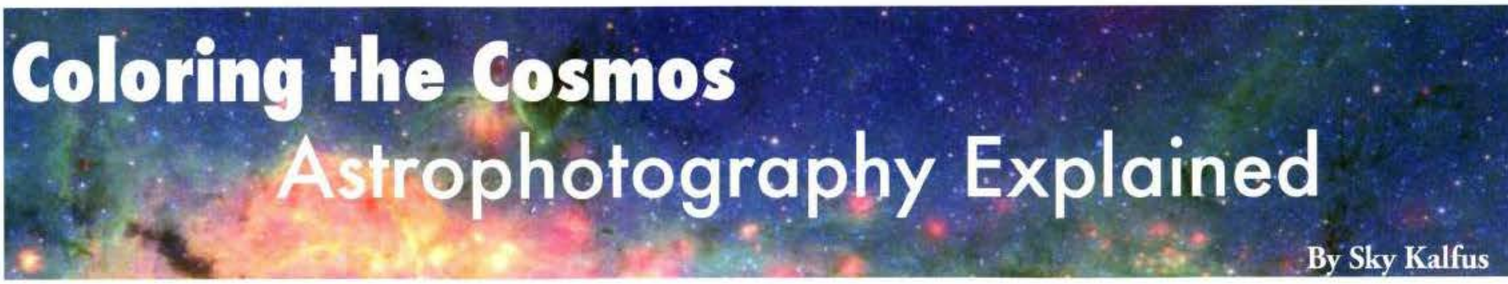
The Synapse: Intercollegiate science magazine

Volume 1 | Issue 1 Article 10

2-1-2012

Coloring the Cosmos: Astrophotography Explained

Sky Kalfus



Coloring the Cosmos
Astrophotography Explained

By Sky Kalfus

Let's imagine you're in deep space. Behind you, our sun is indistinguishable from the billions of stars that compose the Milky Way Galaxy. In front of you, 4,000 light years away, you're able to make out the bright light of the Crab Nebula, a cloud of gas and dust left over from a violent supernova explosion. You recall seeing photographs of the Crab Nebula when you were back home and remember an ethereal crimson cloud with a center of brilliant white. Or was it a green-and-gold ring of algae-like filaments, focused around a haze of blue smoke? Suddenly, it occurs to you that you've seen many photos of the Crab Nebula. Each was entirely unlike the others, and each was entirely unlike the white smudge of light that barely makes itself visible to you from your vantage point in space.

What's going on? Photographs of deep space would have us believe in a Day-Glo universe. We're accustomed to gorgeous, detailed depictions of nebulas and galaxies, rendered in brilliantly saturated hues. But if you've ever been in space, or at least looked at a deep space object through a telescope, you know that those colors aren't visible to the human eye. In fact, many of the colors you see in astrophotographs were never there to begin with. Typically, we expect photographs to show us the world — and the universe — roughly as if we were seeing it with our own eyes. But astrophotographs aim to serve a higher scientific purpose, and can show us much more than that.

Catching Rays

To understand how astrophotographers take pictures, it helps to think of a camera as a data-collecting device. It records the wavelength, frequency, and amplitude of the light it receives. Encoded in this data is valuable information. Chemical elements emit light at specific wavelengths, and if we can identify the wavelengths of light produced by a galaxy or a nebula, we can also identify the chemical elements that compose that galaxy or nebula. We can then infer its origins, its evolution, and the temperatures of its individual stars. A photograph is literally a graph that depicts this information. Color represents wavelength; intensity of the color represents amplitude. (When you get sunburned, your skin is a negative photograph; darkness corresponds to level of light exposure.) In a family photograph, the colors correspond almost exactly to the wavelengths they represent. But in astrophotography, two chemical elements might emit similar but distinct wavelengths of light — say, two different shades of red. It's important that we distinguish these two elements, so an astrophotographer might choose to represent one wavelength of light with a contrasting color, the same way you might choose colors to represent data on a bar graph.

Visible Light

To distinguish the wavelengths of light recorded by a camera, it's easiest to control the light the camera receives. Astrophotographers use a tool called a filter, a piece of colored glass that blocks all but certain wavelengths of light. A filter allows astrophotographers to take a photo of, say, just red light. Typically, astrophotographers will take three photographs of an object, each through a different color filter — red, blue, and green. Separating the wavelengths of light into three photographs makes it possible to adjust the brightness and contrast of specific colors. The three modified photographs are layered to produce a single full-color image with important features made visible.

> **We expect photographs to show us the world roughly as if we were seeing it with our own eyes. But astrophotographs can show us much more than that.**

Most nebulas are surrounded by an abundance of ionized hydrogen gas. Hydrogen is the most plentiful element in the universe, but the red light it produces is faint. By amplifying the red layer of a three-color photograph, the hydrogen becomes visible. The rosy haze that characterizes many photographs of nebulas indicates an abundance of hydrogen gas. A bluish-white fog, like that seen in visible-light photos of the cloud nebula, indicates synchrotron radiation, a bright light emitted by charged, fast moving particles passing though magnetic fields. In the case of the Crab Nebula, it suggests the presence of a rapidly spinning neutron star at its center.

Narrow Band Imaging

The pinkish color of nebulas can also be indicative of ionized helium gas, which, like hydrogen, emits red light. In fact, helium and hydrogen are so similar in color that they're impossible to visually distinguish. When astrophotographers want to differentiate between two elements of the same color, a simple red, blue, or green filter won't do. Instead, they use filters that only let in one specific wavelength of light — say, light emitted by sulfur. With one photograph that only shows light emitted by hydrogen and another that only shows light emitted by sulfur, they can assign an arbitrary contrasting color to one of the photos. When the photos are layered, the contrasting color stands out and separates the wavelengths.

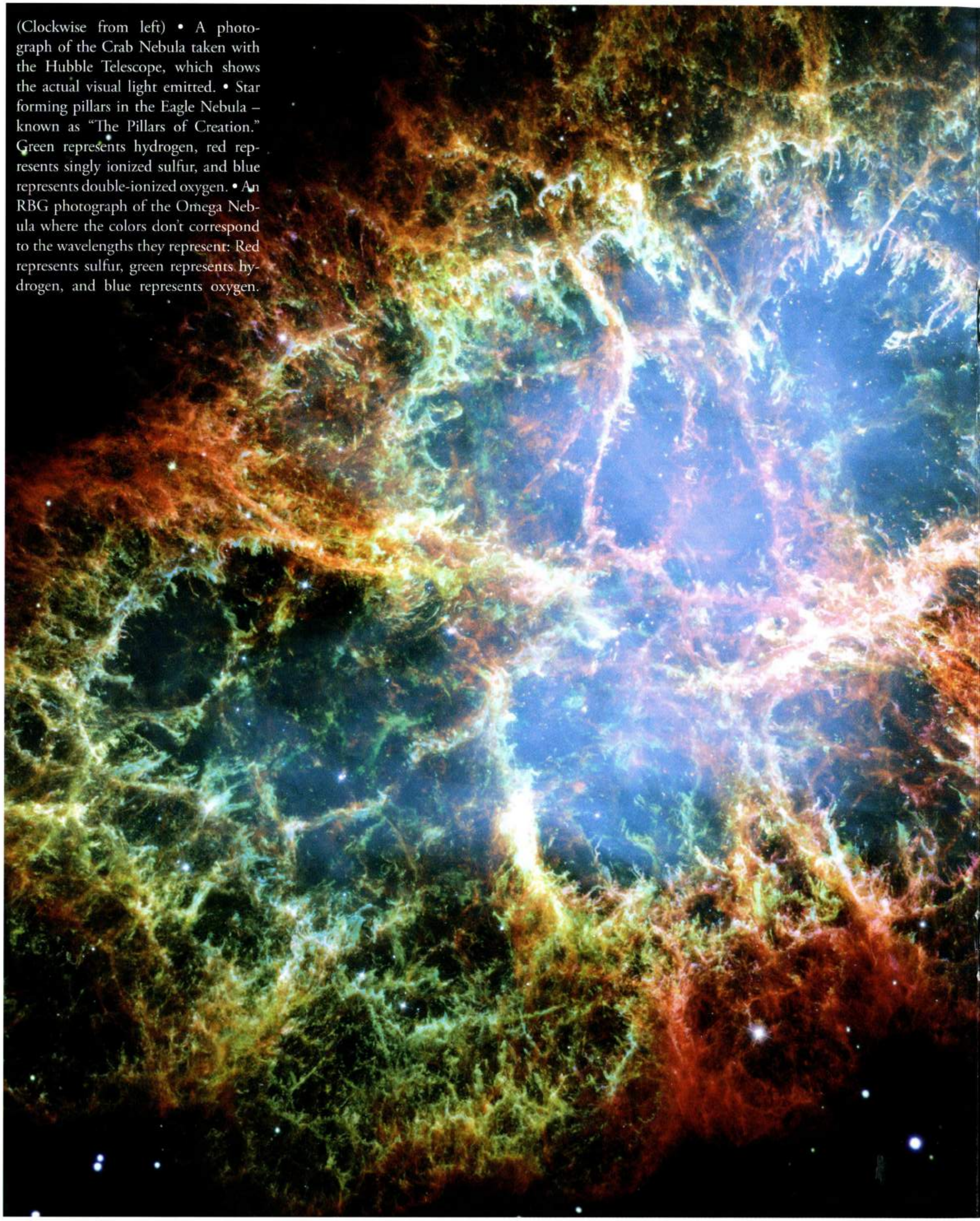
Non-Visible Light

While the visible light emissions of celestial bodies are interesting, space objects emit way more than just visible light. That's why we photograph at nearly every wavelength of electromagnetic radiation there is — x-ray, gamma ray, ultraviolet, infrared, microwave, and radio.

Astrophotographers can represent photos taken in non-visible forms of light by arbitrarily assigning colors to different wavelengths. Since most astrophotographs you see are taken in non-visible wavelengths, most of the colors you see have no basis in fact. Usually, astrophotographers represent low-wavelength light with low-wavelength colors, like red, and high-wavelength light with high-wavelength colors, like blue.

True or False

Are manipulated astrophotographs in "false-color"? Many scientists argue that there's no such thing as "true color". After all, organisms — dogs, lizards, possible extraterrestrials — perceive color in all kinds of ways. It's hard to define what "true color" is. What's important to astrophotographers is to preserve information about the wavelengths of light. Wavelength is an objectively measurable quality. Color is not. Astrophotographs don't show us space as we'd see it with our own eyes. Instead, they give us a kind of super vision, the ability to identify the chemical composition of celestial bodies thousands of light-years away. Through the careful manipulation of the faint fragments of light that reach our astronomical instruments, the universe becomes knowable.



(Clockwise from left) • A photograph of the Crab Nebula taken with the Hubble Telescope, which shows the actual visual light emitted. • Star forming pillars in the Eagle Nebula – known as "The Pillars of Creation." Green represents hydrogen, red represents singly ionized sulfur, and blue represents double-ionized oxygen. • An RBG photograph of the Omega Nebula where the colors don't correspond to the wavelengths they represent: Red represents sulfur, green represents hydrogen, and blue represents oxygen.