Touching the Cosmic Scale

How an astrophysicist gets his head around enormous stretches of space and time

WE OFTEN THINK OF cosmic scales as being nearly ungraspable. Recently, on a long drive, I traveled about one millionth the distance to the Sun, which of course is only the nearest star in our galaxy, which is one of many galaxies in our local cluster of galaxies, which is one of many such clusters in the observable universe. Against such universal scales, the everyday usually doesn't compare.

But the reason for my drive was to see 190-million-year-old dinosaur footprints beside the Connecticut River in west-central Massachusetts. Here, early ancestors of *Tyrannosaurus rex* walked across muddy ground that, over time, solidified into rock and preserved these footprints as fossils.

When I put my hand inside the much larger, three-toed footprint in the sandstone, I immediately noticed how smooth the footprints were compared to the rock around them. Even more than the size of the footprint itself, I was transported by the wonder of touching the very same spot as these amazing creatures that inhabited our planet before us. I stomped across the rock, trying to match their loping gait.

A hundred and ninety million years is a long time, especially compared to the several million years that humans are thought to have existed. Even by cosmic standards, 190 million years is an impressive stretch. It's about 5% of the age of our planet, solar system, and Sun. Over this time, our star has fused 600 Earth masses worth of hydrogen into helium, releasing the energy that powers life on our world.

On Earth, a footprint in the mud is usually one of the most ephemeral traces creatures leave as we interact with our planet. Certainly others that we humans have created, such as pollution byproducts, will be longer lived. On the Moon, however, the bootprints of Apollo astronauts may still exist 190 million years from now without geologic upheaval or atmospheric erosion processes to disrupt them.

DEEP-TIME CAPSULE Buzz Aldrin's bootprint left during the Apollo 11 Moon landing

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Ironically, these lunar bootprints are intensely fragile — held static in the dust only by the lack of anything to disturb them. Given the chance to touch one, though, a lunar footprint wouldn't be smooth. Without the polishing action of wind or water, the Moon's dust, which impacting meteorites have blasted over billions of years, is jagged and crystalline, like microscopic glass shards. It's so abrasive that Apollo 17 astronauts Harrison Schmitt and Eugene Cernan broke down laughing after struggling to pull off each other's dust-caked gloves and helmets after a seven-hour moonwalk, noting that "everything is twice as hard" to remove.

One of the great privileges of being an astronomer is having the chance to reflect on scales of cosmic magnitude every day. Even so, my mind finds a shield against such vastness in familiar numbers like "one solar radius," the radius of the Sun — which feels easier to consider than 700,000 km (435,000 mi) — or "200 parsecs," the distance to Betelgeuse, the red supergiant marking Orion's shoulder.

That mental shield begins to come down when we invoke our senses. By touching the smooth contours of a 190-million-year-old footprint or wrenching off gloves embedded with the crystalline shards of meteorite impacts, we can more deeply appreciate what it means to be one small human in a very, very large universe.

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