People in Astronomy

SANDRA FABER

Sandra Faber is Professor of Astrophysics and Astronomy Emerita at the University of California Observatories, University of California at Santa Cruz. She was born in Boston, grew up in Cleveland and Pittsburgh, and attended Swarthmore College, Swarthmore, Pennsylvania. After graduate school at Harvard's Department of Astronomy, she accepted a position at the Lick Observatory (as her institution was then known), "the only job [she has] ever had."

Professor Faber has always wondered about the large-scale features in the Universe: why there are galaxies, why they look as they do, and how the Universe began.

Among the prizes she has received are the Gruber Prize in Cosmology in 2017, National Medal of Science from President Obama in 2011, the Bart J. Bok Prize from Harvard University and the Dannie Heineman Prize of the American Astronomical Society. She is a Trustee of the Carnegie Institution of Washington and a member of the National Academy of Sciences. In 1996, she was elevated to University Professor at the University of California. She served on the blue-ribbon panel that advised NASA that the Hubble Space Telescope should be serviced once more, by astronauts using the space shuttle. She was recently co-leader of the CANDELS project, which received the largest ever allocation of time on the Hubble; its main goal is to study the birth and evolution of galaxies.

In 1980, she joined six other scientists in a study that eventually showed a large- scale flow of galaxies at a million miles per hour toward the direction in the sky where the constellation Centaurus is located. Our Milky Way is part of this flow. The flow is caused by the gravitational attraction of a large supercluster of galaxies, one of the largest structures yet seen in the Universe. The scientists named it the Great Attractor. Its existence implies, yet again, that most of the matter in the Universe is dark and invisible to telescopes, in this case the dark halos that surround the visible galaxies that compose the Great Attractor.

Her main research effort is now with CANDELS (Cosmic Assembly Near-infrared Deep Extragalactic Legacy Survey) with the Hubble Space Telescope.

Professor Faber has two grown daughters. Her husband, Andy, is an attorney in San Jose.

What kind of research did you do with the Keck telescopes, before you shifted your main research effort to CANDELS with Hubble?

The Keck telescopes are working as well as anyone had hoped and, in fact, have now been copied around the world. Astronomers are finding that they just cannot study faint objects at the visible edge of the Universe without the huge aperture of a Keck or something similar. I led a team to build a giant spectrograph for Keck-II. This spectrograph was used in the DEEP Survey (Deep Extragalactic Evolutionary Probe, linking observations with the Keck telescopes and the Hubble Space Telescope), which ended several years ago, to collect spectra of 50,000 faint galaxies in order to map the Universe as it was billions of years back in time. Most of the data are in, and we are measuring changes in the galaxy population over the last half of the age of the Universe. Professor Faber was for a time Co-Chair of the Scientific Steering Committee of the Keck Observatory as they planned and built their 10-m telescopes.

How about the history of your work with the Hubble Space Telescope?

The Space Telescope has been the biggest roller coaster of my scientific career. First there was euphoria just after launch, when all seemed to be going well. Then we discovered the flawed primary mirror (I was part of a three-person group that diagnosed the error and reported it to NASA). The whole project hastily regrouped and replanned to limp along and do some science with the flawed mirror, while hundreds of people conceived of a strategy to fix the telescope and carried it out brilliantly. The telescope performed beautifully after the repair mission and has delivered more important data than any other telescope in history, and I now find myself with the rewarding assignment of entertaining audiences with slides of gorgeous Hubble images.

The main lesson is, never give up. Pull victory from defeat. The second lesson is that a team of dedicated people can accomplish amazing feats.

What things have you learned with the Hubble Space Telescope?

First, I was part of a team searching for supermassive black holes at the centers of galaxies. Hubble can find them by spotting stars very close to the hole that are orbiting super-fast. Some of these black holes are many billions of solar masses in size. Our team showed that a big black hole lurks at the center of nearly every large galaxy.

Then I was part of another team using the Hubble Space Telescope along with the Keck-II telescope to study the most distant galaxies in the Universe. This was the DEEP Survey mentioned above. Hubble images are crucial because their high resolution shows us distant galaxies in detail, from which we can measure Hubble types and other important quantities. A big discovery from DEEP was that we actually detected disk galaxies turning into elliptical galaxies disorganized "starpiles." It was very exciting to actually see how galaxies assumed their final forms and how the Hubble sequence was made.

And now I'm devoting most of my time to results from CANDELS. The main achievements of the team include: (1) The first complete inventory of galaxy sizes, shapes, and masses back to infant galaxies just 500 million years after the Big Bang. We are really watching galaxies be born and grow up. (2) Simple rules are emerging for galaxy growth. Yes, each galaxy is an individual, but, like people, they all share basic characteristics and grow along simple paths. We are learning those paths. (3) My particular passion: understanding how galaxies grow black holes and how the prodigious energy output from these objects can act back on the galaxy to kill star formation. I think this is why star formation in billions of galaxies is flickering out today.

Tell us about your historic study of the Great Attractor.

Like most of the important things I have done scientifically, the motivation for the project was all wrong. We started out to survey the properties of nearby elliptical galaxies, such things as their brightness, radii, and so on. And we wound up finding a method that could estimate the absolute size of each galaxy and hence tell you how far away each object is. Knowing that, from the Hubble law you could predict the redshift (velocity) of every galaxy. When we compared these predictions with the measured velocities, we found a big discrepancy, and this could be interpreted simply as a streaming motion of all the nearby galaxies toward the center of a hitherto unidentified mass concentration.

This came as a total surprise. We couldn't believe there was such a large supercluster of galaxies so close-by that nobody had noticed before. But fortunately there was a graduate student in Cambridge, England — Ofer Lahav— who had just stored complete galaxy catalogues in the computer, and he was able to make a gigantic map of all the galaxies in that direction in the sky. In this new picture, the Great Attractor appeared for the first time.

WERE YOU SURPRISED AT ALL THE INTEREST YOUR RESULTS GENERATED?

No. I think we generated some of the interest because we were so surprised ourselves. We were stunned. In graduate school, I was taught that the Hubble expansion was very uniform. The typical streaming motion of galaxies [motion relative to the Hubble expansion] was only supposed to be about 100 km/s, so it was a total surprise to find peculiar motions 6 times larger than that.

WHEN YOU WERE IN GRAD SCHOOL AT HARVARD YEARS AGO, WOULD YOU HAVE BEEN SURPRISED AT SUCH A DISCOVERY?

Totally. I have never had long-range goals as a professional astronomer. I've always been a short-range opportunist, so it always comes as a surprise when something interesting turns up.

WHAT IN YOUR VIEW IS THE RELATION OF OBSERVATION WITH THEORY?

Deep down I feel a little sorry for theoreticians because they see the Universe only through the eyes of the observers. An observer at a telescope with a good project is like an explorer in the New World—the view over each new ridge is new. On the other hand, we would never actually understand anything without theory to back it up. So they fit together like hand in glove. Each is essential.

How did you get interested in astronomy?

I was one of those kids who was deeply interested in science. It really didn't matter too much what kind. I had star charts, but I also had a rock collection and read books on spiders. It was only later, when graduating from high school, that I began to focus on astronomy. The reason was simple: I wanted to know where the Universe came from and why it is how it is.

And are you making progress toward understanding the Universe?

I think so, in broad outline—very broad. Actually, I have come to believe there are many universes—an infinite number perhaps. I'd love to know how different they all are from one another, but I don't know the answer to that. However, I do think that ours is roughly the way it is because we are in it. It takes certain restrictions to create intelligent life. Within those restrictions, it is a matter of chance, but the basic restrictions are set by our existence in this Universe. Our Universe has the properties it does because they are required to make our kind of intelligent life.

Perhaps there is an analogy here. Ancient peoples might have wondered why the Earth is as it is. We know now that there are probably millions of planets, but most of them are like the other eight planets in our Solar System — that is, not hospitable to our kind of life. However, out of those millions, there are probably many planets rather similar to our Earth that would do quite nicely. And within that broad selection, our existence on this particular Earth is a matter of chance.

In the same way, I believe that our Universe is just one of many hospitable universes we could inhabit. Our being in this particular one is of no special interest. The really interesting implication is that there must exist "out there" many more universes of vastly different types, most of them possibly so bizarre that intelligent life would find them quite hostile. Out of all of these, ours has the properties it does because we are in it. Recent breakthroughs in quantum cosmology have even found a plausible way to generate all those universes in a never- ending, infinite cascade of big bangs. This idea is speculation right now, but chasing it down is going to provide a lot of excitement in the years ahead.