

Elodie Choquet Episode – ESCAPE project

"One day, while working on archive images from the HUBBLE space telescope, I detected an asteroid belt around a previously unknown star. It's a bit of an adrenaline rush, you think "wow, there's really something here!"

To be sure, I re-analysed the observations and compared them with those from other telescopes, but that was it! It was very exciting because an asteroid belt is what remains of planet formation. So this tells us that, perhaps, somewhere in this system, there is a planet that is evolving but that is simply too faint to be detected with current instruments."

Credits

Introduction

How do you make a scientific discovery? What paths must be taken, and what role do time and chance play?

"Dans les pas d'Archimède" is a series of podcasts from Aix-Marseille Université in which some of its most eminent researchers tell the story of a discovery they have made.

In this episode, astronomer Élodie Choquet tells us how her Escape project is tracking down previously unknown exoplanets.

Episode

My name is Élodie Choquet, I'm an assistant astronomer at the Marseille Astrophysics Laboratory and at Aix-Marseille Université, and I set up the Escape project.

With Escape, we are developing innovative image processing methods that will be integrated into future space telescopes to detect exoplanets, i.e. planets that exist outside our solar system.

We know that they have existed for barely 30 years and we still have a lot to learn about them. The aim is to discover enough of them and observe them to get to know them better, to find out what they are made of, how they are formed and, in the longer term, to find out if some of them have been able to develop a form of life.

Just over 5,000 exoplanets have been identified and confirmed to date, and it is estimated that there is an average of at least one planet for every star in our galaxy. This means that there are between 100 and 200 billion planets in our galaxy alone. ^[1]_{SEP} Some of these are small, rocky stars like our Earth, while others are larger, gaseous stars that look more like our Jupiter. Most, however, have no equivalent in our solar system and are, for us, completely new, so we have everything to learn about these planets.

Musical interlude

The difficulty with exoplanets is that they are both very far from us and hidden by the brightness of the star, because they are so close to the star. It's a bit like trying to observe a tiny firefly that is one metre away from a huge lighthouse, while we ourselves are more than 500 kilometres away.

To observe these exoplanets, the technique I specialise in is imaging. I work with images taken by telescopes. I clean them to remove as much light as possible from the star and try to identify what is around it.

In concrete terms, we develop image processing algorithms, optimising each parameter by inspecting the images in detail, until we see something like a planet or an asteroid belt.

Sometimes we think we've discovered an interesting object. You check the databases to see if the object has already been observed and then you realise that it's an interesting object but one that's already known. Often you realise that it's a distant star in the background that just happened to be in the camera's field of view and has nothing to do with a planet. It's just a distant star. It's happened to me several times. It's always a bit frustrating but it's part of the job.

Musical interlude

My target is Earth-like planets, because that's where we'd like to find out whether life has developed. At the moment, we can't observe them because we don't yet have sufficiently powerful instruments.

Technologies are being perfected and we think that in 2035 or 2040, a large space telescope will be launched that will have all this cutting-edge technology. Before that, in 2027, which is tomorrow at our scale, a smaller space telescope will be launched by NASA called Nancy Grace ROMAN - or ROMAN - which will enable some of these technologies to be tested.

Escape's mission is to develop image processing methods that can be tested on ROMAN and that could enable us to detect planets that are 1 million or even 1 billion times fainter than their star.

Today, the images available come from two types of telescope: space-based and ground-based. And both have weaknesses.

The current space telescopes, the HUBBLE and the WEBB, are very stable because they are in space, but they are passive. They use old technology that does a poor job of masking the brightness of stars, and we can only use fairly basic image processing methods.

Ground-based telescopes, on the other hand, are very large and are equipped with the latest cutting-edge technology and image processing, but they are ultimately limited in terms of performance by the presence of the Earth's atmosphere.

Our idea with Escape is to combine the strengths of both.

Musical interlude

The first step is to collect all the measurements produced by a space telescope, to fully understand and analyse how it behaves as a function of time and observations. We then adapt the image processing methods that have been developed for ground-based telescopes to these space telescope data, to boost our ability to highlight the planets.

In practical terms, this is computer science. We are in front of our computers, developing algorithms and observation methods. I'm really interested in this image work because it enables us to detect these little planets, and then there's the interpretation part: using this light to better understand what they're made of.

When planets are young, they are still hot, as if they have just come out of the oven, and their heat emits light in the infrared. If we collect this light, we will be able to assess the planet's temperature and mass and obtain some information about its atmospheric composition.

For older planets, we will concentrate on the starlight reflected by the planet. Just as when we look at the Moon or our planets with the naked eye, which are illuminated by the Sun, they appear to us in different colours: the Moon is white, but Mars is red and Jupiter is more yellow. These colours give us an indication of the atmospheric composition of the planet. This is what we want to do with ROMAN, because this atmospheric composition is key to understanding what the planet is made of and to discussing its potential habitability.

Musical interlude

I develop my ideas in the hope that they will work, but there are always periods of doubt. When you try something new, you question yourself a lot. Especially at the beginning. You wonder whether it's a good idea, whether it's going to work and whether our results will live up to both our expectations and the financial and human investment.

For me, these periods of doubt are the difficult part of the project. The only thing to do then is to take pleasure from day to day, in our work and in our interactions with people. I at least make sure that the people I work with are happy to do what they do, that they are motivated and valued.

We are currently a team of four people, students and post-docs, and we should be seven in a year or two. I also interact a lot with our colleagues at NASA. I regularly visit the Space Telescope Science Institute in Baltimore, where I've worked in the past.

Escape is an independent project, initiated by me, but it's NASA and the United States that are building the space telescopes of the future, so it's important to work with them to be able to participate and have access to them. They also have a very detailed knowledge of the capabilities of the best current space telescope, JAMES WEBB, which was launched in 2021 and whose first image was published in July 2022.

Together, we're gradually discovering how the telescope has worked since it was launched. We are perfectionists: we will develop small improvements on this or that detail and, put end to end, we become more precise and this has an impact on our search for ever smaller planets. Our collaboration is essential to optimise our work, and particularly in the Escape project.

Musical interlude

It's really the pleasure of observing, and in particular curiosity, that makes the astronomer's job. Scientific subjects are sometimes frightening, especially for young girls, but you really shouldn't let them intimidate you. The important thing about science is to be interested in what's going on around you and to ask questions.

It's not always easy, there's a history of bias, particularly in the scientific professions, which means that a higher proportion of men in the profession hold these permanent positions.

We're fighting to rebalance the field, to make it more representative of the population in general, not just women but also communities that are under-represented in our profession.

There's a lot of work to be done in schools, colleges and lycées to raise awareness of science among young girls. And then on our side, we need to be able to welcome them when they apply for post-doctorate or PhD positions, and then support them for permanent positions in our laboratories and universities.

Conclusion

You have just listened to (or read) "Dans les Pas d'Archimède", the podcast series revealing the scientific discoveries of Aix-Marseille University researchers.

This episode was recorded on the premises of the Aix-Marseille School of Journalism and Communication (EJCAM). It was written, directed and edited by Charlotte Henry de Villeneuve and Merry Royer. The music was composed by Hdv, who also handled the mix. Special thanks to Élodie Choquet for her contribution.