WEAVE spectrograph begins study of galaxy formation and evolution

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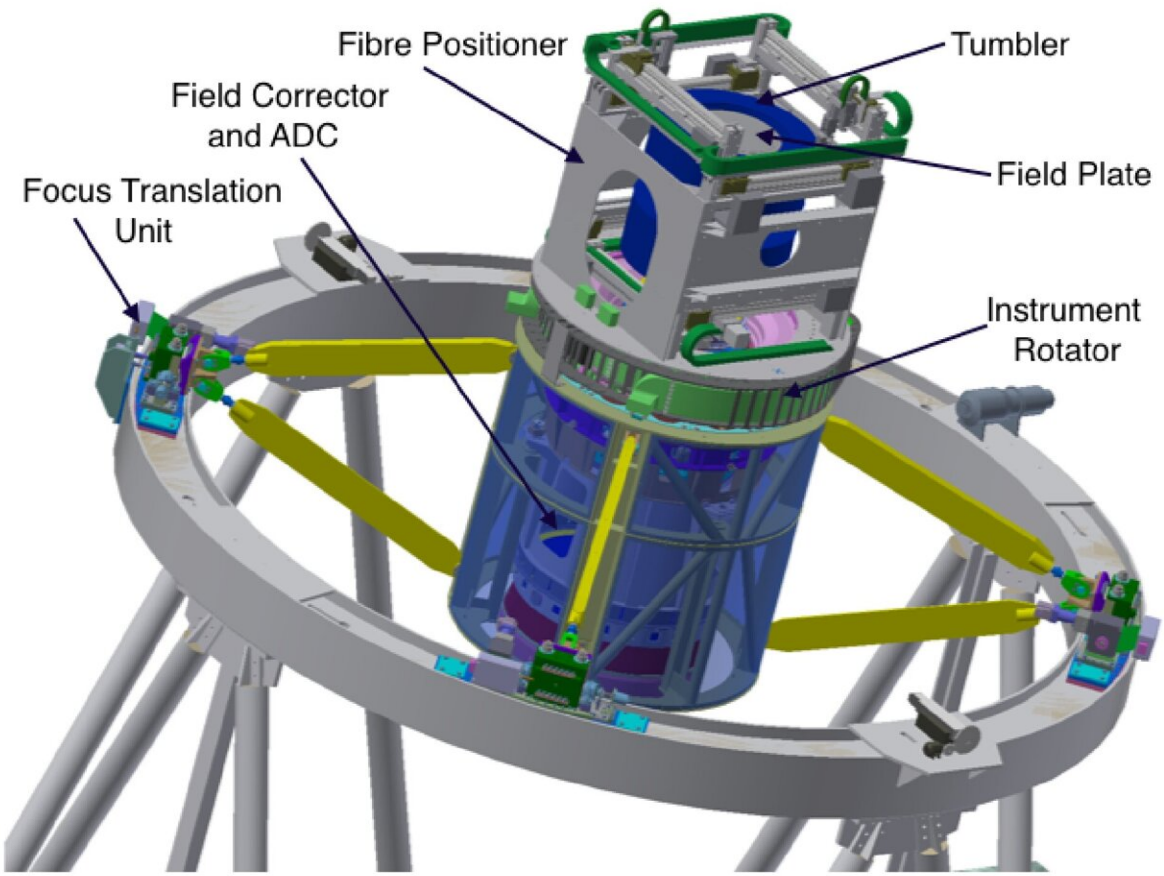

A computer-aided diagram (CAD) representation of the WEAVE top-end assembly, incorporating the prime-focus (field) corrector system, instrument rotator and fiber positioner. The four mounting units on the outer ring of the telescope structure provide for focus and tilt correction of the whole system. Credit: *arXiv* (2022). DOI: 10.48550/arxiv.2212.03981

More than 500 astronomers from all over Europe, including members of Catalan universities and research centers—the UPC and the ICCUB—have designed and planned a total of five years of operations for the WEAVE spectrograph, a powerful instrument recently installed at the Canary Islands observatory.

Combined with Gaia's measurements, it makes it possible to study a wide range of cases in stellar and galactic science. The first observations show unprecedented aspects of the collision between the galaxies at the heart of Stephan's Quintet, 280 million light-years from Earth.

The Isaac Newton Group of Telescopes (ING) and the WEAVE instrument team have presented first-light observations with the WEAVE spectrograph. It is a powerful new generation multifiber spectrograph in the William Herschel Telescope (WHT) at the Roque de los Muchachos Observatory (La Palma, Canary Islands), which has recently been launched and is already generating high-quality data.

Astronomers from all over Europe have planned eight surveys for observation with WEAVE, including studies of stellar evolution, the Milky Way, galaxy evolution and cosmology. Together with the European Space Agency's Gaia satellite, WEAVE will be used to obtain spectra of several million stars in the disk and halo of our galaxy, and thus to do archeology of the Milky Way.

Nearby and distant galaxies will be studied to learn the history of how they grew. Quasars will be used as beacons to map the spatial distribution and interaction of gas and galaxies when the universe was only about 20% of today's age.

First-light observations: Stephan's Quintet galaxies

WEAVE targeted NGC 7318a and NGC 7318b, two galaxies at the center of Stephan's Quintet. Its galaxies, four of which are 280 million light-years from Earth, are colliding with each other, providing an excellent close-up laboratory to study the consequences of galaxy collisions and their subsequent evolution.

The first-light observations were carried out with the so-called Large Integral Field Unit (LIFU) fiber array, one of WEAVE's three fiber systems. When using the LIFU, 547 very compact optical fibers transmit light from a hexagonal area of the sky to the spectrograph, where it is analyzed and recorded.

WEAVE's LIFU has measured a large number of individual spectra of the two central galaxies of Stephan's Quintet and their surroundings, examining the intensity of the colors of their light, from the ultraviolet to the near infrared. Among other information, these spectra reveal essential details to study collision processes, such as the motion and distribution of stars and gas, and their chemical composition. From these data, we can learn how galaxy collisions transform the other galaxies in the group.

ING director Marc Balcells explains that their goal is "to install a unique instrument that will allows us to carry out cutting-edge astronomical research. It has been fantastic to receive financial support from the national research agencies of the three ING partner countries (UK, Spain and the Netherlands) and contributions from other non-ING countries (France and Italy)."

"We are pleased to demonstrate that the LIFU part of WEAVE not only works, but produces high-quality data. The ING telescopes will continue to deliver results of high scientific impact in the coming years. We look forward to announcing soon the first-light events for the other observing modes, which are currently in the final calibration stage."

WEAVE, a new generation spectrograph

The WEAVE spectrograph uses optical fibers to collect light from celestial objects and transmits it to a spectrograph that separates the light according to its different wavelengths. It can work at two different spectral resolutions, which are used to measure the speeds of objects in the line of sight (using the Doppler effect) and to determine their chemical composition.

The versatility of WEAVE is one of its main strengths. While the LIFU mode contains hundreds of fibers in a compact distribution, essential for imaging extended areas of the sky, in the MOS mode about a thousand individual fibers can be placed (by two robots) to simultaneously collect light from stars, galaxies or quasars. During the first five years of operation, spectra of millions of individual stars and galaxies are to be obtained, a goal that can be achieved thanks to the spectrograph's ability to observe so many bodies at once.

Catalan contribution to the spectrograph

The project involves scientists from the Institute of Cosmos Sciences of the University of Barcelona (ICCUB) and the Universitat Politècnica de Catalunya—BarcelonaTech (UPC). The Institute of Space Studies of Catalonia (IEEC) takes part with researchers from the ICCUB and the UPC units.

From the beginning of the project, these Catalan institutions have worked on the definition of its scientific objectives and the selection of the objects to be observed—from stars in various evolutionary stages to star clusters—as well as the sampling of quasars, extremely bright and very distant active nuclei galaxies.

Specifically, two ICCUB-IEEC researchers, Maria Monguió and Mercè Romero-Gómez, and UPC researcher Roberto Raddi, from the Department of Physics, who is a professor at the Castelldefels School of Telecommunications and Aerospace Engineering (EETAC), are members of the international working groups on young stars, galactic archeology and white dwarfs that make up the team of scientists responsible for planning the observations.

Teresa Antoja and Ignasi Pérez-Ràfols, also from the ICCUB-IEEC, co-lead the research teams responsible for galactic disk dynamics and quasars, respectively.

Roberto Raddi, commenting on the contribution of the UPC, says, "Our team will contribute to the study of some 100,000 white dwarfs previously observed by Gaia, and discover the secrets behind the last evolutionary stages of Sun-like stars, including the fate of their planetary systems, and the mechanisms leading to supernova explosions in binary systems with white dwarfs."

Maria Monguió, from the ICCUB-IEEC, explains, "After years of preparation, we hope to soon be able to obtain the first spectra of stars in the disk of our galaxy. The quantity and quality of the millions of spectra that we expect to observe will allow us, among other things, to analyze regions of recent star formation and to measure how stars move. These data, together with those provided by the Gaia mission, will allow us to address fundamental questions about the formation and evolution of the Milky Way."

The work is published on the *arXiv* preprint server.

More information: Shoko Jin et al, The wide-field, multiplexed, spectroscopic facility WEAVE: Survey design, overview, and simulated implementation, *arXiv* (2022). DOI: 10.48550/arxiv.2212.03981

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