Cosmic Cloudshine: Its Beauty Is More Than Skin Deep

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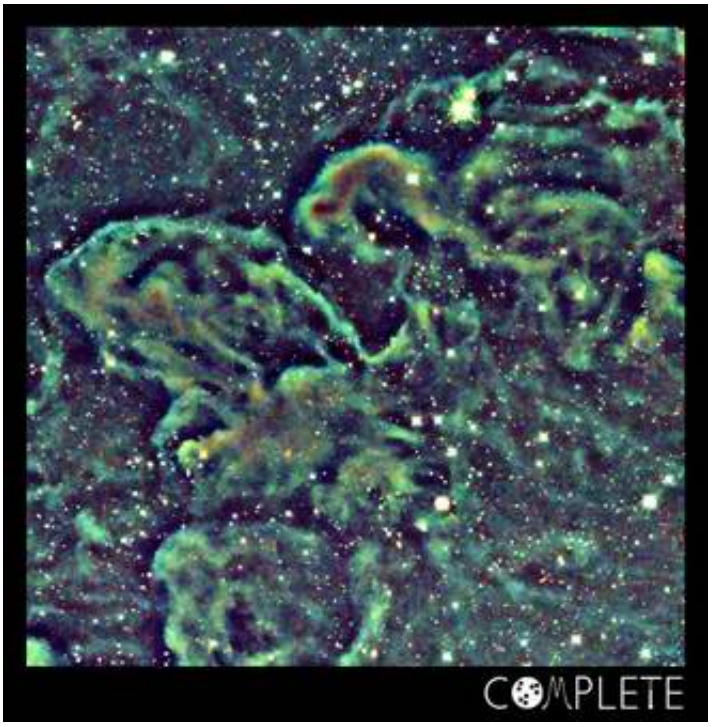

Hubble's iconic images include many shots of cosmic clouds of gas and dust called nebulae. For example, the famous "Pillars of Creation" mark the birthplace of new stars within the Eagle Nebula. Yet despite their beauty, visible-light images show only the nebulae surfaces. Baby stars may hide beneath, invisible even to Hubble's powerful gaze.

This color-coded near-infrared image of L1451 also shows evidence of extensive cloudshine. The near-infrared "color" of a nebula correlates to the nebula's density, and can therefore be used to map its structure. Here, dark reddish-brown regions are denser than the surrounding greenish areas. Using cloudshine, astronomers can study star-forming regions at a very small scale and learn much more about the physics of star formation. This image was taken with the OMEGA 2000 camera at the Calar Alto Observatory in Spain as part of the COMPLETE survey of star-forming regions. Credit: J. Foster & A. Goodman (CfA)

Harvard astronomers have pioneered a new way to peer below the surface using near-infrared light that is invisible to the human eye. The resulting images are both beautiful and scientifically valuable because they can be used to map the structure of interstellar matter.

"We can now see the structure of gigantic star-forming regions over vast distances with a resolution 50 times better than before," said Alyssa Goodman of the Harvard-Smithsonian Center for Astrophysics (CfA). "This technique will revolutionize the way we map stellar birthplaces."

While Hubble's NICMOS instrument and NASA's Spitzer Space Telescope also use infrared light to study nebular interiors, ground-based images at near-infrared wavelengths provide an unparalleled combination of wide-field coverage and high resolution.

"Images like these will give astronomers new insight into what those giant complexes of gas and dust really look like," added Jonathan Foster, a graduate student at Harvard University and the paper's first author.

The researchers took long-exposure photographs of a star-forming region in the constellation Perseus and were surprised to see something they had never seen before. Just as earthly clouds shine orange at night as they reflect light from streetlights below, they discovered that clouds

in outer space show a similar effect. In space, otherwise "dark" clouds of dust and gas are illuminated by faint starlight washing over them.

Goodman and Foster dubbed the new celestial phenomenon "cloudshine." Their long-exposure, near-infrared images uncovered the faintly shining billows of material. Recent advances in infrared detectors, combined with longer than usual imaging times, led to the discovery.

"Other astronomers have seen hints of cloudshine in their images, but our new photographs are the most spectacular evidence of cloudshine to date," said Goodman.

Reflection nebulae such as the wisps surrounding the Pleiades star cluster have been observed for decades. Importantly, the Pleiades and other famous "nebulae" are illuminated from within, by the stars associated with them, as a cloud is when fireworks explode inside of it. Cloudshine is the result of the illumination of otherwise "dark" clouds from "without," by the faint, and nearly uniform, ambient light produced by the sum of all the stars outside the cloud. Simple modeling in Foster & Goodman's paper demonstrates that there is enough of this faint ambient light to illuminate the clouds at the levels observed.

The cloudshine images were obtained as part of the COMPLETE survey (Coordinated Molecular Probe Line Extinction Thermal Emission) of star-forming regions. COMPLETE involves making wide-field, high-resolution studies of three nearby star-forming regions. COMPLETE will allow for detailed analysis and understanding of the physics of star formation on scales ranging from one-hundredth of a light-year up to 30 light-years.

A companion paper by astronomer Paolo Padoan (UC San Diego) and colleagues describes theoretical modeling of the cloudshine effect in

turbulent clouds of gas. They showed that the near-infrared "color" of a nebula correlates to the nebula's density, and can therefore be used to map its structure.

"By using cloudshine, astronomers can study star-forming regions at a very small scale," said Padoan. "We will be able to learn much more about the physics of star formation."

Foster and Goodman anticipate gathering many additional images of cloudshine as the COMPLETE survey continues.

"We can cover wide areas of the sky at high resolution relatively quickly," said Foster. "We expect that this will become the best technique for mapping the density of `dark' clouds with very high resolution."

Foster and Goodman's paper reporting the cloudshine observations has been submitted for publication to The Astrophysical Journal Letters and is available online at arxiv.org/abs/astro-ph/0510624 .

A paper on the theory of cloudshine by Padoan, Mika Juvela and Veli-Matti Pelkonen (University of Helsinki) also has been submitted for publication to The Astrophysical Journal Letters and is available online at arxiv.org/abs/astro-ph/0510600 .

Foster and Goodman's work, and the COMPLETE Survey, are supported by the National Science Foundation, NASA, and Harvard University.

Source: Harvard-Smithsonian Center for Astrophysics