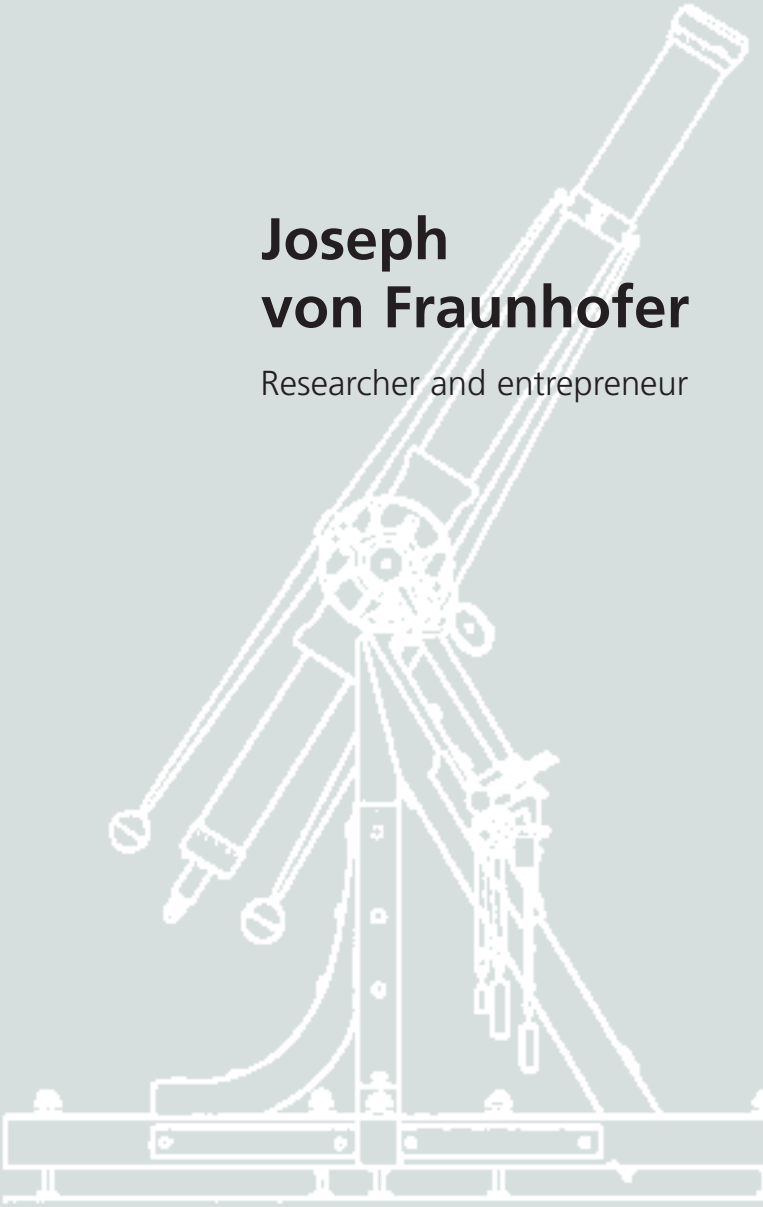
Fraunhofer Gesellschaft

Joseph von Fraunhofer

Researcher and entrepreneur



Joseph von Fraunhofer belongs to that exclusive circle of researchers whose names have been immortilized in the scientific vocabulary. The dark "Fraunhofer lines" in the emission spectrum of the Sun and "Fraunhofer diffraction" are familiar terms to any student of physics or optics. Fraunhofer attained worldwide recognition as a scientist despite the fact that his formal education only extended to a glassmaking apprenticeship, and even though he died at the early age of 39.

Joseph von Fraunhofer's pioneering investigations into various phenomena of optical physics led to discoveries of fundamental significance to this area of technology, and these are still a standard reference today. But his work was not restricted to scientific experimentation and observation: He also made his mark as an innovative entrepreneur and practical inventor. The improvements introduced by Fraunhofer to the manufacturing of glass and optical instruments not only served as a source of inspiration for his scientific research but also brought him commercial success. During his time as manager of the glassworks in Benediktbeuern, he introduced modern production techniques that transformed his place of work into a highly profitable enterprise.

Joseph von Fraunhofer dedicated his life to research of practical utility. That is why the founders of the Fraunhofer-Gesellschaft chose to incorporate his name in that of their organization. It is our declared aim to serve science and industry by emulating his example.

Prof. Dr. Hans-Jörg Bullinger
President of the Fraunhofer-Gesellschaft

Joseph von Fraunhofer – from apprentice to celebrated scientist

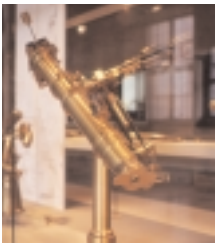
Joseph von Fraunhofer (1787–1826).

There was little indication at the beginning of his career that Fraunhofer would one day be so extraordinarily successful. Born in 1787, he lost both parents at the age of twelve. He was physically not strong enough to become a wood turner, as he originally intended, and instead followed in his father's footsteps as an apprentice glassmaker. But the master-glassmaker who took him on, Philipp Anton Weichselberger, would not allow the young knowledge-thirsty Fraunhofer to read books or to attend school on his free days.

This situation only changed thanks to a favorable turn of fate: When Weichselberger's house collapsed in 1801, Fraunhofer was rescued from the ruins after many hours. The event brought him into contact with the Prince Elector Max IV Joseph, and thereafter with the entrepreneur Joseph von Utzschneider. This unexpected entry into the public limelight gave a tremendous boost to Fraunhofer's possibilities for personal development. From this point onwards, he was allowed to attend school and received instruction in the craft of lens-grinding. It was not long before he was recommended to the renowned inventor and designer Georg von Reichenbach, who employed Fraunhofer as an optician in his workshop, in which Utzschneider was also a partner.

Fraunhofer's talent and determination were immediately evident. Reichenbach and Utzschneider thus appointed him at the very early age of 22 to head of the glass works in Benediktbeuern, which belonged to their company. His work on the development of new types of glass, his decisive improvements in glass production and in perfecting the manufacture of optical instruments, led to remarkable results. Fraunhofer succeeded in establishing standardized production methods, while substantially extending the workshop's product range and thereby boosting the company's commercial success. Its products included telescopes, binoculars, microscopes, magnifying glasses and astronomical telescopes – all produced to then unmatched standards of quality. Fraunhofer's instruments were sold and put to use throughout Europe.

Telescopes.



Refractor (astronomical telescope).

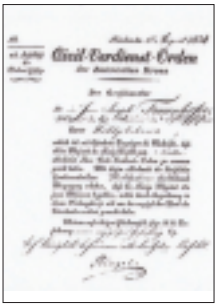
Spectrometer.

Fraunhofer presents his spectrometer.

Instruments he himself developed, moreover, proved themselves indispensable to his own pioneering scientific work. His spectrometer enabled him to investigate sunlight and other sources of light with extraordinary precision; the diffraction gratings he constructed made it possible to analyze the phenomenon of light diffraction and to describe its effects on the manufacture of optical instruments.

Fraunhofer achieved national and international fame and won many honors for his unmatched optical instruments and scientific accomplishments. Leading scientists and politicians of the time visited him at the works where his ideas took shape. These notables included the physicist Carl Friedrich Gauss, Max I Joseph, King of Bavaria, and – it is widely believed – the Czar of Russia, Alexander I.

As a result of his scientific renown, against initial resistance on the part of established scientists, Fraunhofer was elected a full member of the Academy of Sciences. The King of Bavaria made him a Knight of the Order of Civilian Service, thus raising him in status to one of the nobility. Joseph von Fraunhofer died of tuberculosis in 1826, at the age of 39.



Researcher and entrepreneur – Fraunhofer's outstanding achievements

Fraunhofer is regarded as the founder of scientific methodology in the sphere of optics and precision mechanics, as the first German exponent of precision optics, and as an equally successful entrepreneur.

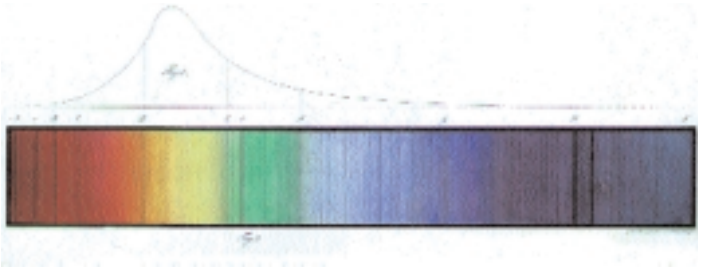
After joining the Mathematical-Mechanical Institute owned by Reichenbach and Utzschneider, Fraunhofer's first efforts at this company's glassworks in Bedediktbeuern focused on improvements to the quality of glass. He conducted precisely documented experiments with altered raw materials and modified melting processes, thus enabling the manufacture of glass without streaks. At the same time, he standardized the processing of finished glass – an absolute innovation at the time – and thereby made the final result independent of the respective skill of the individual lens-grinder.

The historical glassworks in Benediktbeuern with glass furnace.

Built to Fraunhofer's designs: the 9-inch refractor in the Deutsches Museum, Munich.

His precise knowledge on the diffraction characteristics and color dispersion of different types of glass helped Fraunhofer to design exceptionally large achromatic telescopes. This led to a completely new generation of astronomic refraction instruments. These employed lens diameters and generated images of a quality that until then had been considered impossible. The optical quality of these telescopes remained unsurpassed for many decades to follow, and enabled dramatic new astronomical discoveries. Fraunhofer's heliometer, for example, enabled the astronomer and mathematician Friedrich Wilhelm Bessel to determine a fixed-star parallax for the first time, in 1883. Fraunhofer's most famous instrument is the parallactic refractor he constructed for the Imperial Russian Observatory in Dorpat. An identical 9-inch refractor, on exhibit today in the Deutsches Museum in Munich, led the astronomer Johann Gottfried Galle to discover the planet Neptune in 1846.

The new optical instruments developed by Fraunhofer were also of crucial significance in his own research work. Prisms which he made allowed him to investigate the spectrum of visible light. Other scientists before him had already noted dark strips in the spectrum of sunlight, but it was Fraunhofer who first ascertained that these strips – known today as Fraunhofer lines – were an inherent property of sunlight. His fundamental research work on the spectral composition of light from various sources made Fraunhofer one of the founding fathers of modern spectral analysis.



The spectrum of sunlight drawn by Fraunhofer.

Fraunhofer's studies of the diffraction of light represented a further milestone in his scientific career. Using a diamond, he constructed a diffraction grating with grooves spaced only 0.003 millimeters apart. This enabled him to measure the wavelength of light of various colors with extraordinary precision.

Scientific research and practical applications were mutual and complementary stimuli in all of Fraunhofer's work. The discovery and descriptive analysis of the absorption lines in the spectrum of sunlight, for example, allowed the diffraction characteristics of individual varieties of glass to be determined with high precision. Analysis of diffraction was of immediate practical value in the construction of improved telescopes. Fraunhofer knew how the insights gained through experiment could subsequently be utilized in products and processes. The advances he achieved in the manufacture of optical instruments at the same time laid the basis for renewed success in his scientific research. In this way, Joseph von Fraunhofer was one of the true founders of modern application-oriented research.

Diffraction light effects.

Fraunhofer's legacy – optics in science and technology today

Joseph von Fraunhofer's fundamental and systematic research has had a lasting influence on optics. His accomplishments are still of great relevance today, since optical systems are a widespread and meanwhile essential part of our modern world.

This is most clearly apparent in the sphere of information and communications technology. Data transmission via glass fiber represents a vast improvement in performance over the earlier copper cables, and a great deal more information can be stored and accessed on optical data carriers employing R/W lasers than on any other medium. The rapid growth of the Internet makes it clear that optical systems are essential to being able to keep pace with the volume of data stored and transmitted every day. In fact, the wide spectrum of media we are accustomed to today has only become possible through the use of optical data systems.

The CD as an optical storage medium for data.

Processing of a workpiece by laser.

Laser-supported milling.

Light has become a universal tool in science and industry. When concentrated in the form of a laser beam, it can be used to process materials and components. Powerful laser generators allow several meters of sheet steel to be cut per second; the ability to control laser beams precisely, on the other hand, is an essential part of being able to put them to use for data storage or in laser printing.

Optical processes are playing an ever-greater role in measurement technology. With the help of lasers, even the tiniest impurities in the atmosphere several kilometers above the Earth can be detected and diagnosed. Spectral analysis, which in part owes its development to basic principles laid down by Joseph von Fraunhofer, is now a standard procedure in modern laboratory work.

In microelectronics, too, another key technology, optics plays an essential part. Integrated circuits involve the exposure of photosensitive materials to light prior to their chemical processing. The transmission of electrical and optical signals is crucial to the development of modern microsystems.

A micro-optical lens.

Light-emitting diodes in all colors open up new fields of application.

Many modern medical procedures would no longer be conceivable without optical systems. Laser surgery is developing into a preferred technology and advanced optical endoscopes are essential in minimally invasive surgery. Micro-optical analysis devices no larger than a wrist watch allow permanent monitoring of a patient's physiological data.

Innovative sources of light introduce a new dimension to optical technology. Light-emitting diodes and diode lasers are now set to supplant conventional light sources in applications that include monitor screens, light signals, and lighting for rooms and vehicle interiors. Their long life, low price and reduced energy consumption herald a breakthrough for these new sources of light.

Joseph von Fraunhofer's legacy lives on. He gave a decisive stimulus in his time to the rapid development of optics that continues to this day.

Optical testing of a lens.

The concept of applied research – the Fraunhofer-Gesellschaft

However eager he may have been to further the cause of science, Fraunhofer never lost sight of his true objective: to implement his developments in products of practical utility. This principle has also been adopted by the Fraunhofer-Gesellschaft, one of the largest organizations of applied research in the world.

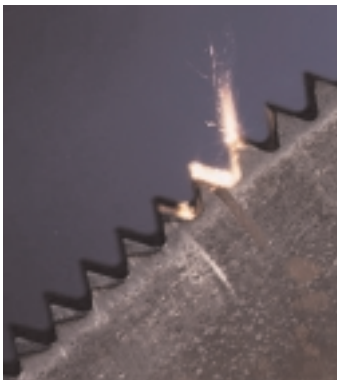
The Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. Its services are solicited by customers and contractual partners in industry, the service sector and public administration.

By developing technological innovations and novel systems solutions for their customers, the Fraunhofer Institutes help to reinforce the competitive strength of the economy in their local region, and throughout Germany and Europe. Through their work, they aim to promote the successful economic development of our industrial society, with particular regard for social welfare and environmental compatibility.

As an employer, the Fraunhofer-Gesellschaft offers a platform that enables its staff to develop the professional and personal skills that will allow them to take up positions of responsibility within their institute, in other scientific domains, in industry and in society.

The globalization of industry and science makes international collaboration imperative. Affiliated research centers and representative offices in Europe, the USA and Asia provide contact with the regions of greatest importance to future scientific progress and economic development.

At present, the Fraunhofer-Gesellschaft maintains roughly 80 research units, including 58 Fraunhofer Institutes, at over 40 different locations in Germany. A staff of some 12,500, predominantly qualified scientists and engineers, work with an annual research budget of over 1 billion euros.



Hardening by laser light.

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