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Onera, pioneer and leader in laser applications, supports "Year of the Laser" in France

The laser was invented 50 years ago, in 1960. To celebrate this landmark anniversary, France launched the "Year of the Laser" at the Palais de la Découverte science and technology museum in Paris on January 7. Since its creation, the laser has revolutionized a number of sectors, especially metrology, or the art of measurement, leading to the development of a host of applications in aerospace and other sectors. Onera, the leading French aerospace research center, has focused on increasing the power and reducing the size of lasers since the outset, contributing to a continuous increase in performance and the scope of applications. Today, Onera is one of the world leaders in lasers, a cutting-edge technology that still harbors a world of potential.

Onera: 50 years of laser research to enhance measurement capabilities

Charles Townes, Theodore Mainman and other pioneers in the United States began developing the "LASER" (light amplification by stimulated emission of radiation) in about 1960, with initial applications targeting the defense and space sectors. Charles Townes was awarded the 1964 Nobel Prize in Physics (along with two Russians, Basov and Prokhorov). That same year Onera acquired its first laser, becoming one of the pioneers in the development of this technology. Jean-Pierre Taran, a research engineer at the time and now High Scientific Advisor to Onera, worked with Townes in the United States for two years. After returning to France, in 1969 he began to build and operate a number of innovative laser-based measurement instruments.

Why did he choose the laser? Because it offers exceptional measurement performance for aerospace applications. In particular, it helps improve the performance and lower the emissions of aircraft engines, detects air movements and turbulence, and improves pilot vision under difficult weather conditions.

Since the outset, Onera has worked on improving lasers (power, directivity, miniaturization, etc.) and expanding the scope of applications. It has been very successful in this endeavor, increasing the power of certain lasers 100-fold, while reducing their size by a comparable amount, all in the space of a few years.

As early as 1970, Onera produced its first ruby lasers for the visualization of airflows, as well as monomode CO_2 lasers to detect air turbulence in clear skies, a very uncomfortable situation for commercial airline passengers. In 1973 Onera participated in the development of the first tunable dye lasers, whose wavelength can be adapted to each gas to be measured. Thanks to this invention, a test setup can analyze, in real time, the chemical composition of fuels during the combustion process, leading to improved aircraft engine performance and reduced polluting emissions.

This type of laser was a big hit, and Onera transferred its technology to specialized firms such as Sopra and Quantel. “There are three successive generations of tunable lasers,” notes Emmanuel Rosencher, scientific director of Onera’s Physics branch, research director and professor at the prestigious Ecole Polytechnique. “The ‘grandfather’ was the dye laser. The ‘father’ is the optical parametric oscillator, or OPO, a compact, robust and energy-efficient device. The ‘son’ is the ‘frequency comb laser’, developed this century, a technology that can produce millions of different laser frequencies to a very high degree of spectral precision, using compact lasers.”

Onera was a key player in the development of very high power lasers for a wide range of applications, including defense and semiconductors. The center’s labs have worked on a variety of technologies, including chemical, discharge and combustion lasers, as well as adaptive optics, which improve laser directivity.

Current developments

Onera also uses lasers to measure airflow speeds, in particular the turbulence generated by aircraft. While in flight, aircraft create “air pockets” that may be dangerous for other aircraft. We have to better understand this type of turbulence if we are to reduce the distance between aircraft in total safety, thereby increasing the frequency of takeoffs. For instance, Onera has optimized “Lidar” technology for aviation applications. Operating like a radar, but using light instead of radio waves, Lidars can be used to analyze the speed of aerosols, or particles suspended in the atmosphere.

Onera is also developing short light pulse lasers to illuminate scenes and allow pilots to see through fog or thick smoke – a technique called “active imaging”. Just recently, for example, an Onera team in Toulouse demonstrated the feasibility of femtosecond lasers (very powerful machines with very short pulse lengths of several billionths of a millisecond), which can “see” through a highly opaque environment comprising a dense suspension of spheres in water.

In addition, Onera has enhanced optical parametric oscillators by designing new materials and new optical architectures.

Over the last few years Onera has also developed fiber-optic lasers, which combine very high power and ease of use. Onera calls on off-the-shelf optical components developed for telecom applications, which will enable the installation of vortex detection systems at all airports.

Looking ahead

Onera continues to apply its expertise to laser technology. It is working on even further miniaturization, so that lasers can be mounted on all aircraft and enable pilots to detect and avoid previously invisible – and very dangerous – turbulence.

Onera is also pursuing research to expand the scope of laser applications outside of aerospace, in the energy sector for example. Onera recently teamed up with the company Leosphere to study wind fields and increase the efficiency of wind turbines. An Onera researcher was named R&D director of Leosphere in June 2008, to oversee the commercialization of Onera’s “wind Lidar” technology, originally developed for the aerospace

industry. This technology, used to measure atmospheric wind speeds, is based on the projection of a laser beam and the analysis of the light radiation reflected back by the environment under study. “We have made amazing progress in visualizing these vortices,” says a delighted Emmanuel Rosencher. “Before, we needed very heavy, dedicated lasers. Today, we’re using optical components developed for the telecom industry, which will enable us to install vortex detection system at every airport, and even in all airplanes.”

About Onera

Onera is the leading aerospace and defense research organization in France. A public establishment created in 1946, it reports to the French Ministry of Defense. Onera has over 2,000 employees at eight major facilities, including 1,500 scientists, engineers and technicians. Building on its multidisciplinary expertise and a world-class fleet of test facilities, Onera works for both government and industry, spanning major corporations and small businesses. Onera deploys an innovative partnership-based approach to research, with five times more contract business per researcher than the average in France. In 2008, Onera had revenues of 202 million euros. Onera is a recognized source of innovative solutions, technical expertise and long-term design vision, paving the way for tomorrow’s programs. Onera has contributed to some of today’s most successful aerospace and defense programs, including the Ariane 5 launcher, Airbus jetliners, Eurocopter helicopters, the Rafale fighter and the Falcon 7X business jet.

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