Hubble's Deep View of the Universe

Red galaxies, blue galaxies; old galaxies, new galaxies. Astronomers have never before had a picture like this.

Last month, the Hubble Space Telescope stared at a tiny patch of sky near the handle of the Big Dipper for 10 consecutive days, generating a high-resolution image that reaches deeper into the heavens than any previous one. A composite of several hundred 15-minute to 40-minute exposures recorded from ultraviolet, blue, red, and infrared emissions, the Hubble picture shows a bewildering array of galaxies.

Like a swath cut through several layers of an archaeological dig, the combined image is thought to include galaxies of all ages. Astronomers believe that the most distant galaxies in this image were recorded as they looked when the universe was only about a billion years old, a mere 10 to 20 percent of its current age.

Known as the Hubble Deep Field, the image contains about 1,500 galaxies, many of them only one four-billionth as bright as the dimmest light the human eye can see and fainter than any existing telescope on Earth can detect. More than just a pretty picture, the Deep Field will help astronomers tackle some of the most fundamental mysteries of the cosmos, including the birth and evolution of galaxies, says Robert E. Williams, director of the Space Telescope Science Institute in Baltimore.

Viewing the image is "like looking down a long tube and seeing all the galaxies along the line of sight," says Mark Dickinson of the Space Telescope Science Institute. "They're all stacked up against one another. . . and the challenge now is to disentangle them."

Willams, Dickinson, and their colleagues unveiled a poster-sized version of the display this week at a meeting of the American Astronomical Society in San Antonio. The team released the data to the astronomical community after only 2 weeks instead of the usual 1 year.

In doing so, says Stanislav G. Djorgovski of the California Institute of Technology in Pasadena, "Williams has invested in science venture capitalism. This will truly stimulate a vast amount of follow-up studies."

Williams *et al.*/NASA

This composite of 276 exposures in blue, red, and infrared light represents about 25 percent of the Hubble Deep Field.

A priority, Djorgovski adds, will be to determine distances from Earth for as many of the galaxies as possible. The expansion of the universe provides the means. That expansion causes distant galaxies to move away from each other faster than nearby galaxies. Thus, by measuring velocity, astronomers can learn how far from Earth a galaxy lies.

Because so many of the galaxies in the Deep Field are extremely faint, Williams estimates that even the world's largest optical telescope, the 10-meter W.M. Keck atop Hawaii's Mauna Kea, can measure the velocity of only about 100 of them. That's why Hubble's color information becomes so important, Dickinson notes.

For instance, very distant galaxies tend to vanish in the ultraviolet, even if they show up clearly at longer, redder wavelengths. That's because hydrogen gas readily absorbs ultraviolet light, and the most distant galaxies have the largest amount of hydrogen gas between them and Earth.

With the help of this effect, known as ultraviolet dropout, Dickinson hopes to determine whether a number of bizarre, stringlike galaxies, also noted in another Hubble image, are truly distant (SN: 7/29/95, p. 69). If so, these filaments may represent the building blocks of the more familiar spiral and elliptical galaxies of today's universe.

Color information may also indicate whether many of the Deep Field galaxies are as compact as they appear or are merely the brightest parts of large, diffuse galaxies, Dickinson adds.

— R. Cowen

CFCs transformed into pillar of salt

Chlorofluorocarbons (CFCs), including refrigerant gases known to harm Earth's ozone layer, have come under political fire owing to industry's stockpiling of them.

Without a practical way to destroy or use CFCs, manufacturers have stuffed warehouses with vast quantities of the inert but environmentally hazardous gases. So unreactive are CFCs that they have resisted all but the harshest chemical treatments—hence their long-term survival in Earth's stratosphere.

Now, Juan Burdeniuc and Robert H. Crabtree, chemists at Yale University, have found a relatively simple way to break down the hotly debated coolants into benign, useful components. In the Jan. 19 SCIENCE, they describe a method of mineralizing CFCs by passing them through a heated bed of sodium oxalate, a harmless powder. The process generates four common chemicals: carbon, carbon dioxide, sodium fluoride, used in toothpaste, and sodium chloride, or table salt.

"It's hard to break down CFCs without releasing corrosive by-products," Crabtree says. "The remarkable thing about this reaction is that sodium oxalate, an innocuous compound found in rhubarb leaves, can destroy CFCs. It's like watching an air pistol punch holes in steel."

Pumping CFCs through sodium oxalate ($Na_2C_2O_4$) at 290°C—kitchen broiler temperature—causes the powder to surrender two electrons to each gas molecule, the chemists posit. In accepting the two electrons, the CFCs release fluoride and chloride ions, which subsequently hook up with available sodium ions to create salts. The remaining materials yield carbon dioxide gas and solid carbon.

"This is cutting-edge work," says Craig A. Burton, a chemist at 3M in St. Paul, Minn. "Normally, we expect to use extremely high temperatures or highly reactive agents to break [CFCs] up. Any work indicating that they will react in moderate conditions is of great interest."

If it succeeds on an industrial scale, this process might prod manufacturers to switch more quickly to less environmentally destructive refrigerants, Crabtree says. As of the beginning of this year, 139 countries had banned production of CFCs. "Companies claim that without an easy way to destroy CFCs, the gases should still be sold in the United States and the Third World," he says.

"But if a cheap CFC destruction method becomes available, perhaps they will switch sooner." *— R. Lipkin*