THE UNIVERSE IN EMISSION

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The Winter Schools

Great advances in astrophysics are usually linked with the development of new techniques and instruments on ever more powerful telescopes. However, these techniques and new instruments and telescopes can only be exploited to full effect with the help of creative and well-trained young researchers.

The Winter Schools of the Instituto de Astrofísica de Canarias (IAC), which this year celebrate their eighteenth anniversary, are particularly conceived to provide their students – researchers at the outset of their doctoral studies or beginning their first postdoctoral contract – with suitable training to tackle the new challenges of frontier astrophysics. These objectives are achieved through a suitable choice of the most competitive topics as the drivers of successive schools, together with a careful selection of the most renowned international specialists that enable us to cover a wide range of the most up-to-date knowledge in the chosen field.

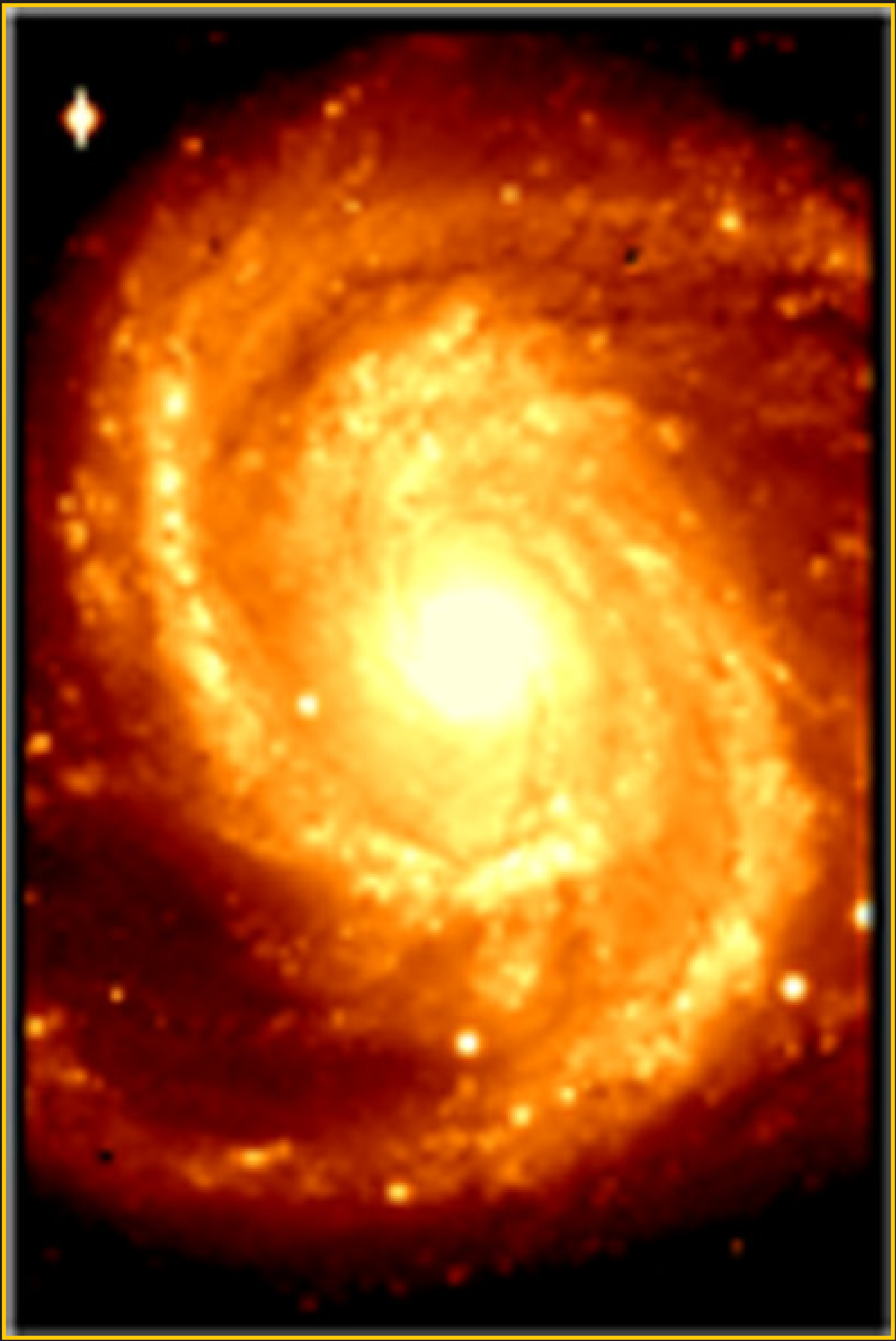
In this way the IAC Winter Schools have to date trained more than 1000 researchers worldwide in the most competitive and cutting-edge fields of astrophysics.

Emission Lines

This year´s Winter School, <<The Universe in Emission>>, is dedicated to the techniques of detection and analysis of objects in the Universe that produce emission lines.

When a solid body, a metal for example, is heated it gives off what is known as a <<continuum>> spectrum. That is to say, it does not emit light at just one wavelength but over a very wide range of wavelengths. In contrast, when a gas is heated to a sufficiently high temperature, it produces what are called <<emission lines>>. The gas emits light at a number of very precise wavelengths, each chemical element having its own characteristic set of lines.

For this reason, the analysis of emission lines enables us to determine the chemical composition of the gas, its temperature, degree of ionization and density. Emission also indicates that the gas is in an excited state, whether through radiation from a star or through some other process. In the case of stellar emission, the intensity of the emission allows us to estimate the mass of stars recently formed in a region; otherwise it might indcate the presence of an active galactic nucleus and allow us to determine its type and properties.



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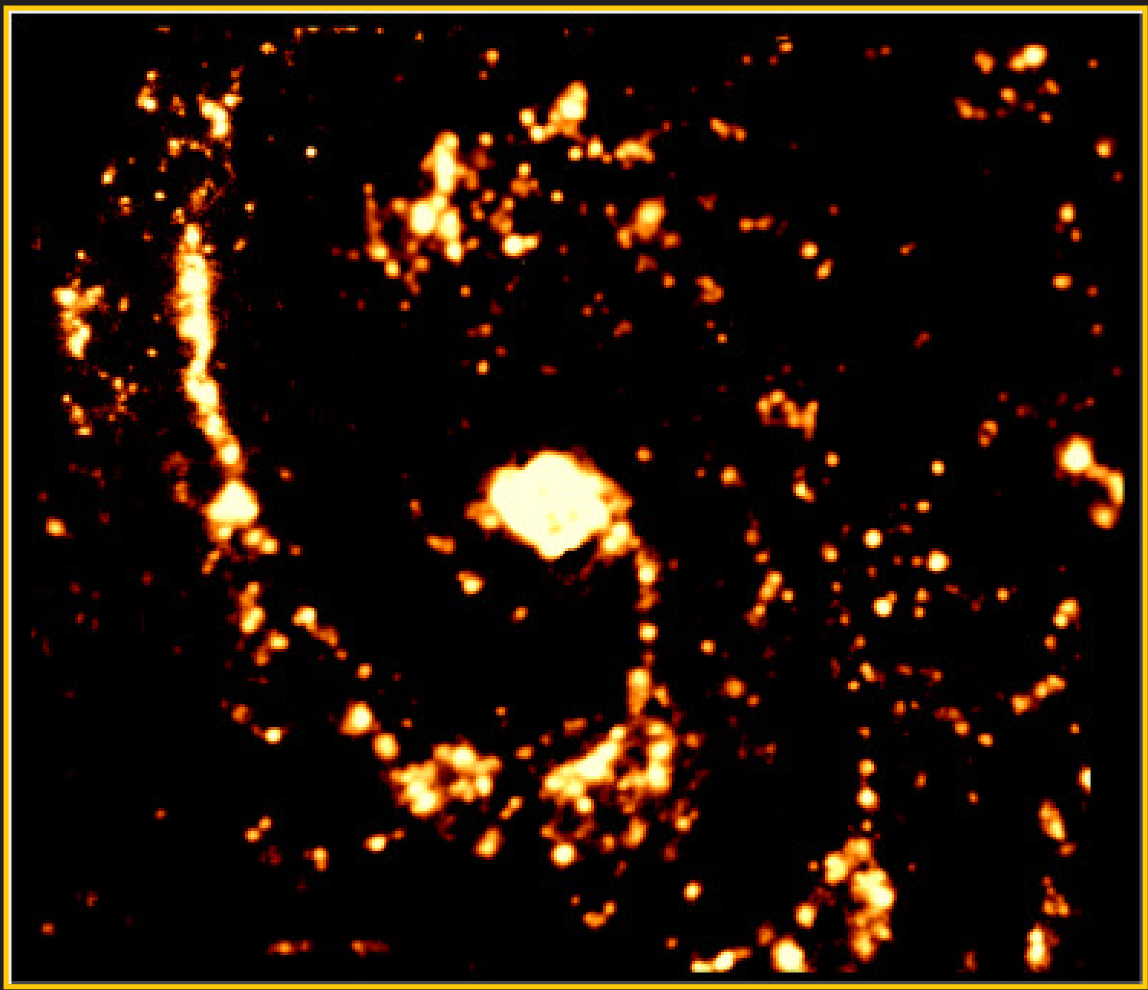
Up. Wide-band Image of the galaxy NGC 4321 in the Virgo Cluster.

Down. Ha emission image of the same galaxy, in the same orientation. In the first case the stellar population of the galaxy is observed, whereas in the second case regions of gas ionized by the young and massive stellar population stand out. Both images were taken by the author using the prime focus of the 2.5 metre Isaac Newton Telescope (up image) and the Cassegrain focus of the 4.2 metre William Herschel Telescope (down image). Both telescopes, belong to the Isaac Newton Group of Telescope and are located in Spain´s Observatorio del Roque de los Muchachos, Garafía, on the island of La Palma.



Consequently, the study of emission lines is fundamental to the analysis of star formation and the chemical composition of objects in the Universe. The OSIRIS instrument, which will shortly come into operation on the GTC (Gran Telescopio CANARIAS), is optimized for the study of emission lines. For this purpose it incorporates what are known as tunable filters. These filters permit observations at a tunable wavelength over relatively narrow spectral range. Changes in wavelength and bandwidth are performed in a question of milliseconds. In this way, any spectral line of any chemical element situated at any redshift or distance can be observed.

Combining the efficiency of OSIRIS with the light-grasp of the biggest telescope in the world will allow the observation of emission lines from the remotest and faintest objects in the Universe. The XVIII IAC Winter School will deal with scientific objectives that will allow us to cover both types of objects, both in the spectral range of OSIRIS and in other spectral ranges, such as the infrared and radio.

Structure and Contents of the School

The opening classes of the School will be dedicated to the study of processes that produce emission lines and the information that these provide. We shall then analyse existing photoionization models and shall finally outline the commonest problems encountered when tackling the study of ionized regions.

Jointly with these introductory lessons, the most conspicuous objects that can be observed in emission will be studied, beginning with those in our Galaxy, such as HII regions, planetary nebulae, supernova remnants, protostars, peculiar and Wolf-Rayet stars.

Quasars and active galactic nuclei constitute another important class of emitting objects. After a review of the various types of active nuclei, the current unified model of is studied in detail and how it allows an explanation of the various types of active nuclei. The lessons on this topic close with the cosmological implications of the study of quasars.

The lessons that follow take the students much further in space and time. The study of emission line surveys begins with an analysis of the various methods and techniques and their biases. Existing surveys and their results are then reviewed, ending with the latest surveys and future perspectives.

These surveys allow the study of the first galaxies, their evolution and the evolution of star formation and metallicity in the Universe. The subject of the primordial galaxies includes the famous (and so far undetected) Population III stars and their observable characteristics, star formation in the Universe and the initial mass function. Lya objects and the methods of their detection, including the novel technique of looking for amplification by the lensing effect, which enables us to reach greater distances, comprise a fundamental part of the classes dedicated to this topic.

The foregoing lessons are linked to those covering the study of high redshift star formation and the basic principles of the formation of line and other structures. They include the study of the reionization epoch and its implications, and the enrichment of the interstellar medium.

This enrichment process enables us to tackle the final topic of the lessons: the chemical evolution of the Universe. Beginning with the basic principles of chemical evolution via analytical models, we interpret the data on chemical abundances in galaxies and their gradients, together with their implications for the formation of the discs of spiral galaxies and their star formation history. We close this topic with the abundance of iron in the interstellar medium and the chemical evolution of quasars.

These theoretical classes are combined with practicals that will enable the students immediately to apply their newly acquired knowledge to the subject of their thesis or to their favourite research topic.