PROFILE - Catherine Cesarsky, French astrophysicist

Astrophysics is an interdisciplinary branch of astronomy which mainly concerns the physics and study of the properties of objects in the universe (e.g. stars, planets, galaxies, interstellar medium), such as their luminosity, density, temperature and chemical composition, their formation and evolution.

This field of research is a pillar of Franco-Swedish cooperation since astronomy and astrophysics is the second most important area of joint publications (after physics) between France and Sweden with more than 2,700 publications over the period 2010-2020. Over the years, French and Swedish astronomers have found reasons to cooperate in numerous programmes on the ground and in space, both on stars and their composition and on the interstellar medium, nebulae and galaxies.
We had the pleasure of meeting a leading figure in this field and a foreign member of the Royal Swedish Academy of Sciences since 2005, Catherine Cesarsky. Read our interview below.
You have a doctorate in astronomy from Harvard University, you did a post-doctorate at the California Institute of Technology, one of the largest research centres in astronomy, before returning to France and becoming a researcher in 1974 in the Astrophysics Department of the CEA in Saclay. Today you are President of the international project office for the construction of the world's largest radio telescope, SKA ("Square Kilometer Array").

What led you to take an interest in galaxies and more particularly in the origin and propagation of cosmic rays?
These things often happen by chance. I was looking for a thesis supervisor when I was a student at Harvard University and I was lucky enough to meet an astrophysicist and plasma physicist from Princeton at a congress who offered me a summer job on cosmic rays. My fresh perspective allowed me to unveil new facets that strongly changed the conclusions of his work. We published together an article which was very well received and it was therefore quite natural that I stayed with him to do a thesis on cosmic rays.
My studies led me to become interested in infrared astronomy. Thus, in 1985, I started to build an instrument for the first infra-red space observatory, ISO: the ISOCAM infra-red camera. This camera made it possible to observe infrared galaxies much farther away than had previously been possible. This led to major discoveries on the evolution of galaxies, a subject to which I have since devoted myself.

You have headed the Directorate of Matter Sciences (DSM *Direction des Sciences de la Matières*) at the CEA, you have been Director General of the European Organisation for Astronomical Research in the Southern Hemisphere (ESO), President of the International Astronomical Union, and you are now President of the SKA Telescope Project Office. This is very impressive, even more so for a woman! What made you take on so many responsibilities?
When I was a young researcher, what interested me was doing research and I didn't have the ambition to become a director. However, in 1984, I thought that space infrared astronomy was very important for the promotion of European astronomy. So I became involved in the development of the ISOCAM camera for the ISO European Space Observatory. I ended up leading the ISOCAM consortium at the request of the other participants. And then I agreed to head the astrophysics department at the CEA, which had not previously worked in infrared astronomy, in order to federate the laboratory around the project.
Later, the CEA management offered me the position of Director of the Department of Matter Sciences (DSM), at the head of a team of about 1800 scientists and engineers.
In 1999, I had the opportunity to return to my discipline by becoming Director General of the

European Organisation for Astronomical Research in the Southern Hemisphere (ESO), which I headed for eight years. Shortly after my return to France, I was appointed, in the Council of Ministers, High Commissioner for Atomic Energy, adviser to the government on science and energy issues.

In your opinion, what are the major challenges facing astrophysics today?

It has long been known that less than 15% of the matter in the universe is ordinary, the matter of which we ourselves, the Earth and the stars are made up. Most matter is "dark", not emitting light, revealed by its gravitational effects on normal matter. The challenge is therefore to understand the nature of this dark matter, its role in the evolution of the universe, in the formation of structures, galaxies and black holes.

Then, in 1996, it was discovered that the expansion of the universe is accelerating, without any reason being known. The usual interpretation is to invoke the presence of a large-scale, repulsive force due to a "dark energy" that fills the universe and whose nature and properties are not yet revealed. For contemporary astrophysicists, this is one of the great mysteries to be unravelled.

Since 1995, humanity has been able to detect the presence of planets around stars other than the Sun: exoplanets. Since then, numerous methods have been used to discover and study these planets. Several thousand of them are now known with extraordinary diversity. It has become a very rich subject of study, which personally interests me very much.

How to respond to these challenges?

Today, astrophysics is an international science and we can practically say that there is a global strategy. In 2022, the European Space Agency is due to launch a satellite, called EUCLID, which will enable advances to be made on dark matter and dark energy. At the same time, the United States, as part of an international consortium, is building a large optical telescope on the ground, dedicated to studying these same problems. These programmes are complementary.

The study of dark energy from the ground can also be carried out using radio waves. This is one of the objectives of the SKA World Radio Wave Observatory, which I am now working on, and whose construction should start in 2021. The headquarters will be in England and the antenna networks in Australia and South Africa. Sweden, which is very strong in radio astronomy, is one of the 14 partner countries.

Next year, the launch of a space mission, called the James Webb Space Telescope, a 6.5-metre diameter space telescope (successor to the Hubble Space Telescope), is expected to make important discoveries about distant galaxies and exoplanets.

At the same time, ESO has begun construction in Chile of the world's largest ground-based telescope, the Extremely Large Telescope (ELT), which will allow advances in many fields, but particularly in the study of extrasolar planets. This project is also close to my heart, and I launched it when I was Director General of ESO.

What links do you have with Sweden?

Sweden, together with Italy and the United Kingdom, was involved in the ISOCAM programme. It developed and delivered the filters for the camera, and successfully led the research on star-forming regions in our galaxy. This fruitful collaboration led to another one on the ground-based infrared camera CAMIRAS, developed at the CEA and implemented on the Nordic telescope in the Canary Islands, NOT, in Franco-Swedish collaboration. The Swedes have also worked alongside us on an instrument. The discussion continues for future projects in space infrared astrophysics.

Sweden is a member of the four international organisations with which I have collaborated a lot in recent years: ESO, ESA, CERN and SKA; the vice-president of the SKA office, with whom I work on a day-to-day basis, is Swedish.