Interview: Donald Clayton

Can we detect the gamma background?

Donald Clayton is a theoretician teaching at Rice University in Houston. Part of a March 3 interview appears here. The balance will appear in a second installment.

EIR: *Explosive Nucleosynthesis,* the proceedings of a 1973 Austin, Texas conference, contains your exciting paper, "Confirming Explosive Nucleosynthesis with Gamma-Ray Telescopes," in which you asked the Almighty for a suitably bright supernova.

Clayton: It has turned out to *be* exciting. As you know, these gamma rays have just been detected from Supernova 1987A by three teams—this is really very exciting.

EIR: In your 1973 program, you proposed that we could "demonstrate that nucleosynthesis is occurring today in the universe"—well we just did that—

Clayton: That's demonstrated.

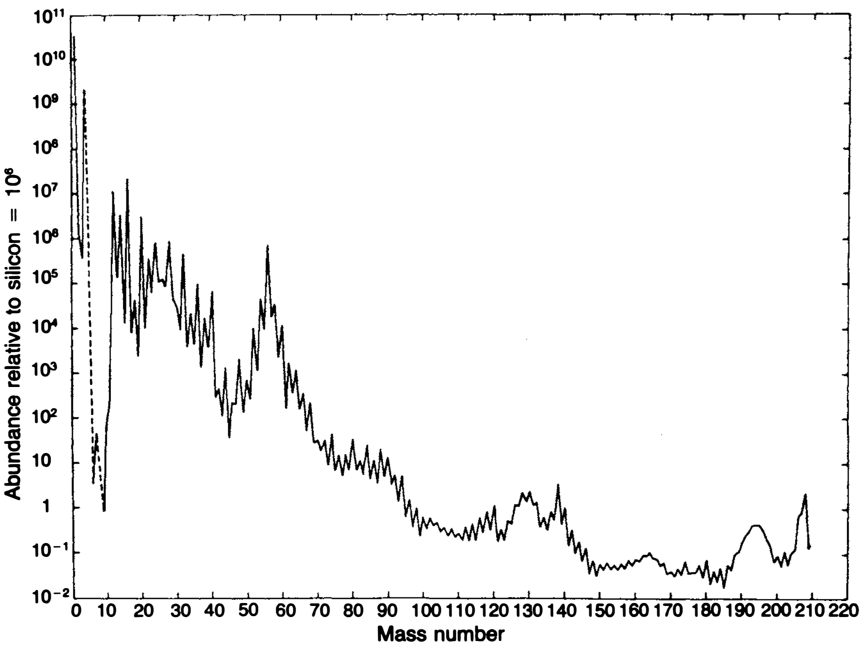
EIR: ". . . and measure its average rate in the isotropic background."

Clayton: This has to do with the sum total of supernovae integrated all over the universe—in the background of the universe—rather than looking at one object. It's still not at all clear whether that will be possible or not. . . . If you are talking about gamma rays filling up the universe, which is what I predicted in 1969, and still is a possibility, an object like this [Supernova 1987A] would not do it. An object of this type, occurring at the known rate in the universe, would not make—at our present rate of sophistication or in the near future—a gamma-ray background in the universe at these energies that would be detectable. However the Type I supernovae still might. On the other hand, we never have had a Type I supernova happen close enough that we could confirm that they are in fact much brighter sources of these cobalt gamma-ray lines than the Type IIs.

EIR: You proposed that we might be able to "determine whether the average rate of nucleosynthesis has been relatively constant or peaks in the distant past."

FIGURE 3

What creative processes lie behind these abundances?

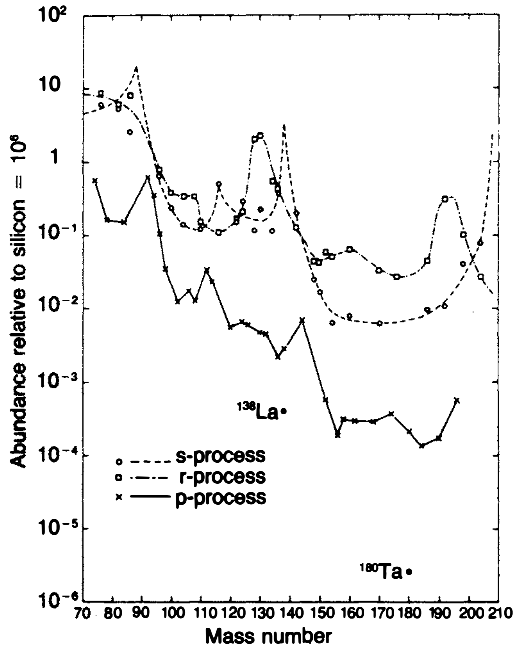


Nuclear abundances in the solar system as a function of mass number. The nuclear abundances are in numbers of nuclei, relative to elemental silicon arbitrarily set at 10^6. These are estimates based on the composition of meteorites and some solar data.

(A.G.W. Cameron, "A Critical Discussion of the Abundances of Nuclei," in *Explosive Nucleosynthesis*, D.N. Schramm and W.D. Arnett, eds., 1973, p. 10. These values revised by Cameron in 1981.)

FIGURE 4

Relative abundances from theorized nucleosynthesis



These are computer calculations of the relative abundances produced by each of the three nucleosynthetic processes believed to be involved in creating the heavier elements. The r-process (rapid) is explosive. The p-process is probably explosive. The s-process (slow) is continuous. See Woosley interview.

(A.G.W. Cameron, *op. cit.*, p. 11.)

Clayton: The nucleosynthesis of iron in the universe would have been happening at more or less a constant rate if the rate of explosions of supernovae had been more or less constant. We can't really see that directly, unless we can look at the accumulated background of the whole universe, and that's because the further away you look, the further back in time you are looking. So this possibility also hinges on finding these gamma-ray lines in the background of the universe. Because instead of being lines, the parts that were created long ago—which are also the parts far, far away—are red-shifted by the expansion of the universe. So a line in the universe, instead of appearing at one energy, gets smeared out into a red-shifted tail, and the shape of that would allow us to determine whether the rate today which is not red-shifted has changed—any photons we see today from radioactive decay in the universe that are not red-shifted are of necessity emitted nearby, and therefore relatively recently. Whereas those that are red-shifted were emitted long ago and far away.

EIR: To do that you don't need a supernova, just a big enough instrument, is that right?

Clayton: That's right. You just have to have the instrument. I'd say one of the best bets for that, for example, would be if we do go back and make a lunar base, we might set up a gamma-ray observatory on the back side of the Moon.

EIR: Has anybody designed the instrument that will do this?

Clayton: There are instruments *designed* that could do this. But the closest that we are approaching [to them] is NASA's Gamma Ray Observatory, which is still manifested for launch in 1990. I am co-investigator on the GRO, and NASA plans it as number two of its flagship series of space observatories. However, it is doubtful that the four instruments that are going to be on that observatory will *yet* have quite the sensitivity to measure this background of the universe. I mean we will try. But the objective is going to be to try to find gamma rays from a lot more individual objects.

EIR: If the instruments on the GRO are marginally adequate for this job of measuring the background, is it that we need a larger-scale copy of those same instruments, or do we need a new technology?

Clayton: The technology is within reach. The basic problem is that if you take a counter [with surface area] of 10 square centimeters, you might expect to only get a few gamma-ray photons per day. You need therefore a very long observing time to build up enough counts, and that's also not practical. Because the cosmic rays make accidental background counts. What you really need is a place where you can build a very large detector with a large collecting area, but have the luxury of being able to shield it from things coming from unwanted directions. For example, on the Moon you could easily build a tunnel down from the surface and put a gamma ray telescope down at the bottom. So it would be shielded in all directions, except for viewing out the hole.

We know how to do the gamma-ray detection technology. What's needed is a large, stable platform to operate for a long time in a low-count environment out there, and we haven't quite got that yet.

EIR: I think all of the latter points of your seven-point program depend upon this business of being able to measure the background.

Clayton: The latter points depend upon getting the background of the universe. They contain very profound conclusions. But on the other hand, they required the first points. We have to be able to prove that individual supernovae do create the elements. We have to have some measurement of the yields of radioactive species from individual objects, so we know really how nature is doing it, how nature constructs *its* devices. Supernova 1987A is a great, great opportunity in this regard. . . . You might also want to look at a more recent contribution of mine on this same subject in *Essays in Nuclear Astrophysics* in honor of Willy Fowler [Barnes, Clayton and Schramm, eds., Cambridge University Press, 1982].