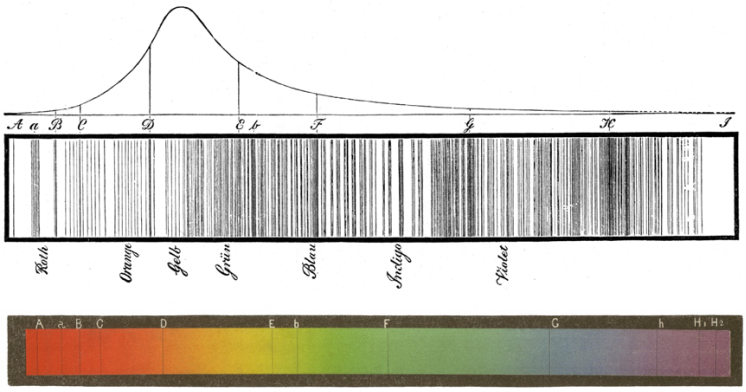
then

The First Diffraction Gratings

Close, equally-spaced grooves on a surface can disperse light, separating the frequencies. This simple tool launched spectroscopic science and more.



Top: Joseph von Fraunhofer's diagram of the lines of the solar spectrum. Bottom: Solar spectrum with Fraunhofer lines, lithograph, published in 1877. [Getty Images]

1821: Dispersing spectra with wire

Although the first diffraction grating was made by astronomer David Rittenhouse in 1785 out of parallel hairs laid in fine screws, it wasn't until 1821 that Joseph von Fraunhofer built the first grating ruling engine. In his model, wire mesh acted as multiple thin slits, and moving the slits closer together further dispersed the spectrum. This discovery essentially turned spectroscopy into a quantitative science, and later allowed Fraunhofer to accurately measure the solar absorption lines now named for him.

G. Harrison in his MIT lab. [OSA Historical Archives]

Holographic gratings. [Image courtesy of Edmund Optics]

1949: Setting the rules

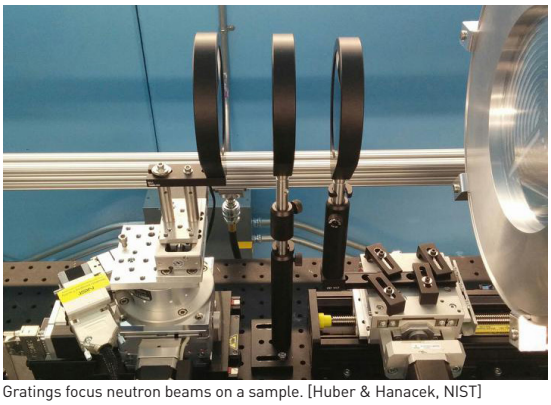
In his definitive 1949 paper on diffraction gratings, George Harrison, MIT, USA, wrote that "no single tool has contributed more to the progress of modern physics than the diffraction grating, especially in its reflecting form." Harrison invented the echelle spectrograph in 1949 and was the first to design a practical ruling engine, which was equipped with an interferometric position control. Thanks to this new method, and the development of high-fidelity replication processes, a range of high-quality gratings hit the market in the 1950s.

1967: Holographic gratings

Rather than the mechanical process used for ruled gratings, holographic gratings are produced using an optical process where an interference pattern is generated to expose a photoresist surface. With this method, groove form and spacing are extremely uniform, so the gratings produce less stray light. With the invention of lasers in 1960, two pairs of researchers, one in Germany and one in France, were able to craft holographic plane gratings suitable for spectroscopy before the end of the decade.

Beyond Spectroscopy

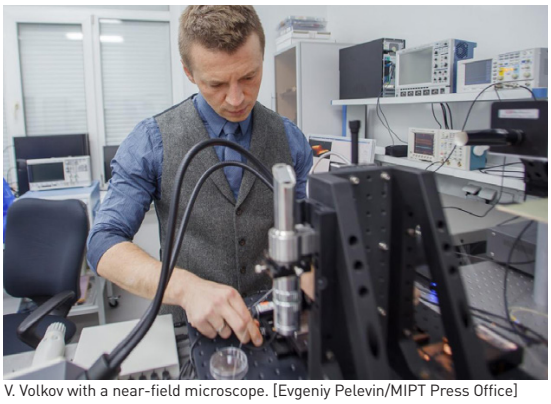
Today, diffraction gratings are ubiquitous—a fairly simple yet important optical element used in countless applications, from astronomical imaging to atomic physics.



Gratings focus neutron beams on a sample. [Huber & Hanacek, NIST]

2018: Diffracting neutron beams

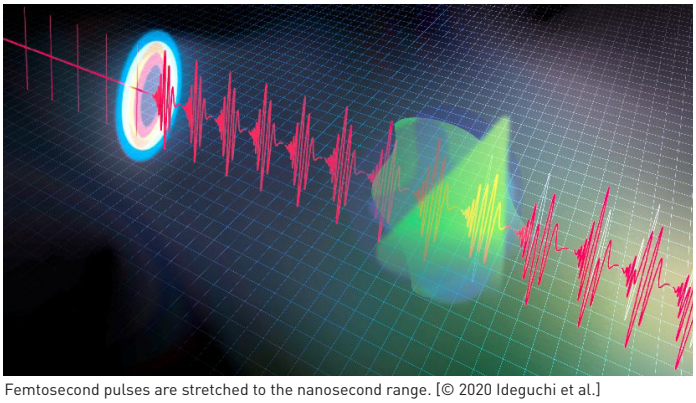
A team has designed silicon lenses that act as diffraction gratings not for light but for neutrons, enabling a three phase-grating moiré neutron interferometer. The lenses split and redirect a neutron beam so the waves bounce off an object and collide with each other, resulting in an interpretable interference pattern. The technique can be used to scan thick objects, which could benefit materials science.



V. Volkov with a near-field microscope. [Evgeniy Pelevin/MIPT Press Office]

2020: Superlens compresses light

A group of Russian and Danish researchers experimentally observed a plasmon nanojet for the first time—a step toward realizing the densely packed optical components needed for future optical and plasmonic devices. The superlens—which enables nanoscale focusing of light—works by shining a laser onto a diffraction grating in a gold film, compressing the beam into more manageable electromagnetic oscillations.



Femtosecond pulses are stretched to the nanosecond range. [© 2020 Ideguchi et al.]

2020: Faster IR spectroscopy

In Japan, researchers stretched light to develop what they say is the world's fastest infrared spectrometer, extending a short pulse of mid-IR light to detect and analyze spectra around 100 times faster than is possible with other technology. After an MIR pulse passes through a sample, it is time-stretched in a diffraction grating and mirror-based system before the pulse is picked up and analyzed by a quantum cascade detector. The system could move the ball toward high-speed continuous measurement of nonrepeating phenomena.

A spectrum of applications

Diffraction gratings are a basic building block for novel, complex devices, and they continue to enable impressive optical and engineering advances. One can find them in the spectrographs orbiting Earth in satellites, capturing and analyzing stellar spectra. They're also used in cutting-edge lasers for wavelength selection and pulse compression. And in modern telecom, gratings help to manage the signals traveling through optical fibers by separating the individual wavelengths.

For a list of references and further resources on diffraction gratings, go online: **www.osa-opn.org/then-now/gratings**.