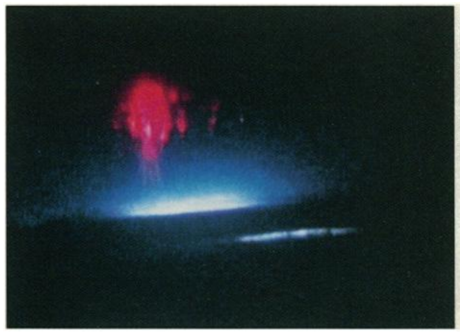
ATMOSPHERIC RESEARCH

Stalking Flashy Beasts Above the Clouds


UNIVERSITY OF ALASKA

Red sky at night. A so-called red sprite dances as high as 95 kilometers above a thunderstorm.

From the time of Benjamin Franklin on, thunderstorm researchers entranced by the commotion inside storm clouds have missed a quieter, more mysterious display taking place far above them. A few observers—mostly pilots—did spot strange flashes of light far above storm clouds, but they were never taken seriously by the research community. That neglect ended last summer when researchers turned highly sensitive cameras to the sky above the flood-gushing storms of the Midwest and recorded flashes by the hundreds, reaching tens of kilometers above the cloud tops (*Science*, 27 May, p. 1250). This summer, atmospheric scientists are back with more and better equipment, and they're finding there's even more to watch.

"There's more than one type of luminous phenomenon over clouds," says meteorologist Walter Lyons of Mission Research Corporation (MRC) in Fort Collins, Colorado, who recorded more than 600 flashes last summer. "There's a whole zoo of things running around." Two of the showiest members of the menagerie are red, carrot-shaped "sprites" and fountainlike blue jets. But although a four-institution project (involving the University of Alaska, MRC, Stanford University, and Pennsylvania State University) is studying the appearance and behavior of the flashes from the ground and from high-flying aircraft, the mystery has been slow to yield. "It's getting curiouser and curiouser," says Lyons.

Most curious of all are the blue jets, which "look for all the world like there was an explosion [in the cloud top] and out comes some stuff," says Eugene Wescott of the University of Alaska. He and his colleague Davis Sentman captured the first images of blue flashes when the researchers flew above Midwest storms early last month to make the first color video recordings of upper-atmosphere flashes. Wescott doesn't think anything is literally exploding out of cloud tops to produce these sprays of blue light, which stab upward at 300 times the speed of sound to altitudes of 25 kilometers above the cloud tops. Nor do the jets resemble topsy-turvy lightning bolts, which on rare occasions have been seen striking upward from cloud tops. So what are they? "I haven't a clue," admits Wescott.

Red sprites seem a bit more understandable. Sentman and Wescott's color video images of the sprites confirm Lyons' visual report of last year that sprites are usually red—salmon red to the human eye. The color suggests to atmospheric chemist Russell Armstrong of the Nashua, New Hampshire, office of MRC that the light comes from oxygen or nitrogen molecules excited by collisions with high-energy electrons—the same process that produces similar hues in the aurora. The presence of high-energy electrons, in turn, would support the idea that flashes are a long-distance effect of lightning within the clouds. In this scenario, the largest lightning strokes send an electromagnetic pulse into the thin upper atmosphere, where it rips electrons from air molecules and accelerates them to produce light.

The brightest part of such a flash, however, should appear above an altitude of 80 kilometers in the lower ionosphere, where the electrons no longer have to be torn from air molecules because they are already running free. And there's the rub: The sprites seen this summer are at their most intense 10 kilometers below that, notes Lyons. "There's something we don't understand." One more thing, that is.

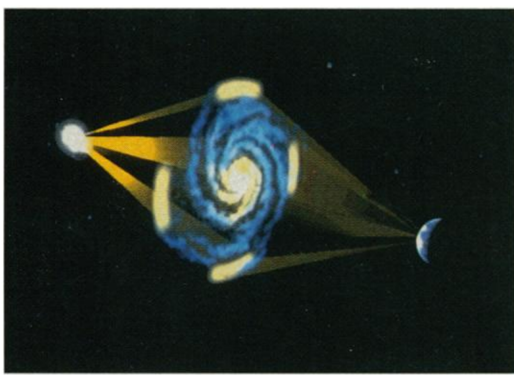
–Richard A. Kerr

COSMOLOGY

Spoiling a Universal 'Fudge Factor'

Even the most enthusiastic cosmologist will admit that current theories of the nature of the universe have some big holes. One such gap is that the universe seems to be younger than some of the objects contained within it. Another problem is that the observed universe just doesn't appear to have enough matter in it to explain the way it behaves now, nor the way theorists predict it will evolve.

To overcome these problems, many cosmologists have suggested that the equations of gravity should contain a number called the cosmological constant: a fudge factor that, if it has the right value, would make these bugbears disappear (*Science*, 5 November 1993, p. 846). But a new analysis of observations of gravitational lenses—galaxies whose gravity bends the light of more distant objects—shows that, if the constant does exist, it cannot be big enough to explain the anomalous age of the universe or the missing mass. "The lensing statistics really are becoming a problem for the cosmological constant models," admits cosmologist George Efstathiou of Oxford University.


D. BERRY/STSCI

Cosmic optics. Light is bent by a galaxy to produce multiple images of a distant quasar.

Estimates of the age of the universe center on observations of distant galaxies: how far away they are and how fast they are receding as the universe expands. These data let cosmologists put a date on the Big Bang, and the current estimates put the beginning of time at around 8 billion years ago. But models of stellar evolution suggest that some star clusters are at least 5 billion years older than that, a discrepancy that is difficult to explain.

The emptiness of space is arguably an even tougher problem. According to the simplest current theories of the very early universe, there should be just enough matter in the cosmos to allow it to expand forever; any more matter and gravity will be strong enough to halt the expansion and pull the universe back into a cosmic crunch. Cosmologists express this theoretical prediction by saying that the value of "omega"—a measure of the density of matter in the universe—is precisely 1. Observations of the real universe tell a different story, however: omega values of just 0.2 are typical.

Many cosmologists felt that something quite fundamental needed to be done, so they proposed restoring the cosmological constant, originally suggested by Albert Einstein in 1918. In a universe with a cosmological constant, all of empty space would be endowed with extra energy, gently pushing distant galaxies away from each other. This would make the universe appear younger than it really is, because it boosts the speed at which galaxies recede from one another. The constant can also help with the value of omega: Because of the equivalence of mass and