SCIENCE NEWS OF THE WEEK

Cosmic Blackbody: Confirmation and Questions

When the cosmic background (radio) radiation was discovered about 15 years ago, its intensity at the first wavelengths measured seemed to fit the spectrum of a blackbody at about 3°K. As more and more frequencies were measured, their intensities also tended to fall on the 3° blackbody curve, even, or especially, in stretches where that curve deviates significantly from other possibilities such as a Rayleigh-Jeans spectrum.

The discovery made a revolution in cosmology. It lifted the big bang theory of the origin of the universe out of a rather obscure place in cosmologists' regard and made it the dominant cosmological model of our time. Since then the question has been how close to the simon-pure theoretical blackbody curve the actual cosmic background radiation comes and what can be learned from deviations, if any, about the physical details of the history of the universe.

How close? In the April 2 PHYSICAL REVIEW LETTERS D.P. Woody and P.L. Richards of the Lawrence Berkeley Laboratory present the results of a measurement over a fairly wide frequency range (2.5 to 24 waves per centimeter) that yields an accuracy of better than 10 percent of the peak flux of a 3° blackbody. As Woody and Richards point out, some of the earlier measurements on which belief in the blackbody is based were incapable of detecting deviations from a blackbody as big as 20 percent. The new measurement was done with a specially made spectrophotometer, in which for high accuracy the actual measuring implements are kept at liquid helium temperature. It was flown on a balloon from Palestine, Tex., to minimize atmospheric absorption.

In the view of a colleague, George F. Smoot of LBL, who is studying another delicate aspect of the cosmic background, its polarization, the experiment of Woody and Richards is "a remarkable achievement. It really is the first good experiment to show [the spectrum is] thermal." Arno Penzias of Bell Labs in Holmdel, N.J., who won the Nobel prize last year for his part in the original discovery of the cosmic background, calls the observation "a superb piece of experimental work, a tribute to their experimental skill." It is, he says, "the first very profound improvement in our knowledge of the spectrum." He points out that they were able to determine not only the intensity of the radiation, which is a first-order effect, and the shape of the spectrum, which is second-order, but also the third-order deviations. "Such things are extremely difficult to measure."

Deviations? Let us go back to the beginning of Woody's and Richards's paper, where they state the thesis of their investigation. "In its most elementary version this theory [the big bang] predicts a blackbody spectrum for the CBR." The textbook picture of a blackbody is of a heated box with a lot of radiation inside. This radiation has been in there long enough to reach a kind of equilibrium with itself. The box is black on the outside, because all the radiation is on the inside. For the benefit of the outside observer, who always lives in textbooks, a pinhole is made in the box. This lets out some of the radiation so that the observer can determine that there is a blackbody there.

In the case of the universe we don't need the pinhole because we are inside the box. But the observing job is complicated. We have to see that the brightness is the same in all directions and that the spectrum in all directions is thermal (that is, there is no nonthermal source of radiation in the box). Does the spectrum that Woody and Richards find correspond to the Planck curve (perfect thermal spectrum) for 2.96°K?

It doesn't. There is a small, but apparently real, deviation. It is expressed by Woody and Richards as a curve with the shape of a 2.79° blackbody and an emissivity of 1.27. That is a statement likely to stop a physicist cold. By definition the emissivity of a blackbody is 1. Anything else, being less than a perfect radiator, has an emissivity less than 1. Enhancement of a perfect radiator seems impossible.

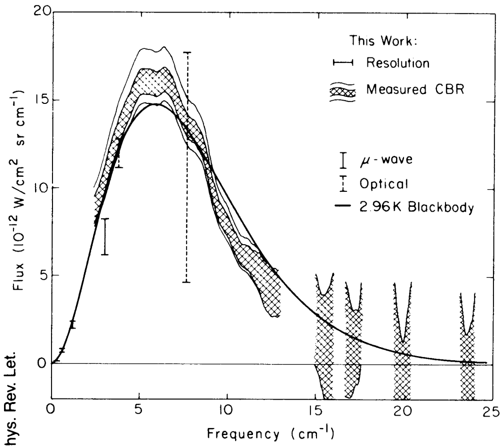
That isn't implied, says Woody. The 1.27 is "just a mathematical parameter" put in to characterize the shape of the data curve. Its physical interpretation, if any, is not specified. Yet it does indicate that the deviation goes the wrong way.

On the basis of emendations to the simplest forms of the big bang theory, alterations to the blackbody can be calculated. There are physical processes that theorists think may have gone on in the early universe (some seem to be necessary to provide for such things as the formation of galaxies) that would have fogged up the inside of the box a little and degraded the blackbody slightly from perfection. This should lead to an emissivity less than 1. As Woody puts it, "Standard calculations show an effect opposite of ours."

There are some nonstandard calculations that might explain it. Woody cites particularly the "chronometric cosmology" of I.E. Segal, a mathematician at Massachusetts Institute of Technology. But the attitude of experimentalists seems to be to hold their intellectual breath and wait.

Penzias is not disturbed by deviations. To him the overriding thing is the blackbody character of the radiation. Deviations may not mean much. Smoot would like to see the experiment repeated to confirm the deviation. "It's hard to see where they made a mistake," he says. But the deviation does go in the wrong direction.

A repeat is not likely soon. The experiment is difficult, delicate and expensive. Woody has now moved from LBL to Caltech's Owens Valley Radio Observatory, and both he and Richards have gone on to other work. A similar experiment is not likely until the COBE satellite does it five years from now. Meanwhile people will have time to speculate. ☐



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Measured radiation conforms closely to blackbody but falls off the curve in places.

Saturn: A ring within the rings?

Although the classically recognized rings of Saturn are generally described as a threesome, various observers have from time to time reported signs of what may be two additional rings, inside and outside the accepted trio. The existence of the extra rings has been less than certain — they are much less dense than the others if present at all and thus much more difficult to detect — and there are at least two reasons researchers wish they knew more about them: The recent discoveries of very different types of rings around Uranus and Jupiter have shown that wide, bright, "Saturn-style" rings are not the only possibility, and improved knowledge of any of them could help with the study of the rest. The other reason, which makes the first more critical, is that three spacecraft are now on their way to Saturn, and all three will pass at some point through the plane of the rings. Will they survive the crossing?

All three will go outside the main three-ring system, but for different reasons. The path of Voyager 1, which will pierce the ring plane on Nov. 12, 1980, was determined by the need to get a close look at Saturn's moon Titan. Voyager 2, due on Aug. 27, 1981, is aimed for a point at which Saturn's gravity will swing the probe to-