To the edge of the universe

iram
Institut de
Radioastronomie
Millimétrique

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To the edge of the universe

IRAM is a leading astronomical research institute that operates two world-class radio observatories.

Institut de Radioastronomie Millimétrique

The IRAM organization

IRAM is an international research institute and Europe's leading center for radio astronomy at millimeter wavelengths.

Its mission is to explore the universe, study its origins and its evolution with two of the most advanced radio astronomy facilities in the world:

NOEMA is the most powerful millimeter observatory of the Northern Hemisphere, located in the French Alps.

The 30-meter telescope is one of the largest and most sensitive radio telescopes to date built in the Spanish Sierra Nevada.

IRAM scientists and engineers work at the forefront of modern radio technology. The institute's laboratories cover the complete field of high frequency technology. With their unique expertise, IRAM staff develop cutting edge technology for the IRAM facilities and to the benefit of the international astronomical community.

Europe's leading institute for millimeter astronomy

Pioneers in high frequency technology

Exploring the outer reaches of the universe

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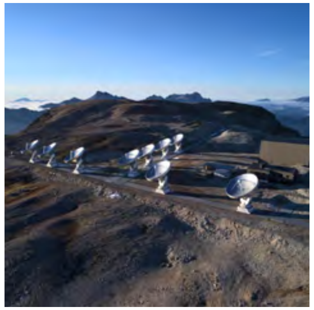
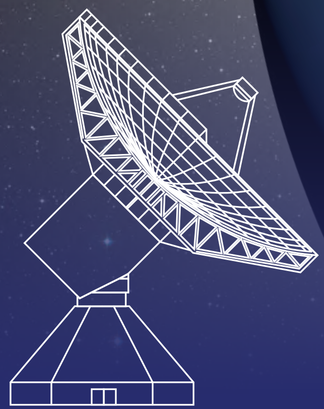
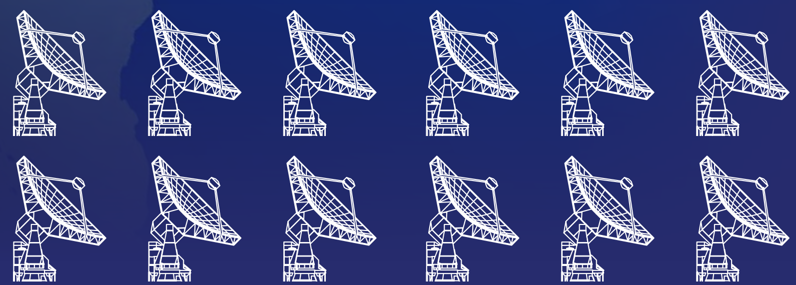




The 30-meter telescope



NOEMA

A pioneering European collaboration

IRAM was founded in 1979 by the French CNRS (Centre National de la Recherche Scientifique), the German MPG (Max-Planck-Gesellschaft) and the Spanish IGN (Instituto Geográfico Nacional) - initially an associate member, becoming a full member in 1990. Today, the institute is considered a model of scientific multinational cooperation.

The IRAM Headquarters are located in Grenoble (France). More than 120 scientists, engineers, technicians and administrative personnel from over 10 countries around the world work for the IRAM observatories.

IRAM supports the scientific research of more than 5000 astronomers worldwide.

NOEMA observatory
Plateau de Bure, France

NOEMA is the biggest astronomical facility on European ground: it consists of a large array of 15-meter antennas working together as a single telescope.

The observatory operates at over 2500 meters above sea level on one of the most extended European high altitude sites, the Plateau de Bure in the French Alps.

With its 12 antennas arranged in different configurations that can spread over distances of up to 1.7 kilometers, NOEMA is the most powerful instrument of its kind in the Northern Hemisphere.

Why so many antennas?

Instead of operating one giant telescope, NOEMA relies on several smaller and easily movable antennas placed on tracks.

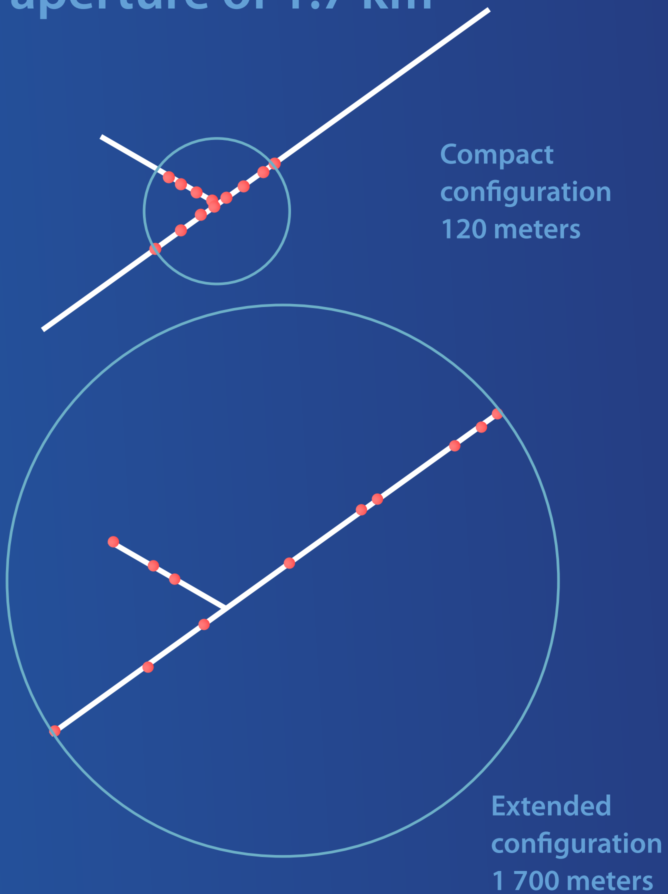
Together, the NOEMA antennas have the resolving power of a telescope with a diameter of more than 1.7 kilometers which is the distance between the outermost antennas.

What is an interferometer?

During observations, the NOEMA antennas function as a single stationary telescope, a technique called interferometry.

All NOEMA antennas point towards the same cosmic source. The signals received by each antenna are combined by a supercomputer that produces images of outstanding sensitivity and resolution of the astronomical source.

A telescope with an aperture of 1.7 km



Moving the antennas into different configurations allows astronomers to zoom-in and -out on the cosmos, which is crucial to provide the most informative view of cosmic objects.

The 30-meter telescope
Pico Veleta, Spain

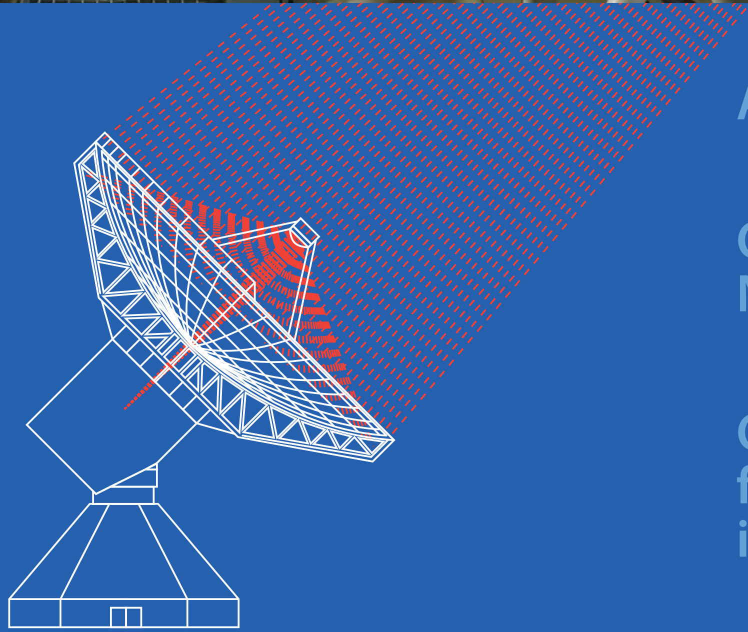
A unique astronomical instrument

Located in the Spanish Sierra Nevada, the 30-meter telescope is the world's premier single-dish facility for astronomical research in the millimeter wavelength range.

Its large surface and unique wide-angle camera give it an exceptional sensivity and make it a perfect tool for the exploration of large cosmic objects such as galaxies and interstellar clouds.

The 30-meter telescope also allows astronomers to access parts of the southern skies and therefore to observe the black hole at the center of our galaxy.

The 30-meter telescope support structure securely holds one of the largest and most sensitive dishes for millimeter observations.



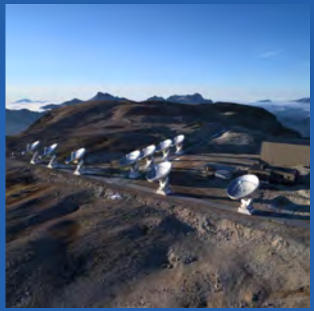
A unique single-dish, 30 meters in diameter

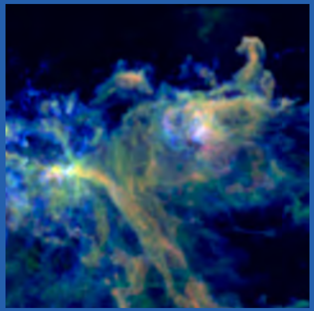
Operating at the top of Pico Veleta in the Spanish Sierra Nevada

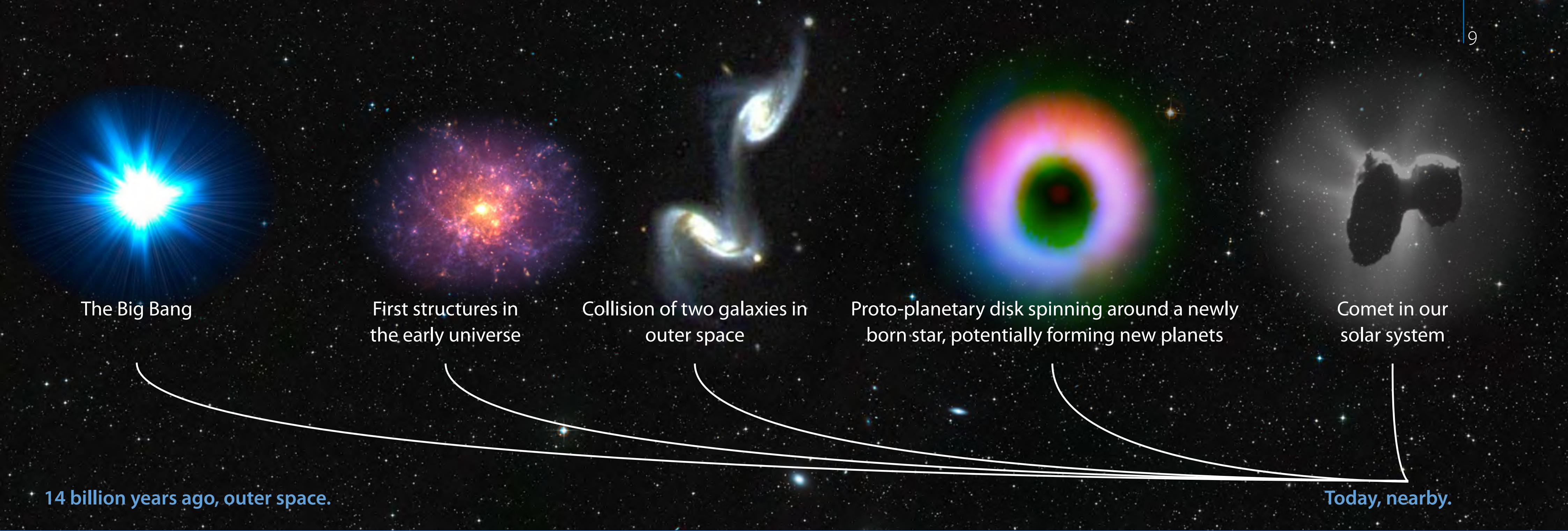
One of the world's most sensitive radio telescopes for exploring large cosmic objects such as galaxies or interstellar clouds

Combined power: IRAM's facilities and how they work together

NOEMA functions like a variable lense camera by changing the configuration of its antennas allowing scientists to zoom-in and -out of a cosmic object and observe the tiniest details. Working with the 30-meter telescope and its wide angle of vision, the result is a giant virtual telescope with a unique set of capabilities.



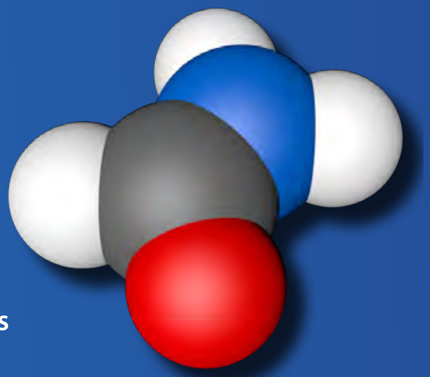




Both IRAM facilities trace cosmic objects back to the Big Bang

NOEMA and the IRAM 30-meter telescope are able to:

- **see the formation of the first galaxies in our universe**
- **observe super-giant black holes at the center of galaxies**
- **analyze the chemical evolution and dynamics of nearby galaxies**
- **detect organic molecules and the key elements of life**
- **investigate the formation of stars and the appearance of planetary systems**



NOEMA detected the presence of formamide in space, a potential prebiotic precursor to the formation of amino acids, and hence to the origin of life on Earth.

Formamide molecule: carbon (grey), hydrogen (white), nitrogen (blue) and oxygen (red).

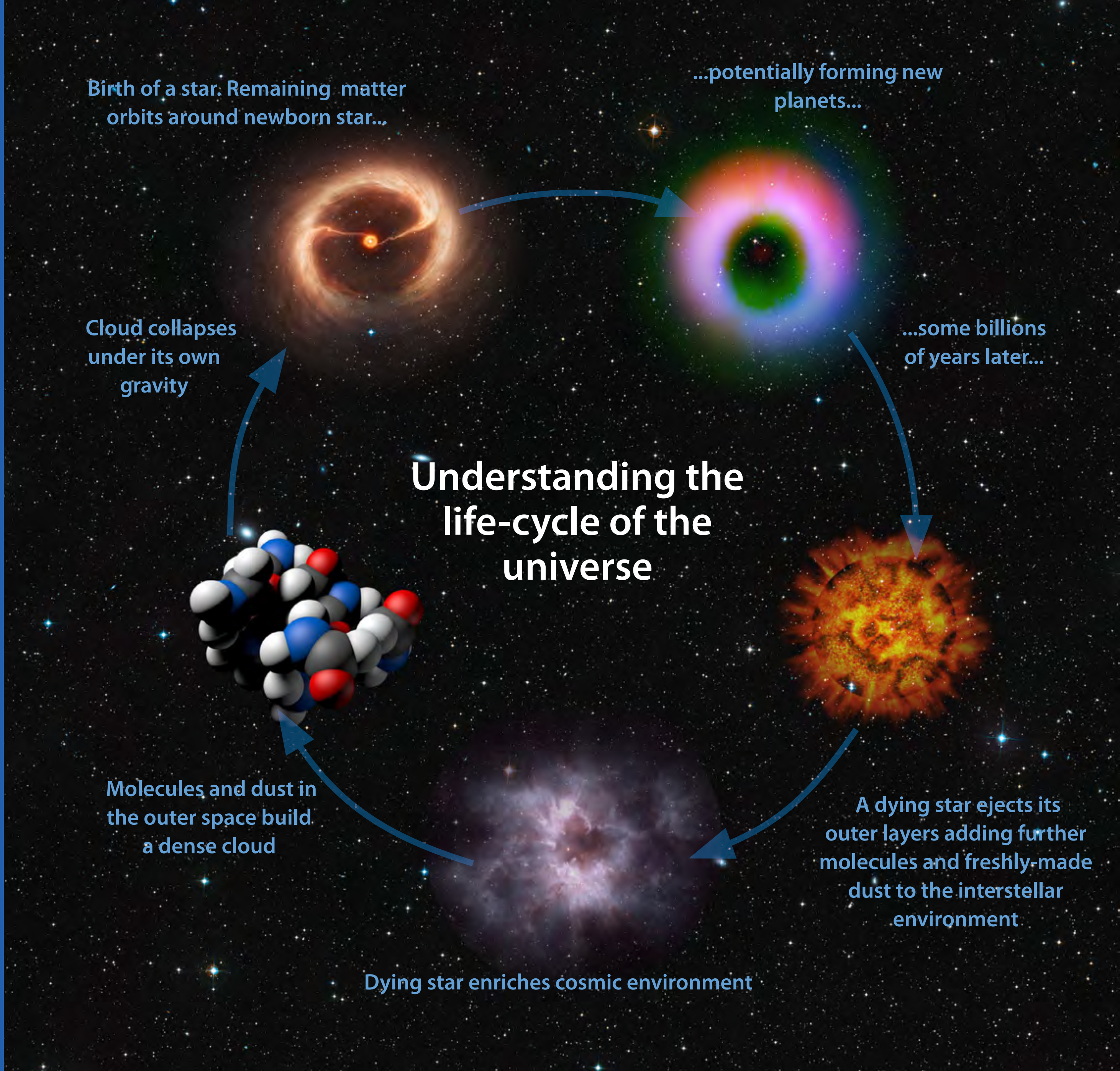
Why radio astronomy at millimeter wavelengths?

Among the most fundamental questions of modern-day astronomy are: where do the key elements of life come from? Do they already exist in space?

Most of the chemical elements like iron or oxygen, are formed inside of stars. At the end of their life most stars eject these elements into space, enriching the surrounding interstellar environment. Yet, it is still not understood exactly how these elements group together and form complex prebiotic molecules, the basic components of human DNA.

Searching for this missing link is one reason why it is crucial to understand exactly how stars are born, eventually forming new planets around them and – at the end of their life – how they die. However, stars are born in opaque clouds, surrounded by gas and dust which makes it very difficult to get a glimpse of their birth process.

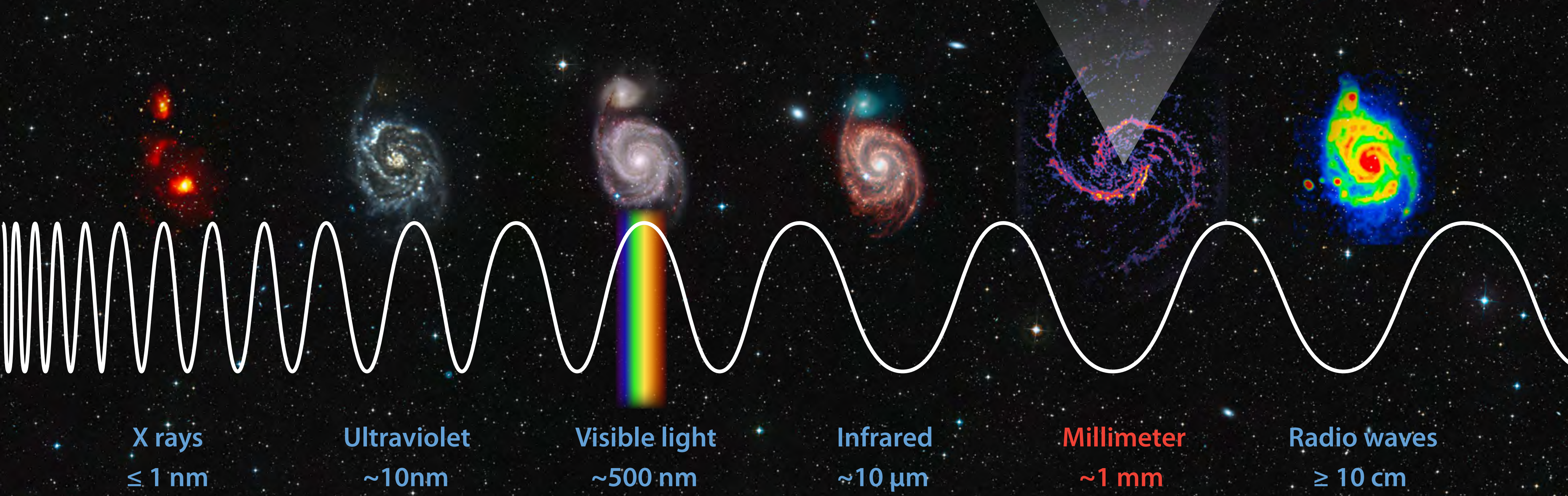
NOEMA and the 30-meter telescope are the ideal instruments to observe the life-cycle of stars. They are able to penetrate dense clouds of gas and dust, revealing the hidden secrets of star formation, and allow scientists to track and study them.



Investigating what is optically invisible

Each cosmic object emits different categories of light depending on its age, composition and temperature: visible and ultraviolet light but also infrared and radiowaves. In order to get a complete image of a cosmic object, its origins and its evolution, modern astronomy combines observations of different wavelengths, all complementary to one another.

Visual of the M51 galaxy from data collected at millimeter wavelengths by the IRAM observatories

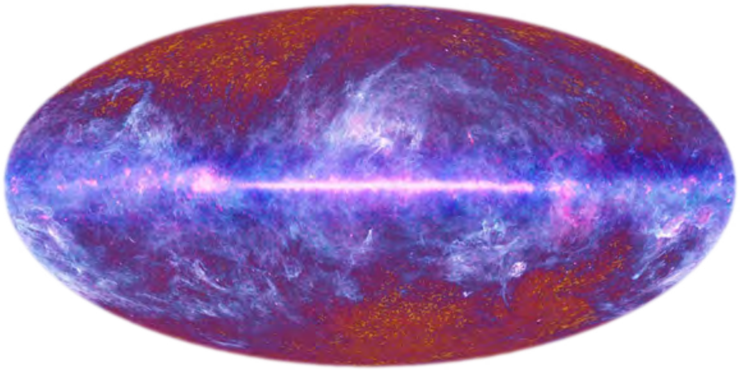


From the microcosmos to the macrocosmos

Cosmic signals travel more than 13 billion years through space until they reach Earth which is one reason why they are incredibly weak.

NOEMA would have to collect these signals over a period spanning the entire age of the universe (~14 billion years) to obtain enough energy to power an ordinary light-bulb for only ten seconds!

Both IRAM observatories use cutting edge instrumentation to capture these infinitely weak signals. In its own laboratories, IRAM engineers and technicians are conducting research at the forefront of modern technology and keep developing faster and better solutions for the future.

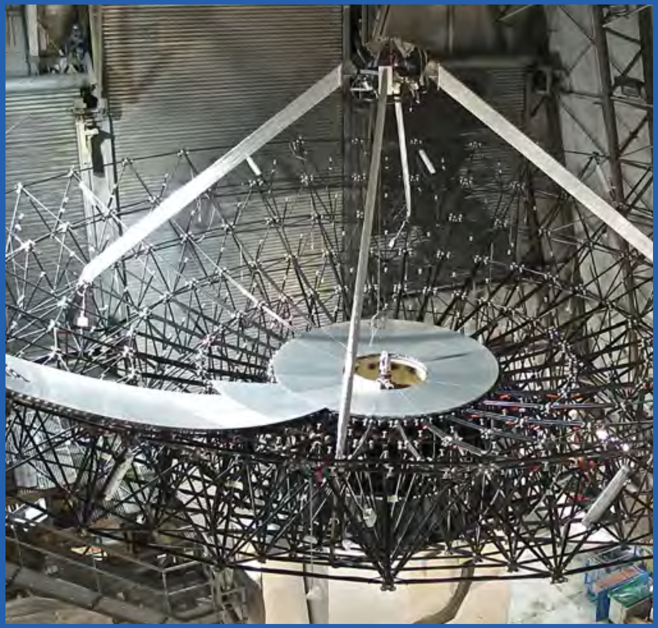


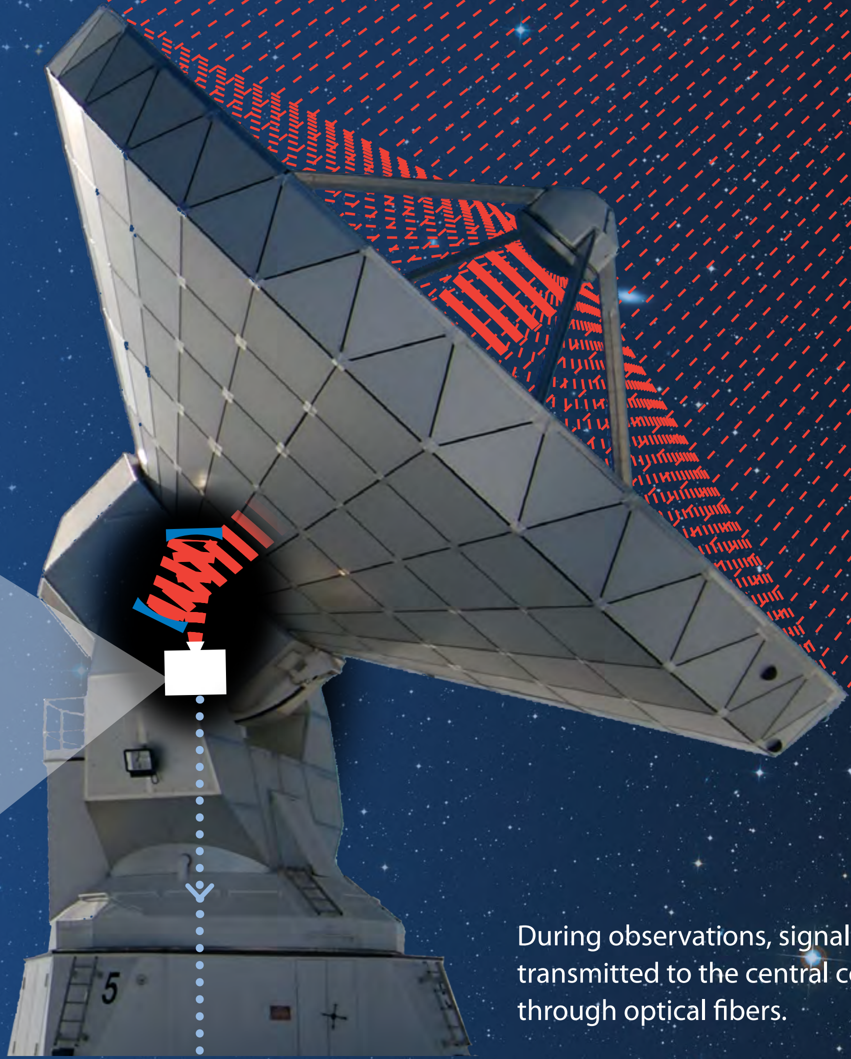
Planck's all-sky image of cosmic background emission

NOEMA antennas: capturing the infinite

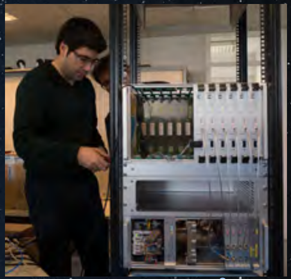
Each NOEMA antenna weighs over 120 tons. The dish is made of 176 aluminium panels adjusted to achieve an overall parabolic surface precision of less than 40 microns, the width of a human hair.

At the heart of each antenna are the most sensitive reception systems ever built for modern-day telescopes like NOEMA. The entire systems, including its smallest element, a junction, are manufactured in the institute's own laboratories. The junction itself measures less than one micrometer and guarantees a perfect reception even of the most remote signals that have travelled more than 13 billion years to Earth.



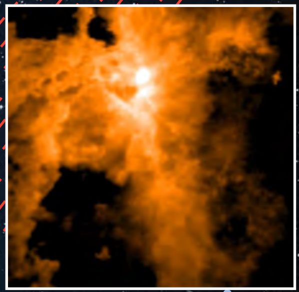


During observations, signals are transmitted to the central correlator through optical fibers.



The correlator is an impressive super-computer. Designed in the IRAM laboratories, it is the 'brain' of the observatory. The actual NOEMA correlator processes every day the equivalent of the daily Internet traffic of a country like France.

IRAM scientists and engineers develop advanced software programs for antenna control, astronomical observations and celestial data reduction.



Finally, the astronomers obtain detailed images of our universe, the dynamics of galaxies, stars and planets or even still unknown structures.

Global outreach

IRAM has a world-wide network of partners and cooperations, including international research programs and transnational initiatives.

The institute maintains close research partnerships with high-profile universities and research organizations in North-America and China as well as with other radio-astronomical facilities including the ALMA observatory in the Southern Hemisphere.

IRAM's industrial network spans several European countries. In total, IRAM works with over 200 companies specialised in high-tech electronics, mechanical engineering, micromechanics and the IT domain.

IRAM also exports its technical and instrumental know-how. Transnational organizations like the European Space Agency benefit from IRAM's developments for their missions.

Both IRAM observatories are regularly linked to a worldwide network of radio telescopes, the Event Horizon Telescope (EHT). It combines telescopes across four continents from Europe to the South Pole, through Chile and Hawaii.

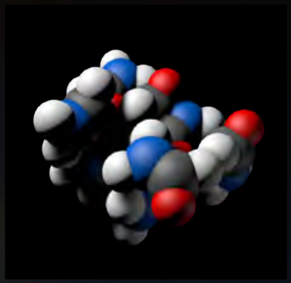
The EHT has a resolving power equivalent to a telescope almost the size of Earth. One main goal of the project is to image the black hole at the centre of the Milky Way, about 26,000 light years away from Earth.

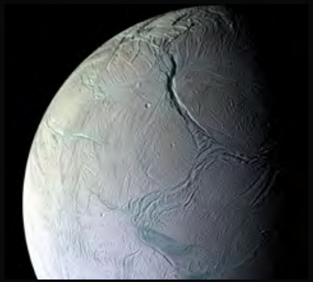
The main areas of research today...

IRAM's scientists and facilities conduct a broad research program dedicated to excellence and focused on the key questions of modern astronomy.

The IRAM telescopes are at the origin of a large number of ground-breaking discoveries regarding the birth and death of stars, spinning black holes in the early universe, gaseous disks and planetary systems orbiting around forming stars, and the potential molecular precursors for the emergence of life in the universe.

Additionally, the IRAM facilities discovered one third of the interstellar molecules identified to date - a major contribution to the development of exobiological research.



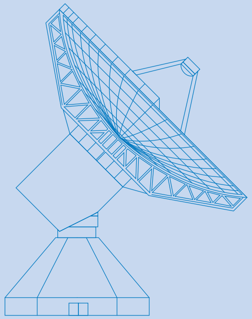


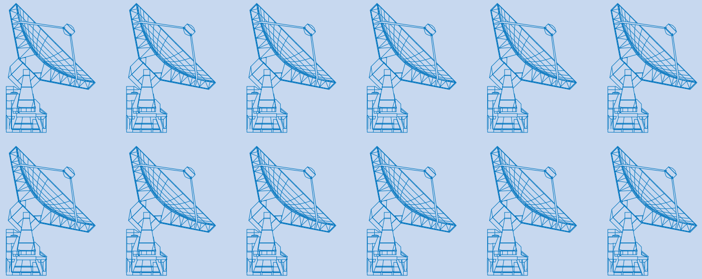
... and the important discoveries of tomorrow.

The universe which surrounds us still holds a number of important mysteries for us.

NOEMA and the 30-meter telescope will help to solve these mysteries and each observation adds some crucial information to what is still the big puzzle of our universe.

IRAM telescopes technical data





	30-meter telescope	NOEMA observatory
Location	Pico Veleta, Sierra Nevada, Spain	Plateau de Bure, Hautes-Alpes, France
Altitude	2850 meters	2550 meters
Longitude / Latitude	03:23:33.7 W / 37:03:58.3 N	05:54:28.5 E / 44:38:02.0 N
Number of antennas	1	12
Antenna diameter	30 meters	15 meters
Antenna weight	800 tons	125 tons
Antenna mount	Alt-azimuth, steel on concrete pedestal	Alt-azimuth, steel on autonomous bogies
Dish panels	420 aluminium panels on honeycomb back-up structure	176 aluminium panels on honeycomb back-up structure
Secondary mirror diameter	2 meters	1.5 meters
Surface precision	55 microns	< 40 microns
Tracking precision during observations	< 1°/3600 (less than one arcsecond)	< 1°/3600 (less than one arcsecond)
Frequencies / wavelengths	70 to 375 GHz / 4.3 to 0.8 millimeters	70 to 375 GHz / 4.3 to 0.8 millimeters

Photo credits

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