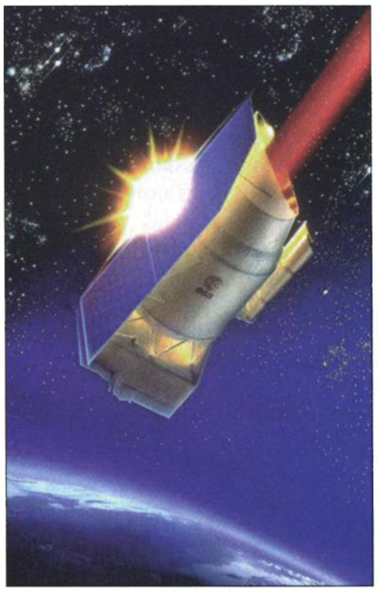
optimized the levels of dopants, impurities added to control the numbers of electrons and holes. But even as it stands, the new material has promise, because it outperforms the competition at temperatures below zero degrees Celsius. "People are desperate to find a material that will work much below room temperature," Kanatzidis says, "so it can take over where the other material leaves off."

–ADRIAN CHO

ASTRONOMY

Fine Details Point to Space Hydrocarbons

On Earth, it's hard to avoid polycyclic aromatic hydrocarbons, or PAHs. Made up of two or more fused benzene rings, they turn up in cigarette smoke, car exhausts, or just about anywhere that hydrocarbons burn at high temperature. But for nearly 2 decades, astronomers have argued about whether these molecules are as ubiquitous in space as they are here at home. They were puzzled by the fact that certain interstellar gas clouds in regions of space too cold to produce thermal emissions nonetheless produce characteristic emission bands in their infrared spectra. These bands look teasingly similar to the emissions bands produced by PAHs, but they are not exactly the same, and the failure of chemists to reproduce precisely the observed spectra in the laboratory has led some astronomers to argue that the emission bands are caused by small solid particles, such as soot or hydrogenated amorphous carbons. But astronomers picking over data obtained by Europe's Infrared Space Observatory (ISO), who met in Madrid last week,* believe they have evidence that clinches the case for PAHs in space.



Cold gaze. ISO spotted strong evidence for polycyclic aromatic hydrocarbons.

ISO, a 60-centimeter infrared telescope launched by the European Space Agency in November 1995, made over 26,000 observations before it ran out of the liquid helium needed to cool its telescope and detectors in April 1998. One of its tasks was to solve the riddle of PAHs. Some astronomers have suggested that PAHs could form in the atmospheres of carbon-rich stars and be ejected into interstellar space when the stars die. In the cold of space, such molecules would sometimes be struck by ultraviolet photons, causing the carbon atoms in the benzene rings to vibrate. Changes in vibrational energy are emitted as infrared light—a process called relaxation—just as sound is emitted from a gong when it is struck. Because of the numerous different shapes and sizes of PAHs, their spectra are dominated by bands of emissions, rather than discrete peaks.

Critics of this model argue that the emission bands just don't match those of PAHs in the lab. "The spectroscopy obtained [in lab experiments] with solid materials, such as anthracite, give a better spectral agreement," says Cécile Reynaud of France's Atomic Energy Commission in Saclay. PAH supporters counter that in cold interstellar space, there is simply not enough heat to produce thermal emissions from such solid particles. "With 15 degrees [kelvin], you won't have emission in the near infrared," says Alexander Tielens of the University of Groningen in the Netherlands. Very little ultraviolet radiation will cause relaxation in PAHs, however, so this could still occur even in the frigid environs of interstellar clouds.

Now, a team led by Christine Joblin of the CNRS Space Study Center for Radiation in Toulouse, France, believes it has convincing evidence. By studying the high-resolution spectra obtained with ISO's short-wave infrared spectrometer, they found that the emission bands are made up of a forest of sharp peaks. "This structure cannot be explained by solids—one expects wide and smooth bands—and we can explain this structure by assuming that we are dealing with a family of molecules," says Joblin.

To finally settle the matter, chemists will have to duplicate this detailed emission structure in the laboratory. Pascale Ehrenfreund of Leiden University in the Netherlands says finding laboratory spectra of PAHs that match astrophysical spectra is just a matter of getting the right mix of ingredients. But "if you have a family of 200 molecules, it is very difficult to pick the right ones on Earth. … You need a lot of laboratory studies in order to really make a perfect fit," she says.

Douglas Hudgins and his colleagues in the Astrochemistry Laboratory at NASA's Ames Research Center in Moffet Field, California, are attempting to do just that. And Hudgins believes that the ISO data will make his work much easier. "Up to this point, the quality of our laboratory spectra was much, much better than the quality of available astronomical data," but now the ISO spectra should make comparisons much sharper, says Hudgins. So will ISO data settle the matter? "Absolutely … I think there is overwhelming evidence supporting molecular PAHs and PAH ions in space."

–ALEXANDER HELLEMANS

Alexander Hellemans writes from Naples, Italy.

* ISO Beyond the Peaks. The 2nd ISO workshop on analytical spectroscopy, 2–4 February, Villafranca del Castillo, Madrid, Spain.

PLANETARY METEOROLOGY

Deep, Moist Heat Drives Jovian Weather

The weather on Jupiter is awesome but frustratingly mysterious. Great jets of 750-kilometer-per-hour wind girdle the planet, marking off distinctive, dark and light bands of clouds. And oval "storms" of various sizes and hues roll between the jets, ranging from small, short-lived eddies hundreds of kilometers wide to huge, long-lived swirls. The grandest of these ovals, the 20,000-kilometer Great Red Spot, has been at it at least since Galileo's day 300 years ago. But what, meteorologists have wondered, makes it all go? The sun bathes the jovian cloud deck in feeble light, while deep-seated heat energy that has lingered since the planet formed seeps out. Which of those two energy sources predominates in driving Jupiter's weather engine? And how does that energy get bundled into the small eddies on which the jets and spots feed?

In two papers in this week's issue of *Nature*, researchers provide an answer: Deep heat funneled upward by local storms is a major driver of jovian weather. They show that much if not all of the deep heat escaping the interior flows up through towering thunderstorms. These disturbances can go on to become small eddies that eventually give up their energy to storms such as the Great Red Spot. "Where these little guys come from has always been the question," says planetary meteorologist Timothy Dowling of the University of Louisville in Kentucky.

Lightning, captured by the imaging system aboard the Galileo spacecraft orbiting Jupiter, was the key to running down jovian weather's major energy source. On Earth and apparently on Jupiter, lightning and the water-fueled engine that drives thunderstorms are intimately connected. In a terrestrial thunderstorm, water vapor in rising warm air condenses. The condensation releases more heat that pushes the rising air upward even harder. This "moist convec-

CREDIT: ESA