What is a space physicist?

By Prof. Patricia Reiff, Rice University

Recently I gave a keynote address at the "Aerospace Academy", held annually at Rice for exceptional high school students. The talk was on "Space Weather" and its effects, but it also was a way to introduce space careers. I said I was a "space physicist" which is a branch of study that falls between Astrophysics (of distant objects) and Geophysics (the study of the Earth). The Sun is the logical link between space physics and astrophysics; the Earth's magnetic field and ionosphere is the link between space physics and geophysics.

As a practical matter, the difference between space physics and astrophysics is, if you can **GO THERE AND MEASURE IT**, it's space physics. If it has to be studied completely remotely, it's astrophysics. We have now flown by all the planets and many of the moons and asteroids in our solar system (including Pluto), and each time we have been surprised by what we have observed and measured there. I love finding new things out, so that's why I'm a space physicist.

Why not an engineer? My uncle John Reiff Sr. was a rocket engineer at White Sands, and my niece Ciara is an engineer also. My son earned a degree in Mechanical Engineering as well…

So then what is the difference between scientist and engineer? When we travel to a distant body, if we are surprised, scientists are delighted but engineers are petrified! They build a system designed to work in the environment they expect, and if the environment is different, well, there may be troubles they didn't anticipate.

So, the progress of science needs all hands… the scientists with the vision and the curiosity, the engineers with the technical expertise, the computer scientists with programs to operate the spacecraft and get the data back, the analysists who study that data and publish the results, the various supporting staff, and most importantly the public who recognizes the importance of scientific research and funds the Big Projects that can answer the Big Questions.

Is science ever finished? Like a lotus, each time we peel a layer off, we find new information and new questions. Each time we design a new instrument with new capabilities, we see the world in a new way and it reveals its mysteries. In the IMAGE mission, for example, we imaged the earth's cold plasma cloak for the first time and watched it respond to changes in the solar wind. And the neutral atom imager did the same with the energetic ions trapped in the Earth's magnetic field. A similar imager sees the interaction at the far edge of the solar system, where the solar wind meets interplanetary space, a place where Voyager just recently flew through. The mission I'm working on now, the Magnetospheric Multiscale, is measuring particles and fields at a resolution a hundred times better than previous missions, and has unlocked the

mystery of magnetic reconnection as well as the waves on the boundary that can also inject particles and energy into the earth's magnetosphere.

So, I've been counting electrons and protons in space for 55 years now, and it never gets boring… the things our teams been able to discover have revolutionized our knowledge of this amazing process that occurs everywhere from the Earth to the Sun, to pulsars, magnetars and blazars… giving the "ground truth" so that remote sensing projects can unlock the mysteries of the far distant universe that we will never explore in person.

Two of my favorite quotes:

British biologist J. B. S. Haldane said in 1927: "My own suspicion is that the Universe is not only queerer than we suppose, but queerer than we can suppose." This was later requoted by Eddington as "Not only is the universe stranger than we imagine, it is stranger than we can imagine" and by Heisenberg as "Not only is the Universe stranger than we think, it is stranger than we can think".

The second was the unofficial motto of the IMAGE mission, from Marcel Proust (1923):
"the real voyage of discovery consists not in seeking new landscapes, but in having new eyes".

He was apparently talking about art not science but the import is the same…

We see the universe through the eyes of our space missions, our ground and space-based telescopes, and the intellect and effort of thousands who make it happen every day. And the surprises still come, like quantum entanglement and multidimensional strings… where will science take us next?

And don't forget the visionaries of science fiction, who looked forward to what could be. We can forgive them for imagining intelligent life on Venus and Mars (that we know now are devoid of anything but perhaps some deeply buried bacteria).

So here's my plot for a new scifi novel. (If anyone uses it, I want a cut of the royalties!). Many novels use wormholes as a mechanism to jump across the vastness of space by a black hole bending space enough to connect to a similar "white hole" on the "far side" of the universe. But traveling through that hole will spaghettify you into a tiny string of atoms that may not recreate you on the other side. My proposal (and yeah, I haven't worked the equations yet), is to create a mini "solar system" of, say 12 identical mini black holes in orbit around their mutual center of mass, equally spaced far enough apart and with identical velocities so that they don't swallow each other. But at the center of mass, their gravitational forces will all vectorially add to make a single WIDE region in the center, with a large schwarzschild radius that maybe could bend space enough to make that wormhole wide enough for spacecraft to pass though. Just a fun thought. Probably frame dragging or stray magnetic fields would make it unstable, but hey,

it would be fun while it lasted, and that's the point of Sci-Fi, it doesn't have to be actually possible, just reasonably plausible.

And if you want to see a system orbiting a center of mass which is well outside the heavier object, you need to look no further than Pluto and Charon. They are both so close together that they are doubly phase-locked – they BOTH keep the same face towards each other as they orbit around their joint center of mass, which is the point that is ACTUALLY in orbit around the sun. In fact, you could build a space elevator between Pluto and Charon through that center of mass, and it would be close than our geosynchronous orbit. (We imagined such an elevator in our planetarium show "It's About Time".)

Patricia Reiff

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