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## The Cosmological Constant

James Glanz discusses the hypothesis, based on observations of supernovae, that our universe may be expanding at an accelerating rate ("Cosmic motion revealed," Breakthrough of the Year, 18 Dec., p. 2156). There is, however, a fundamental assumption involved that is not stated. All the measured supernovae must follow the same law of luminosity versus time.

A similar assumption applies to finding the distance of Cepheid variable stars and seems to be true. However, the distant supernovae did not start out with the same elements as those nearby: nearby supernovae initially contained the materials from earlier supernovae. If a stellar model builder could show that the requisite small amounts of heavier elements increase the luminosity of a supernova by 10 to 15%, then the need for acceleration would vanish. We could then reset the cosmological constant to zero, stop looking for grand sources of acceleration, and accept the viewpoint of Albert Einstein in his later years.

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***Response***

In concluding that cosmic expansion is accelerating, the supernova teams have taken up each of these interesting issues in great detail.

First, the luminosity "law" for the specific type of supernovae in question is not an assumption but an empirical fact. Extensive studies of nearby regions of the universe have shown that the rise and fall for intrinsically brighter supernovae is slower than for dimmer ones. This law allows the astronomers to calibrate the actual brightness of the supernovae quite accurately.

The law holds for nearby supernovae in a whole range of environments—from old elliptical galaxies to younger spiral galaxies. Among those environments, the range in the abundance of heavy elements is probably wider than the difference between a typical nearby galaxy and a distant one, so there is no compelling reason to think that distant supernovae behave much differently from nearby ones. Strengthening this conclusion are detailed observations of how the spectra of nearby and distant supernovae evolve during the explosion. Major differences in composition should be reflected in the spectra, but they are virtually identical.

Finally, computer models have shown that, while variations in heavy-element composition should have subtle effects on the rising part of the curve, the overall shape remains largely unaffected.

The supernova teams are expanding their work in each of these areas. So far, however, no such effect has been able to shoot down the conclusion that the expansion of the universe is accelerating. Strange as it seems, the best available evidence points to a cosmological constant that is not zero.

— **James Glanz**

## Analyzing Solitaire

Dana McKenzie quotes Persi Draconis to the effect that "we cannot analyze the common game of solitaire," but explains