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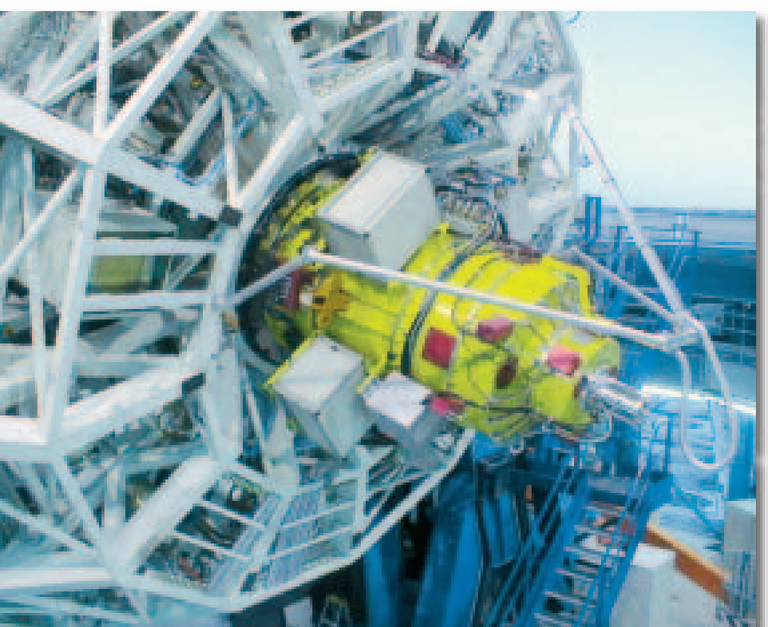
"**Eyes**" for a Telescope

It is not enough for a telescope to possess a large reflecting surface. Only when the image quality of the astronomical instruments and the optical components are at their best is it possible to make new discoveries about the cosmos.

Telescopes were at one time purely observational instruments through which astronomers studied the night sky for hours on end. Today they primarily serve as measuring devices. The light emitted from stars is carefully registered and analyzed with the help of various astronomical instruments. CCD (Charge Coupled Device) chips, which are far more sensitive than the human eye, are used as receivers.



The VLT instrument FORS1 is flanged on to a support element of the main mirror. The imaging optics, made of special glasses from Schott, are located in the yellow cylinder. The silver and red boxes contain the electronic components and the servomotors for the control system.

How does a modern telescope function, and what can be "seen" through it? First of all it has to "capture" as much light as possible from space. This is the task of the telescope's main mirror, and the larger the mirror surface, the better the results. With the help of another mirror, the collected light is united in a focus. This is where the astronomical instruments are positioned to analyze the starlight. A spectrograph is used to investigate the spectral composition of the light that is emitted from a star or reflects from a planet. Just as fingerprints are individual, every element displays its own typical spectrum. This is how information on the chemical composition of cosmic objects can be obtained and conclusions drawn as to their properties and age.

FORS – Instruments for the Very Large Telescope

The Very Large Telescope (VLT) in Chile, currently the world's largest and most powerful telescope, has four main mirrors made of "Zerodur" glass ceramic from Schott, each with a surface of over 50 square meters and a diameter of 8.2 meters. The VLT can focus light interchangeably with twelve different astronomical instruments. Two of these are practically identical – the FORS1 and FORS2 (Focal Reducer / low dispersion Spectrograph). These enable the device, which weighs more than two tons, to take pictures and carry out measurements (e.g. spectroscopy and polarimetry).

The imaging optics of the FORS instrument consists of a total of 17 lenses. This optical system has two main functions. It must decrease the size of the image, so that it fits on the 5 x 5 cm surface of the CCD chip (hence the name focal reducer). In addition, it must correct any image distortions caused by the telescope mirror, as the mirror system in itself can only provide good image quality in the proximity of the optical axis.

Stringent requirements for optical glass

FORS was designed for use in a very large wavelength spectrum – from 330 nanometers in the near UV range to 1100 nanometers in the near infrared range. This poses very high requirements for the transparency of the imaging optics. Most optical glass is rejected for lens material from the start, as it contains silicon or boron, and they absorb UV light.

The VLT on Cerro Paranal in Chile is currently the world's most powerful telescope.

The Centaurus A galaxy photographed by the VLT instrument FORS2.

The dispersion from FORS should also be low. Dispersion here refers to the dispersion of colors that occurs when light is refracted. The index of refraction in all glasses depends on the wavelength. The dispersion of the whole system can be minimized by skillful combination of different glass types.

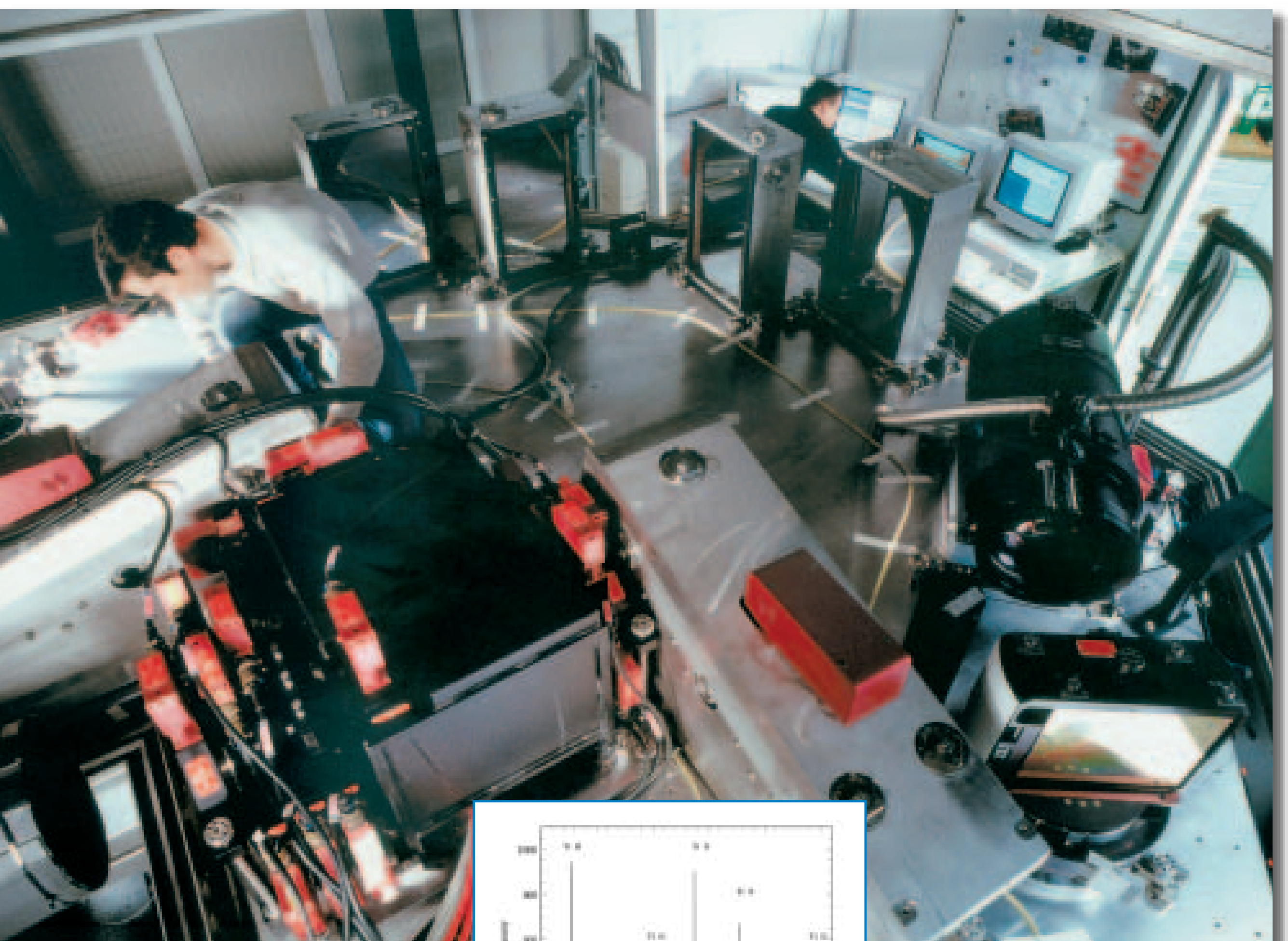
Schott glass FK54 is a special glass characterized by good UV transparency and very low dispersion. It is based on glass forming fluoride and phosphate, and due to its unusual dispersion characteristics, is especially suitable for correcting the dispersion of other glass used in a lens system. Special FK54 melts were produced and for each of the two FORS instruments, six lenses for the imagine optics were made.

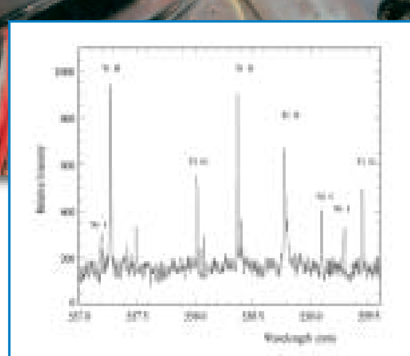
Optical crystals for the UVES instrument in the VLT

Another astronomical instrument in the VLT is the Ultraviolet / Visual Echelle Spectrograph (UVES). UVES possesses two "arms" – one for UV and blue light, the other for visible and infrared light.

The "blue arm" is unique because it can already begin to function at a wavelength of 300 nanometers. The choice of transparent materials for such a short UV wavelength is even more restricted than for the FORS instrument. In this case, quartz glass (SiO_2) and calcium fluoride (CaF_2) are used. CaF_2 is not an optical glass, but a crystal whose primary use is in the semiconductor industry, where it is employed in the optics of the wafer stepper for micro-lithography chip production. Schott Lithotec AG in Jena, Germany is the global leader in the production of CaF_2 crystals. Schott also provided some of the crystals used in UVES. ◂

An interior view of the UVES VLT spectrograph. Optical crystals made of calcium fluoride (CaF_2) were used to make its optical components. Some of these crystals were produced by Schott Lithotec AG in Jena.





The UVES VLT spectrograph was deployed to measure the spectrum of the star CN Leonis, located 8 light years away from Earth. The peaks in this small section correspond to the spectral lines of the elements nickel and titanium.