Cosmic archeology

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William Harris

As human beings, its easy to feel big - we have machines that allow us to see particles that are less than a billionth of a metre big, we've built towering skyscrapers hundreds of metres tall, we fly thousands of kilometres around the world in mere hours and we've even traveled more than 380,000 kilometres to the moon.

However, perhaps it is good to be reminded every so often of our size in the scale of things. A very large human could be about two meters tall. This person would be about six million times bigger than some fairly typical plant cells - they would also be about six million times smaller than the earth's diameter and nearly three trillion times smaller than the

solar system. Now imagine our solar system to be the size of a bacterium (about one millionth of a meter) - on this scale, the universe would be the size of the earth.

The universe is huge - a fact that is certainly realized by astronomers like McMaster University's William Harris. Harris, a professor in the department of Physics & Astronomy, has spent nearly 30 years at McMaster studying this awesome universe and giving insights into the big questions. In fact, Harris takes great pleasure in co-teaching a course titled "The Big Questions." This cross-disciplinary course has no science pre-requisites and is designed to encourage thought, conversation and learning about issues including the origins of the universe and the evolution of life.

Combined with his love of teaching, Harris notes, "I really do enjoy research. I always have, and that's lasted right up to today. I still feel like I'm an active scientist with lots of ideas. I'm not running out of energy or things to work on."

Harris also notes that he genuinely enjoys the collaborative nature of the work he does. Graduate students, postdoctoral fellows and colleagues from around the word often work with Harris on joint projects. As Harris observes, research is very much a "cooperative enterprise."

Harris, through funding from the Natural Sciences and Engineering Research Council (NSERC), studies cosmic objects known as globular clusters. Harris explains that these objects can be 13 billion years old, almost as old as the universe itself (around 13.7 billion years). According to Harris, "The kind of work I do in some sense resembles cosmic archeology. The types of cosmic objects that I work on tend to be the very oldest ones. It's one way of getting at the series of events in the early universe that built the galaxies we see around us today. These things must have had a start & how long ago was that? When were the

first stars made in these galaxies? How did the galaxies themselves assemble into the enormous structures that we see everywhere around us in space today?"

To answer these questions Harris looks to the stars, and he travels all over the world to get the best view. He says, "The modern trend has been to build observatories in very remote locations so they're far away from city lights; they're on the tops of mountains; and fairly close to the equator & (and in places where) the air above the mountain top is very stable so it doesn't blur out the star. When you combine all these things, there aren't many such places in the world."

Consequently Harris has made many trips to major observatories in places such as Arizona, Hawaii and Chile. In case you are contemplating a career switch towards astrophysics, you should first realize that these research trips are far from vacations. Harris says, "I have never once come back with a sun tan. I've spent almost all my time there (Hawaii) on the top of this remote isolated volcano that looks like the surface of the moon. At 14,000 feet the air is thin and it takes two or three days to adjust to the oxygen deprivation. The travel is fun, but it is sometimes physically challenging."

Harris vividly remembers his glimpses into the giant telescopes housed in these observatories as "awesome and exciting." He recalls the first time he peered into the eyepiece while sitting high above the ground in the small observation cage of the telescope: "You could just look directly at this spectacular star cluster or this galaxy through this immense telescope and this thing would just leap out at you and you'd stare at it and you'd get this odd kind of vertigo sensation that you were being drawn into it and you'd feel like you were just on top of the world."

The light Harris collects through these telescopes is the keystone of his research. Harris takes the largely colourless light emitted from the very

old stars in the globular clusters and then breaks it into a continuous stream of all the colours of the spectrum using a prism or other tools - for a visual, recall the Pink Floyd graphic. However, this rainbow of colours is not complete; it contains black bars where very specific colours are missing. Harris equates this to a "barcode." Like a barcode, these black gaps hold very specific information.

To understand why these colours are missing, physicists shift their focus from very large stars to very tiny atoms. Atoms have the ability to absorb light; however, they can only absorb very specific colours of light and each atom, such as hydrogen, helium, or oxygen, absorbs unique colours. As light come out through the surface layers of the star, these certain colours are absorbed and therefore never reach the telescope. By examining the spectrum - a technique called spectroscopy - Harris can determine what the star, or globular cluster composed of many stars, is made of. This knowledge allows Harris to determine important information about the start of the universe, the formation of the very first stars and how these early stars contributed to the formation of middle aged (five billion years old) stars like our sun or celestial babies that are merely a few million years old.

Harris' research uses light to shed light on issues that every curious mind considers at some point. He notes, "Astronomy is not something that any of us need to do or use or think of in our daily lives. We can all live perfectly good, happy, productive and useful lives without ever once looking up at the night sky. However, having said that, the practical value doesn't always link to importance. Personally, I feel that the broader importance of a subject like astrophysics is inspirational. People need frontiers and curiosity and a sense of wonder and we're genetically hard-wired to have those qualities inside of us."

Through his work, Harris has come face to face with the awesome magnitude and beauty of the universe. He recalls, "You can look at a

faint smudge of light through a telescope & and that's a remote galaxy that is seven billion light years away and that light has been traveling all that time just to reach our telescope. That's amazing, just to think of connecting to something that old. Or if you look at a globular cluster through the telescope it has this beautiful symmetry. Thousands of tiny points of light all collected in this big spherical ball and those objects are so beautiful you can't help but be impressed by them."

Source: McMaster University (by Graham Jansz)