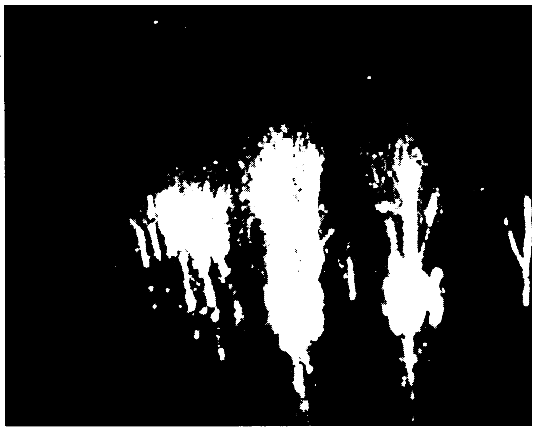
Elusive beasts dance high in the night sky


Lyons

Carrot-shaped sprites over high plains.

Once considered a sleepy part of the sky, the middle atmosphere has recently gained a reputation as the home of Earth's most exotic fireworks. Peering high above the tops of thunderstorms, researchers are discovering new forms of lightning that flash red and blue in the shapes of giant jellyfish, carrots, doughnuts, and trumpets.

Though rumors of lofty lights had circulated for years among pilots and weather watchers, atmospheric scientists first observed these flares in the early 1990s. This summer, 50 researchers from the United States, Japan, and New Zealand gathered at mountaintop observation stations in the Rocky Mountains to capture the most detailed pictures yet of the electric beasts. The scientists unveiled their results this week at a meeting of the American Geophysical Union in San Francisco.

The recent discoveries have electrified a formerly quiet, obscure branch of atmospheric physics. "Four or 5 years ago, I would go to [these] sessions, and there were maybe 10 people in the audience at most. Within the last 2 years, these meetings have become packed, and it's getting worse and worse," says Robert Roussel-Dupré of Los Alamos (N.M.) National Laboratory.

Whereas normal lightning streaks through the lower atmosphere, the high-altitude flares occur in the stratosphere and mesosphere—from 17 to 105 kilometers above ground. Because they lie above storm clouds, the flares are normally hidden from people directly beneath them. Adding to their reclusive nature, these flickerings last for just a few thousandths of a second. Lower-altitude lightning can persist for seconds (SN: 12/23&30/95, p. 421).

Like biologists tracking new animal species on an uncharted island, atmospheric researchers are still simply trying to document the various phenomena above clouds. They have identified three categories. Bloodred features known as sprites appear between 50 and 90 km in altitude and can last long enough to be seen by observers to the side of a storm. Doughnutlike bursts called elves, which often occur with sprites, flicker for less than a millisecond at 85 to 105 km. Indirect evidence suggests that they are red. The rarest and lowest flashes, called blue jets, shoot from the tops of storms and flare out like the bell of a trumpet.

From a station on Yucca Ridge, Colo., scientists this summer detected 1,127 sprites and elves during 21 nights of watching storms brew on the high plains, reports Walter A. Lyons of Forensic Meteorology Associates. Lyons' home on the ridge served as the central research facility; teams also stationed themselves on other mountains in Colorado, Wyoming, and New Mexico.

The scientists detected a new form of sprite that differs from the traditional jellyfish shape, with its downward-pointing tendrils. The subspecies has a thin body and branches upward and out, like the leaves on a carrot. "We found that sprites are vastly more complicated than we had thought," says Lyons.

To study elves, researchers from Stanford University built a special instrument with 12 light-capturing tubes. Their observations indicate that elves start at a central point and expand in a circle until they reach several hundred kilometers across.

This style of growth matches predictions made previously by Umran Inan of Stanford and his colleagues. They had proposed that elves stem from extra electromagnetic pulses triggered by lightning. The pulses race upward, generating light when they reach the ionosphere. The theory predicts that elves should start right above the lightning and then spread as the pulses reach more distant parts of the ionospheric layer.

Roussel-Dupré agrees that the pulse model fits the new observations but suggests that the pulses could come from sprites rather than from regular lightning. As for sprites, there is even less agreement on what causes these flares and how they assume such a variety of shapes. —*R. Monastersky*

Scattered light reveals polymer wave motion

Thin polymer films form the basis of products ranging from biological glues to nonstick coatings. In many applications, the polymer molecules stick out from a surface like grasses growing in a microscopic field. Rooted at one end, the molecules reach up and undulate as if blown by the wind.

A new method of characterizing these waves could lead to better understanding of the properties of polymer films. Researchers at the Institute of Electronic Structure and Laser in Heraklion, Greece, tracked the movements of tethered polymer molecules by measuring how they scatter light. The motions of the polymers can either enhance or interfere with the way they stick to surfaces, affecting their performance as paint primers and other coatings.

Although scientists have looked at the static properties of what they call polymer brushes—measuring their density, for example—this new technique is "definitely one of the first" ways to study their collective motion, says Anna C. Balazs of the University of Pittsburgh. "It's a very elegant technique. It's clever in that it isolates information that you're looking for, and it doesn't destroy the sample." The study appears in the Dec. 20 SCIENCE.

The team immersed one side of a glass prism in a solution containing suspended polymer molecules, which coated the surface. Each molecule consisted of a short segment of polyethyleneoxide, which stuck to the glass, and a longer chain of polystyrene, which stretched out into the solution.

The researchers then shone a laser beam through the prism so that it hit the interface between the glass and the solution at an angle shallow enough to reflect most of the beam. A little light got through the glass, however, and passed through the undulating polymer molecules, says study coauthor Bradford J. Factor, now at the Chandler, Ariz., offices of Intel, an electronics company. By measuring how that little bit got scattered, the researchers could record the molecules' wavy movements.

The waves of the brush are complex, Factor says, but they can be thought of as combinations of several distinct patterns of motion. The experimental technique lets researchers analyze each pattern separately and track how the movement dies down over time.

The technique also ensures that not much light is scattered off the polymer molecules remaining in the solution. Such noise would overwhelm the signal created by the fine movements of the tethered molecules. "We concentrate the light very close to the [prism] surface," Factor says. "The molecules that are far away from the surface don't see the light." The researchers can control the depth of the light's penetration by varying the angle at which the laser beam strikes the interface.

Balazs would like to see the technique used to investigate what happens when two polymer brushes come into contact, as when two coated surfaces are brought together.

The technique could also characterize biological systems, such as cell membranes or proteins adhering to surfaces. —*C. Wu*

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