According to Captain James Kirk, space is the final frontier (although oceanographers might have something to say about that). Beyond the Earth’s atmosphere, there is a vast area of the Universe that we will likely never completely understand, despite the best efforts of mathematicians, physicists and astronomers. However, rather than being a source of frustration, space represents infinite possibility, which is why astronomers like Dr Gail Zasowski, based at the University of Utah in the US, enjoy what they do in their professional lives. Gail is an astronomer with a particular interest in understanding where and when our Milky Way galaxy formed its 100 billion stars. Her research will help us understand how the infant Milky Way grew into the massive spiral galaxy that we see today.

However, in recent years, astronomers have been able to peer farther into the Milky Way than ever before. A lot of the difficulty in observing our galaxy is because of the thick clouds of gas and dust that fill the disc part of the Milky Way and block the starlight behind them. But some surveys, including the second generation of the Apache Point Observatory Galactic Evolution Experiment in the Sloan Digital Sky Survey III and IV projects (www.sdss.org), use infrared light to study the stars, which is much less affected by the intervening dust. The problem of perspective still exists, but astronomers are getting closer to being able to characterise the Milky Way in the same way as external galaxies.

WHAT ARE OUR CURRENT LIMITATIONS REGARDING UNDERSTANDING THE HISTORY OF OUR GALAXY?

Ironically, the main limitation to our understanding is closely related to the main advantage: that we are embedded inside the Galaxy. It can be thought of as the difference between looking at a map of a city and standing on a street in that city. "Looking at a map is like looking at other galaxies – we can see the overall shape and structure, where the business and residential areas are, and so on," explains Gail. “But standing in that city has historically been like studying the Milky Way – we can’t see the pattern of streets or what the next neighbourhood looks like, but we can see the people and the shop windows, smell the smells, hear the sounds.”

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WHY IS THE MILKY WAY SO IMPORTANT?

We can observe the Milky Way at a higher resolution than other galaxies because of our proximity to it. Although there are some challenges as previously noted, we can observe the small-scale building blocks of galaxies, such as individual stars and small gas clouds. “These observations have
shaped our understanding of a large fraction of
astrophysics, from what happens in the interiors
of stars to the ways a whole galaxy can change
over billions of years,” says Gail. “We then apply
this understanding to interpret our observations of
other galaxies – where we can’t see things at the
same level of detail – and create a picture of how
galaxies in the Universe, and the Universe itself,
have evolved since shortly after the Big Bang.”

The ‘big-picture’ questions Gail and her team
are trying to answer include: “Where and when
did the Milky Way’s stars form?”, “What are
the main sources of heavy elements in today’s
Milky Way stars, and when and how were they
synthesised?” and “What is the best way to apply
what we learn in our Galaxy to understanding
what happens in other galaxies?”

Addressing these questions involves answering
smaller ones, like: “How old are the stars in
a specific part of the Milky Way and what is
their chemical makeup?”; “What series of
evolutionary events could give us this pattern
of stellar ages and chemistry?”, and “How
does the gas and dust between the stars move
around throughout these events?”

METHODS, FINDINGS AND SUCCESSES
To uncover what elements are in a star, Gail and
her team are part of a larger team that measures
the star’s light at different wavelengths. Atoms of
different elements absorb that light at different
wavelengths, so models are fitted to the pattern
of absorption compared with wavelength to
determine how much of each element is present
in the star. These same models also account
for the temperature, surface gravity and other
properties of the star that are necessary for
computing distances and ages.

Gail’s group has worked hard to link detailed
measurements that can be made in the Milky
Way with global measurements that can be
made in other galaxies (which are less detailed
but cover a higher number of galaxies in
different environments with different histories).
“It has been very exciting to see many different
analyses on stars in different parts of the Milky
Way come together in a comprehensive picture
of where and when its stars formed, including
the influence of gas accretion events billions of
years ago, which strongly affected the regions
near the Sun (but which probably happened
before the Sun formed!),” explains Gail.

“It has also been extremely gratifying to see the
students and post-doctoral researchers in my
group taking ownership of their work and leading
their own projects, often collaborating with each
other and with very little input from me. I value
the success of the scientific work for increasing
our understanding of the Universe and for
launching the careers (in and out of academia) of
so many hard-working scientists.”

WHAT ARE THE LONG-TERM PLANS
FOR GAIL’S RESEARCH?
Many of the upcoming datasets – including
for the SDSS-V (www.sdss.org), the next
data releases from ESA’s Gaia mission (sci.
esa.int/web/gaia) and NASA’s Roman Space
Telescope (roman.gsfc.nasa.gov) – will provide
ever-larger troves of measurements of the
stars in our Milky Way and nearby galaxies.

“I am excited to work on recreating the history
of our galaxy – playing the movie of its life,
backwards – by mapping out where and when
the stars form, how they release their new
elements back into the galaxy and how those
new elements move around between the stars
before being incorporated into the next stellar
generations,” says Gail. “I love learning things
that no one has ever known before.”
EXPLORE CAREERS IN ASTRONOMY AND ASTROPHYSICS

- For people who are interested in learning more about cutting-edge research, Gail recommends the AstroBites website: astrobites.org

- Sea and Sky (www.seasky.org/astronomy/astronomy-resources.html) is a website dedicated to providing useful resources for budding astronomers. There is a wealth of information contained on its website, so we recommend you explore it!

- According to National Careers, astronomers in the UK can expect to earn between £15,000 and £60,000 per year, depending on their level of experience: nationalcareers.service.gov.uk/job-profiles/astronomer

PATHWAY FROM SCHOOL TO ASTRONOMY

- Gail says that maths and physics are definitely important, but something that is often overlooked is communication skills, especially writing and public speaking. Being able to report and explain complex ideas and analyses in a clear, concise way is incredibly valuable. So, try and take a technical writing or a public speaking class.

- Two or three A levels, or equivalent, including maths and physics.

- You’ll need a degree and postgraduate qualification to work as an astronomer. You’ll usually need to have achieved a first or a second class (upper) in your degree. Relevant subjects include maths, physics, astrophysics, astronomy and space science.
WHAT WERE YOUR INTERESTS WHEN YOU WERE GROWING UP?
I’ve always loved reading, especially science fiction and historical novels. In school, I enjoyed science and language classes the most – I love learning how systems work, both the physical system of the Universe and human systems of language and communication. I’m also an avid outdoor enthusiast and love camping and spending time in nature, especially here in Utah, with its red-rock canyons, deserts and incredibly dark night-time skies!

WHO OR WHAT INSPIRED YOU TO BECOME AN ASTRONOMER?
It wasn’t until I was at university that I understood that ‘astronomer’ was a job that people could have (my earlier schools didn’t really push science as a career). I took an introductory astrophysics course during my first year at university, and the combination of the enormity and beauty of the Universe, coupled with actually being able to understand pieces of it with maths and physics, was irresistible.

WHAT ARE YOUR PROUDEST CAREER ACHIEVEMENTS SO FAR?
I am very proud of the scientific knowledge that my team and I have contributed to our understanding of the Universe. I am also proud of what I have been able to do in the classroom and broader environment in the field and my department. Both of these were recognised with a Cottrell Scholar Award (rescorp.org/cottrell-scholars) in 2021, which honours early-career faculty who have shown excellence in both research and education.

HOW DO YOU DEAL WITH CHALLENGES AT WORK?
Deep breaths! Very few things are solved well if people are worked up or angry. If the science or the data are challenging, I take a step back and think about the root of the problem. Taking a walk or working on something else for a while can be very useful. It’s helpful to remember that the Universe isn’t trying to be difficult! Often, things are just more complicated than we anticipated they would be, and our job is to make our treatment of the data more sophisticated in response.

If there are tensions with people causing challenges, I take a similar approach: focus on why people are acting like they are, not the effects on me or my feelings. If someone is behaving inappropriately, that does need to be addressed, but often the root of the conflict is a misunderstanding or miscommunication that a calm, neutral message can resolve.

HOW DID DR GAIL ZASOWSKI BECOME AN ASTRONOMER?
GAIL’S TOP TIPS
1. Be the kind of person others want to collaborate with! Be respectful, acknowledge others’ time and efforts and learn how to communicate professionally and courteously.

2. Be realistic. The job market is difficult now and we don’t anticipate it getting much better soon. Pursue your dreams but be open-minded about alternative ways of using your skills.

3. Think about what you really want – studying physics and astronomy gives you knowledge and skills that are useful in a much larger setting than just academia.