

Slim Volume's Star Dust Blog

Howdy pals'n'gals, Slim Volume here with a riff on something called Star Dust, which was mentioned in a recent post by a friend of mine. The narrative went something like this: he hears what he called an "atheist scientist"- I'm guessing it was probably Carl Sagan- gush about how we are all made of star dust, and responded by saying big deal- so are dog turds. This got me to thinking about star dust, atheism, dog turds, and scientists- a process which occupied me for three hours early this morning before the sun came up- and below you can read the result. SPOILER ALERT: This is going to get a bit technical, but bear with me- I'll try to make it worth your while.

In an earlier post from a couple of years ago, I riffed on the element iron. I won't repeat that post here (you can look it up, or just wait for me to publish my book of collected posts) but will instead ask you all this question: ever wonder where iron comes from? Lots of people have, most of them scientists, and here's the string of clues you have to make sense of to get to the answer.

To begin with, it is possible to measure the amount of work required to build an atom of iron out of its constituent raw materials. In fact, one of the big research programs that began in the 1940's was to determine this number, called the nuclear binding energy, for each element in the entire periodic table. What was found was that for all elements lighter than iron, the process of squeezing the necessary protons and neutrons together to try and fuse them into an iron nucleus took a lot of work, but once you were done and had the fuse lit, so to speak, the resulting reaction released a stupendously huge amount of energy. The first step in this process- fusing hydrogen into helium- is in fact how the sun generates heat and light and also forms the basis for how hydrogen bombs work. Subsequent steps in this process- where we for example fuse helium nuclei and more hydrogen together to get the next heavier elements in the table- release progressively less energy than the first step and the reaction eventually comes to a final halt with iron. Fusing another helium together with iron actually consumes, rather than releases, energy.

So the amount of heat and pressure it takes to crush all those protons and neutrons together hard enough to trigger the fusion reaction and get it going can be both measured in a particle accelerator and calculated from first principles, and it is far in excess of any temperature and pressure available anywhere on or in the earth (even at its core) at any time in its history except right now, in nuclear reactors and particle accelerators. What this means is this: the iron that forms a significant fraction of the earth's mass, the iron that is in the soil and gets taken up by green leafy vegetables, the iron that we then eat and digest, the iron which finally ends up in our red blood cells and muscles and brains, was not formed on earth. For the same reason of course, neither was the iron we might find in dog turds. But the Big Idea here, an Idea much bigger than Whether Or Not There Is Iron In Dog Turds, is that none of the iron in our bodies- none of it- was formed on earth. It all had to come from somewhere



else, where the temperatures and pressures were great enough to light that fuse and get the fusion reaction series to go to completion.

The fusion factory, in which all the elements heavier than hydrogen- up to and including iron- were formed, is found only in the cores of stars. All the calcium, sulfur, oxygen, nitrogen, carbon, phosphorus, ALL of that stuff our bodies are made from- was built up step by step in the cores of STARS. More than that: small stars like Our Mister Sun run out of mojo once they have fused all their hydrogen into helium, because the pressures and temperatures available in their cores is insufficient to light the fuse on the subsequent reactions in the process. To get iron, you need a star about three times heavier than the sun, which brings us to the next Big Question: How does the iron that piles up in the core of a massive star get out, so we can build planets and eventually people out of it? The answer to that Question-with-a-capital-Q is even Bigger than whether or not there is iron in dog turds, and we know the answer.

Those big stars, the ones big enough to burn their hydrogen all the way out to inert iron, are so heavy that the only thing preventing them from collapsing under the influence of their own gravity, is the heat and pressure released by fusion reactions in their core. When they run out of hydrogen- a process requiring hundreds of millions of years- the fire goes out, the heat stops being generated, and the whole star collapses in on itself in a fraction of a second. All the outer layers of the star get sucked in by gravity and bounce off the iron core to produce an explosion brighter than the total light output of the galaxy that the star inhabits: this is a supernova. Much of the iron in the core, and everything else the star was made of, gets blown into space with tremendous speed where it eventually cools and condenses into... dust. Literally, star dust- or as Carl Sagan put it, "star stuff".

The supernova explosion is sufficiently powerful that elements heavier than iron get formed in the explosion cloud too, and get similarly blown into space along with everything else. The iron that was right down in the center of the collapsing core gets squished into a ball of pure neutrons which we won't worry ourselves about in this post, but we now come to the central point of my post today, which is this:

This sequence of events- the mechanism by which the iron in your blood was 1) formed and then 2) distributed into space- is accurately verified by observations of Supernova 1987A. It is profoundly remarkable. It is, in fact, a Big Deal that is in no way diminished or invalidated by the fact that some of that star dust found its way into your dog's turds. Furthermore, this account is true whether or not you are an atheist. It is true whether or not you are a scientist. And it is true whether or not you might happen to be arrogant- which in my opinion Carl Sagan was not, having studied his writings and heard and seen him speak.

I defend Carl here because he has been dead for decades and hence cannot defend himself.

That's Slim's story for a chilly Tuesday morning, and he's sticking to it.