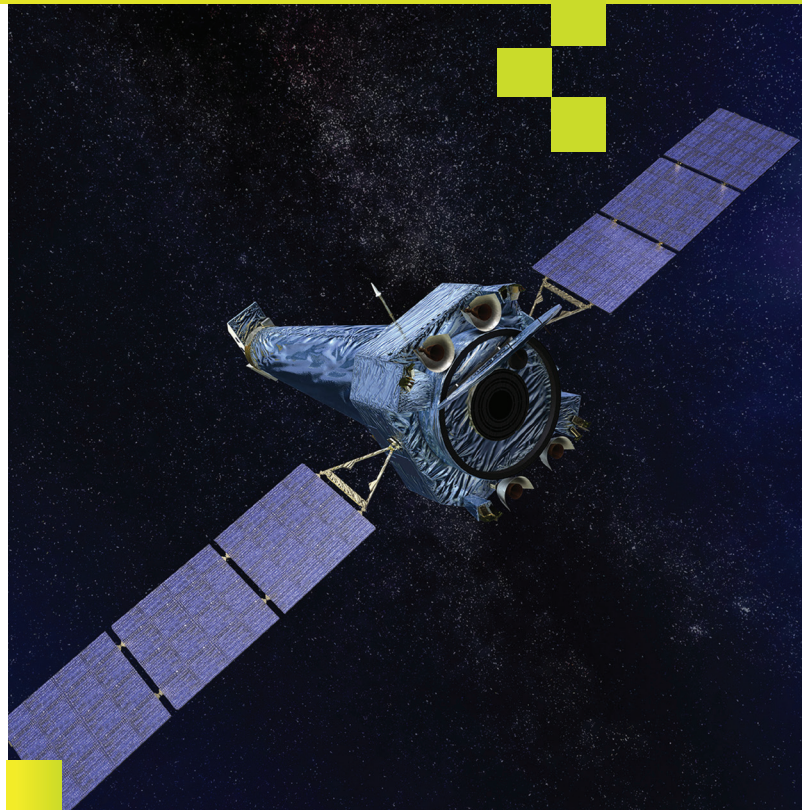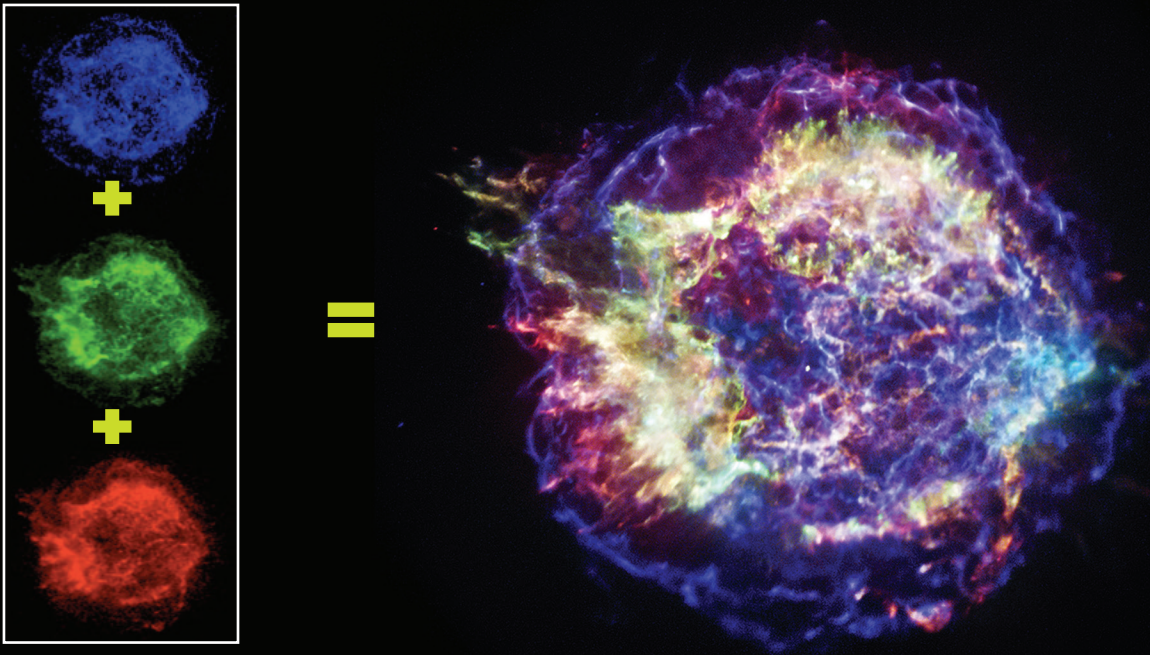
X-rays cannot be seen by human eyes, and therefore, have no "color" to us. Visual representation of X-ray data, as well as radio, infrared, ultraviolet, and gamma rays, involves the use of representative color techniques, where colors in the image are assigned to depict intensity, energy, temperature, or another property of the data. Scientists select different colors to highlight the important properties of the astronomical object being studied. The science informs the colors used.

PUTTING IT ALL TOGETHER

The colors in this image of Cassiopeia A (above) show energy, where low-energy X-rays are colored red, medium-energy X-rays green, and high-energy X-rays blue.

UNDERSTANDING CASSIOPEIA A

The Chandra image (right) shows the 320-year-old remnant of a massive star that exploded to form the supernova remnant Cassiopeia A (Cas A, for short). Located in the constellation Cassiopeia, it is 10 light years across and 10,000 light years away from Earth. The material from the explosion is rushing outward at supersonic speeds in excess of ten million miles per hour. As this matter crashes into gas that surrounded the former star, shock waves analogous to sonic booms heat the gas and the ejected matter to temperatures in excess of fifty million degrees Celsius. The colors in this picture show the brightness or intensity of the X-rays with the yellow revealing the areas with the most intense X-ray emission.
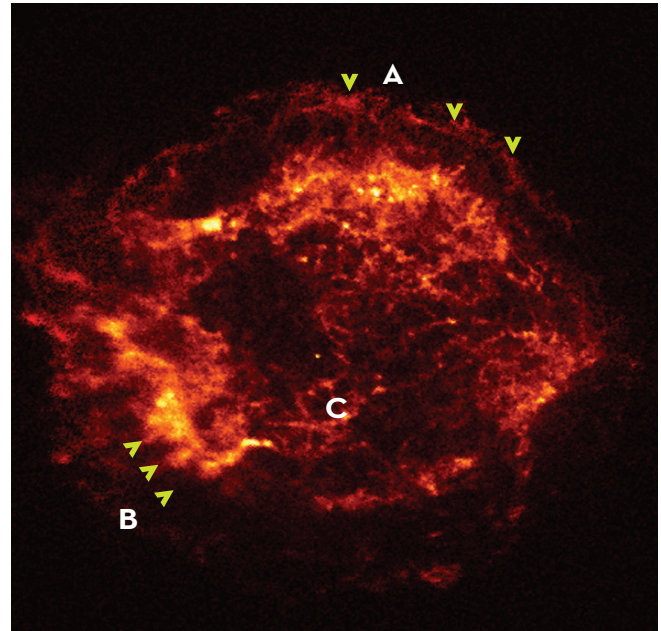
In the image, two shock waves are visible: a fast outer shock (arrow A) and a slower inner shock (arrow B). The inner shock wave is believed to be due to the collision of the ejecta from the supernova explosion with a circumstellar shell of material, heating it to a temperature of ten million degrees. The outer shock wave is analogous to an awesome sonic boom resulting from this collision. The small bright object near the center (circle C) may be the long sought neutron star that remained after the explosion that produced Cas A.