2

De-Coding Starlight Activity:
From Pixels to Images

RECOLORING the UNIVERSE

National Aeronautics and Space Administration

The Scenario

You have discovered a new supernova remnant using NASA's Chandra X-ray Observatory. The Director of NASA Deep Space Research has requested a report of your results. Unfortunately, your computer crashed fatally while you were creating an image of the supernova remnant from the numerical data. To fix this, you will create, by hand, an image of the supernova remnant.

To create the image, you will use "raw" data from the Chandra satellite. You have tables of the data, but unfortunately don't have all of it on paper so you will have to recalculate some values.

In addition to the graph, you will prepare a written explanation of your discovery and answer a few questions.

COMPLETE THE FOLLOWING TASKS:

1

Calculations

Your mission is to turn 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 1. Before making the image, you will need to 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 have to fill in the blank pixels. This is the grid in which you will draw the image

2

Coloring the Image

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

Each of the five colors will represent a range of intensity values. Select the range of intensities assigned to each color. Fill in these range values and associated colors on the legend at the bottom of the image grid sheet. Using colored pencils, shade in the grid using your color legend.

Hint: as you assign colors to ranges, it is best to pick colors that are "close" to each other as you move from one range to another. For example, in the range with the lowest intensities you may assign the color red. In the next lowest range, you would then assign the color orange, rather than indigo.

A. PIXEL TABLE

Raw data of the newly discovered supernova remnant collected from the Chandra X-ray Observatory.

Missing Grid Coordinate	Observation 1	Observation 2	Observation 3	Observation 4	Observation 5	Average Number of Photons
A4	39	40	40	42	42	
B6	59	61	62	60	58	
B7	62	71	missing	63	missing	
B8	64	68	71	71	72	
C3	50	54	52	50	54	
C6	33	missing	missing	31	38	
C10	64	63	61	64	missing	
D2	41	missing	missing	missing	43	
D6	104	missing	105	108	108	
D7	140	144	142	141	137	
D10	62	50	57	50	52	
E7	41	43	43	36	40	
E8	214	210	210	210	214	
F2	missing	49	49	47	47	
F4	153	missing	154	155	156	
F6	148	135	missing	missing	130	
F8	152	141	147	145	144	
G2	49	51	48	50	missing	
G4	130	123	missing	missing	124	
H2	51	49	53	50	50	
H3	34	25	38	31	26	
H4	115	114	missing	128	123	
H6	95	97	missing	missing	missing	
H8	115	115	115	113	112	
H10	73	83	missing	80	81	
I3	missing	39	35	37	42	
I5	58	69	54	missing	65	
I9	68	77	80	81	missing	
J6	46	49	55	missing	48	
J7	61	69	79	74	54	

B. 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		48				46	18	7
3	23	36		35	30	27	21			13	0
4		43	24	8	216				54	21	3
5	36	58	37	44	36	20	33	105		23	4
6	32				12		18		24		17
7	24		32			17	12	126	64		21
8	18		36	237			155		22	74	6
9	16	75	38	34	26	12	14	21		37	4
10	8	71			42	23	64		31	16	2
11	3	3	2	1	0	0	2	0	1	0	0

C. COLOR LEGEND

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

3

Preparing the Presentation

Include a drawing of what the actual supernova remnant would "look" like. On a separate sheet of paper, write a detailed description (1-2 paragraphs) of the prominent features of the supernova remnant. Describe how the image shows a neutron star, a fast outer shock wave, and a slower inner shock wave.

4

Answer these questions:

The NASA director has the following specific questions about your findings.

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.

Because your computer crashed, you had to draw the image by hand. In 3-4 sentences, explain why would it have been easier to use a computer? Consider that the Chandra satellite actually sends millions of data from each observation and how long it would take to process millions of data by hand.

GATHERING DATA

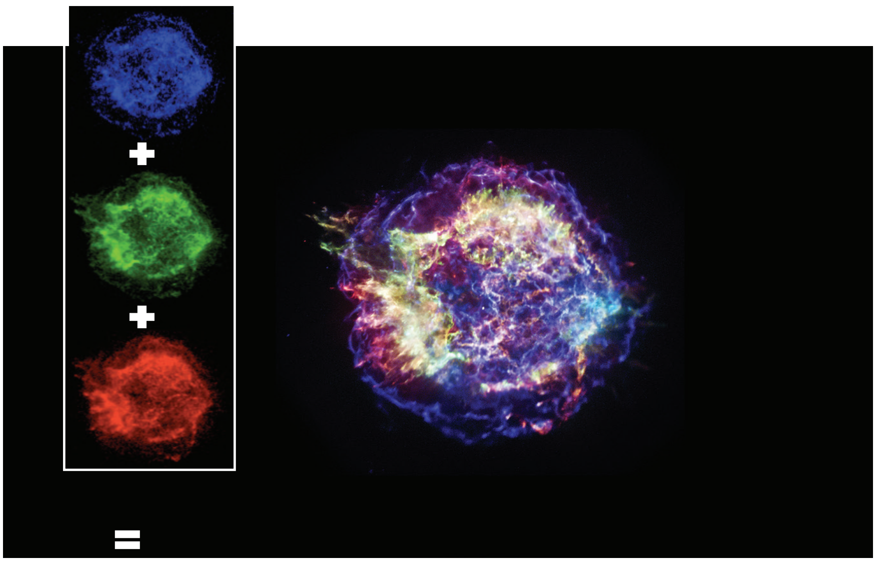
NASA's Chandra X-ray Observatory is a telescope designed to detect X-ray emission from very hot regions of the Universe such as exploded stars, clusters of galaxies, and matter around black holes. As the photons—individual packets of electromagnetic energy that make up electromagnetic radiation—coming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

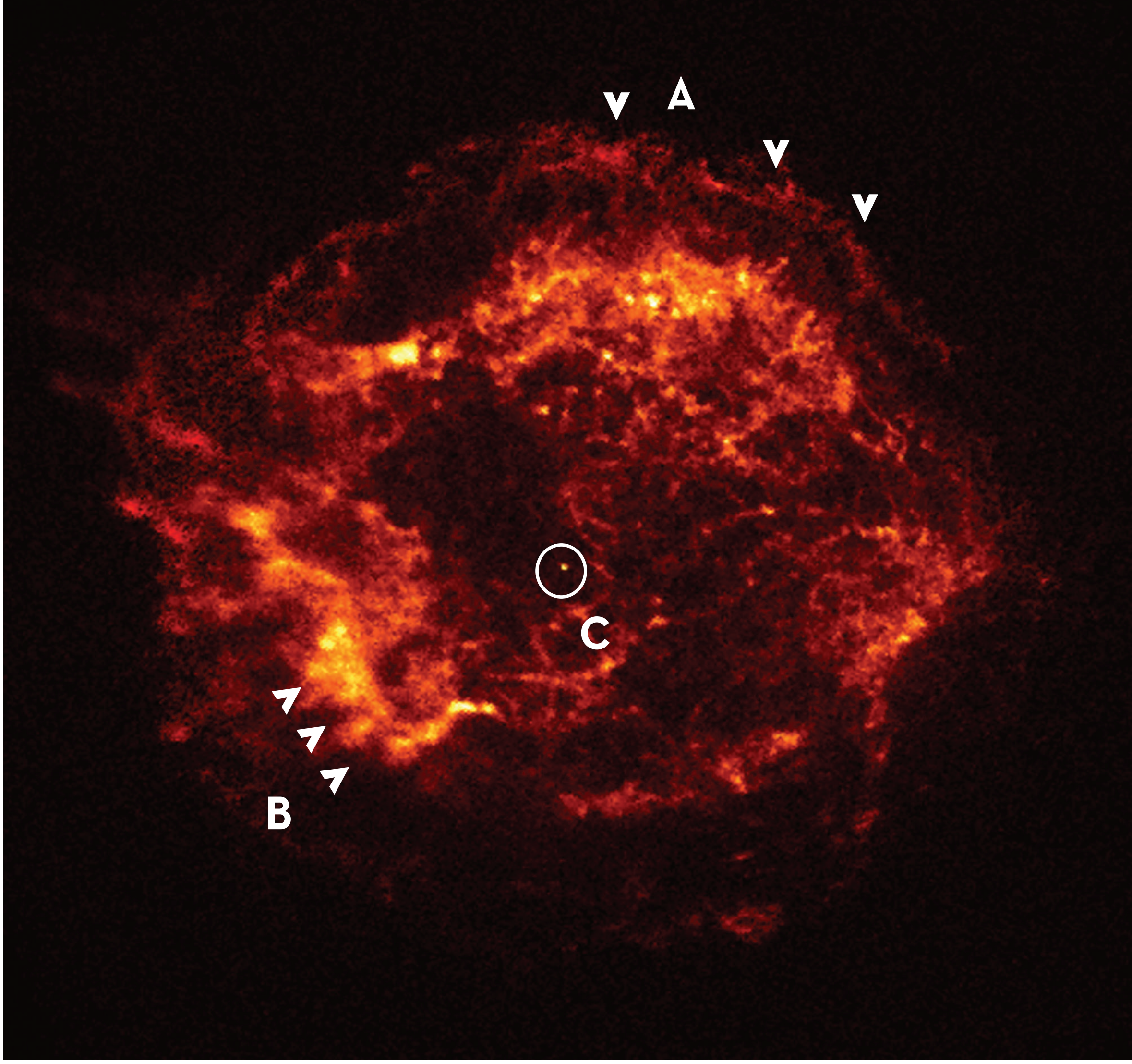
Every 8 hours, Chandra then downloads millions of pieces of information to Earth. Chandra's data arrive at the Chandra X-ray Center packaged in the form of 0's and 1's that only a computer could love. The flood of numbers must then be converted into images using scientific software. Scientists and programmers 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. So the science informs the colors used.

PUTTING IT ALL TOGETHER

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





UNDERSTANDING CASSIOPEIA A

This Chandra image 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 awesome sonic booms heat the gas and heat 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, where yellow reveals 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.

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 as part of a supernova that destroys the rest of the star. Typically neutron stars are composed almost entirely of neutrons, are about 20km in diameter, are about 1.5 times as massive as the Sunstar as part of a supernova that destroys the rest of 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.

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