# Podcast Interview: Philipp Heck

**PNAS:** Welcome to Science Sessions. I'm Paul Gabrielsen. In 1969, a meteorite struck the town of Murchison, Australia, yielding more than 100 kilograms of debris that would prove exceptionally valuable to science. The meteorite itself is 4.6 billion years old and contains grains of stardust that far predate our Solar System. In a recent PNAS article Philipp Heck, of the Field Museum of Natural History and University of Chicago, and colleagues used trace amounts of noble gases to uncover not only the ages of those grains, but also the story of their travels through interstellar space. Heck explains how that story begins.

**Heck:** The journey of interstellar dust starts with a star During most of its life the star quietly produces helium in its core by fusion. But at the end of its life is when the hydrogen fuel is exhausted in its core; the helium that was formed burns in fusion to form carbon. This releases a lot of energy and the star becomes a red giant and the carbon that's formed within the star gets pushed to the surface by convection and then leaves, eventually, the star in a stellar wind, and this gas condenses, when it gets cool enough, to form smoke. To form dust particles.

**PNAS:** Conventional radiogenic dating techniques can't be used on stardust. There aren't enough uranium or lead isotopes in the sample to obtain an age, and the initial compositions of the grains aren't known. So Heck and his colleagues turned to another method. Cosmic rays are high-energy particles that bombard the surfaces of all bodies, including grains of stardust. As they do, they break atoms apart, creating what are called cosmogenic nuclides. Measuring the amounts of cosmogenic nuclides can reveal how long an object has been exposed to cosmic rays, and hence its age.

**Heck:** What we do is determine the abundance of neon isotopes and of helium isotopes that were produced by cosmic ray interactions. The cosmic ray flux is pretty constant over long time scales. We know that from studies of iron meteorites which have very long exposure times. And we also know the cosmic ray flux outside of our heliosphere outside of the Solar System thanks to data from the Voyager I spacecraft that left the Solar System. So counting those cosmogenic nuclides in the dust particles enables us to determine an age for those grains.

**PNAS:** Studying, handling and transporting grains of dust present special challenges.

**Heck:** We always hand-carried those grains in our pockets so they wouldn't get lost. That's always the part that makes me most nervous, traveling with this precious material. It survived billions of years in the galaxy and I don't want to lose them on a flight.

**PNAS:** Heck calculated ages for 40 grains of stardust, and more than half had been traveling through space for less than 300 million years before the formation of the Solar System and the Murchison meteorite. That's in line with estimates that these dust grains persist for around 100-200 million years before being broken apart by supernova shockwaves. However, some grains were more than a billion years older than the Solar System. Something, Heck says, must have helped them survive.

**Heck:** One of the conclusions that we came up with was that those grains floated through space not as individual grains, but as part of aggregates. We came to that conclusion based on the difference in helium and neon atoms that we see.

**PNAS:** Cosmogenic neon and helium atoms are lost from a particle at different rates, depending on the particle's size. When correcting for the particles' current size, the researchers found that the neon and helium ages of the grains didn't match.

**Heck:** The only explanation that can explain such a result is if the grains were larger in space than they are now. We changed the size, the virtual size of the grain until the helium and neon ages matched and we came to the conclusion that some grains were larger than 200 microns. They were not that large grains, there were other aggregates that were held together probably by some abiotic organic matter.

**PNAS**: The ages of the 40 grains, taken together, didn't match with a model of the galaxy in which stars had been forming at a constant rate. The distribution, skewed toward young grains, suggested instead a period of enhanced star formation around 7 billion years ago.

**Heck:** And astronomers find, through independent studies earlier, they found that 7 billion years ago there was a moderately enhanced phase of star formation where about 50% more stars formed than normal. Stars that formed 7 billion years ago became dust producing around 2-2.5 billion years later, ejected it into the interstellar medium, and then 300 million years later the Solar System formed and those dust grains were incorporated into the forming Solar System. So there was a natural explanation of this age distribution.

**PNAS:** Heck hopes to study additional grains from additional meteorites using additional cosmogenic nuclides to further confirm the story of the Murchison stardust.

**Heck:** Likely all meteorites sampled the same reservoir, but it's still good to have samples from different sources just to make sure this assumption is right. And also to look beyond neon to look at other isotope systems to explore how we can use lithium isotopes. If we use lithium, helium, and neon and all come to the same conclusion then we have even more confidence in our results.

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