News from the webb

On December 25th 2021, the largest space telescope ever built was launched from Kourou on Ariane 5. After receiving this wonderful Christmas gift, astronomers around the world are now eagerly awaiting the first observations of the Webb telescope.

After receiving this wonderful Christmas gift, astronomers around the world are now eagerly awaiting the first observations of the Webb telescope. However, unlike most of its predecessors, the Webb telescope was not optically operational after its launch. Six months have been planned to bring the Webb into its full scientific capabilities. As of April 1st 2022, no big issues have arisen and all optical parameters that have been checked and tested are performing at the level, or above, of the expectations. Below is a summary of the milestones that have been achieved since the launch:

On Jan 4 2022, the deployment of the five-layered sunshield that protects the telescope from the light and heat of the Sun, Earth, and Moon was successful. This crucial step took 7 days with the unfolding and tensioning of the five thin plastic sheets coated to reduce the solar power received by the telescope by a factor of about one million. The 74 cm secondary mirror was then deployed at 7 m in front of the primary mirror, which was still folded at that time. The telescope was fully deployed on January 8 when the two folded wings of the primary mirror were opened out. The Webb Space Telescope reached its desired orbit, nearly 1.5 million kilometers away from the Earth at the second Sun-Earth Lagrange point on January 24.

While the telescope and instruments were still cooling down, alignment of the telescope started in mid-January and underwent a series of steps to get each individual segment aligned and cophased.

After moving the 7 actuators of each segment of the primary mirror to their flight position, the next step was to identify the 18 images of a star given by each segments using the NIRCam instrument. After repositioning them in a hexagonal pattern (Image 1), each individual image diffracted by a segment is focused by updating the alignment of the secondary mirror and optimizing the positions of the mirror segments using their actuators.

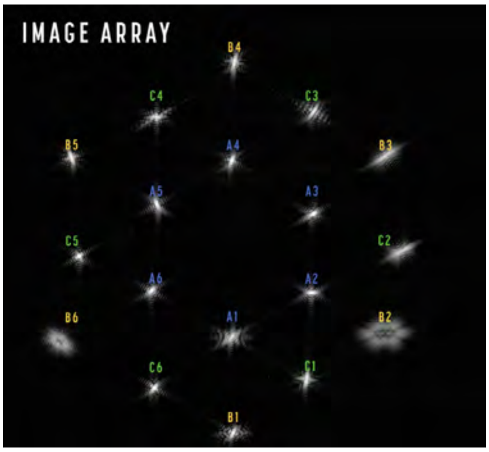

Figure 1: Diffraction image of the same star by each of the 18 segments of the primary mirror. The segments are tilted to create a hexagonal grid on the NIRCam instrument. Each image is labelled with the corresponding mirror segment that captured it. Credits: NASA/STScI/J. DePasquale. https://blogs.nasa.gov/webb/2022/02/18/webb-team-brings-18-dots-of-starlight-into-hexagonal-formation/

After superimposing the 18 images on top of each other, the segments still required to be co-phased with each other by following two steps:

1) Dispersed fringe spectra recorded on NIRCam from 20 separate pairings of mirror segments allow a coarse correction of the vertical displacement (piston difference) between the segments.

2) A fine correction is applied based on the estimation calculated by phase retrieval algorithms using defocused images.

This alignment stage was completed on March 11 with the release of a first image (Image 2) showing the diffraction-limited image of an alignment star and already plenty of small galaxies in the background...

Early April, this was completed with the alignment of other Webb instruments: the Fine Guidance Sensor (FGS), the Near-Infrared Slitless Spectrograph (NIRISS), and the Near-Infrared Spectrometer (NIRSpec). The Mid-Infrared Instrument (MIRI) continues its cooling and should soon reach its cryogenic operating temperature (7K). A second multi-instrument alignment will then be carried out to finalize adjustments of the instruments and mirrors.

The instruments will be tested in their different observation modes, to make sure that they are ready for scientific observations. Before the end of this commissioning phase, a few observations will be made. Once processed, they will provide the very first images available to researchers and public illustrating the capabilities of the James Webb Space Telescope. Where Webb will look first has not yet been disclosed but stay tune... The images will probably be spectacular !

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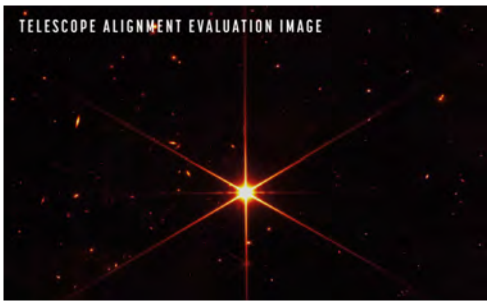
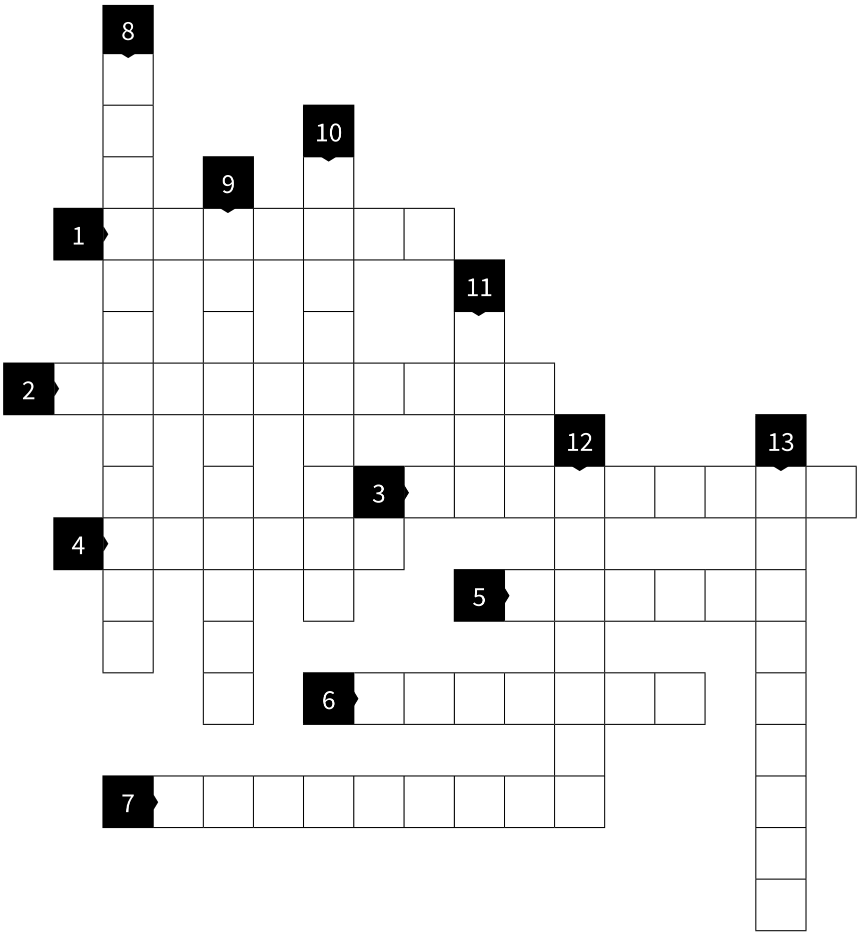


Figure 2: First diffraction-limited NIRCAM image released. Hundreds of galaxies can already be detected in this image. © Nasa. https://www.nasa.gov/press-release/nasa-s-webb-reaches-alignment-milestone-optics-working-successfully.

CROSSWORDS
ON OPTICAL FREQUENCY COMBS

By Philippe Adam



1 Its phase has to be compared with envelope
2 Needed mode to generate frequency combs
3 Interval precisely equal to the repetition rate
4 Spanning music
5 2005 Nobel Prize in Physics
6 Used to measure unknown frequencies
7 Straightforward application of FC
8 Very straightforward application of FC
9 Separation frequency between two modes
10 Long wavelength today produced by photonic chips
11 Nonlinear effect which could induce FC in micro-resonators
12 Efficient (or finesse) factor
13 Transmitted from pulse to pulse

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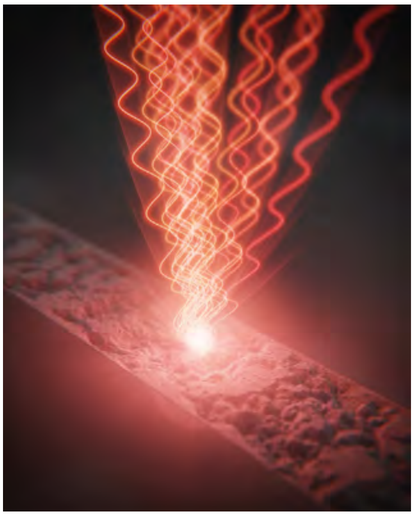
Electrically driven random lasers

Random lasers (RLs) are intriguing devices that attract the interest of researchers for the varied phenomena they present in areas such as complexity, chaos etc.

But they also have a practical aspect with promising applications as light sources for illumination in microscopy, sensing, super-resolution spectral analysis, or complex network engineering. RLs usually require two material components associated with the amplification (gain) and feedback (light diffusion) processes inherent to lasing. Thus, they have been customarily obtained from optically pumped organic dyes, optical fibers and crystals powders, or electrically pumped semiconductor heterostructures. Semiconductor RLs are usually manufactured by introducing light-diffusing defects in the active layer, something that adds a degree of complexity to the manufacturing process and spoils the ease of realization potentially offered by messy structures. The direct availability of electrically pumped RLs, avoiding an involved and expensive manufacturing process, could crush the principal hurdle to their use in research and technology.

A team of researchers at ICMM (CSIC), in Madrid realized a procedure to manufacture a semiconductor RL from an off-the-shelf laser diode. The fabrication simply uses the high energy pulses from an ablating laser to sculpt the output mirror to create submicrometric roughness. The optical feedback provided by the ablated front mirror in combination with the intact rear mirror results in strong modification of the cavity modes and leads to laser emission with a random multimode spectrum. This in turn lowers the spatial coherence and messes the angular pattern. The speckle, characteristic of highly coherent light sources, is here strongly reduced.



REFERENCE
A. Consoli, N. Caselli, and C. López, "Electrically driven random lasing from a modified Fabry–Pérot laser diode," Nat. Photonics 16, 219–225 (2022).

Brillouin light amplification in silica nanofiber gas cell

Brillouin scattering in optical waveguides draws plenty of attentions since it has been widely exploited for various important applications, such as microwave photonics, highly coherent fibre laser, and distributed fibre sensor. EPFL scientists, in collaboration with FEMTO-ST Institute, have achieved a huge amplification of light over a few centimetre with tapered silica optical fiber surrounding by high pressure gas. The strong Brillouin gain in the evanescent field together with the high tunability offered by the gaz (gaz type and pression), makes the integrated Brillouin amplifier very distinct compared to its solid material counterpart. They research team has demonstrated a 79-times higher peak Brillouin gain coefficient in the nanofibre gas cell with 57 Bar of $C0_2$ compared to that in a standard single-mode fibre.

Yang, F, *et al.* "Large evanescently-induced Brillouin scattering at the surrounding of a nanofibre" Nat. Comm. **13**, 1432 (2022). https://doi.org/10.1038/s41467-022-29051-8

ADVERTORIAL

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Michael Mei, Menlo Systems

Menlo Systems recently celebrated its 20th anniversary. *What were your initial motivations for creating a new company in the field of optics and photonics? What have been the main steps in terms of growth and development?*

In the 1990s, Prof. Theodor Hänsch's group at the Max-Planck Institute of Quantum Optics performed precision measurements on the hydrogen atom, but rapidly the possibilities to measure the wavelengths were exhausted. Frequency measurement, on the other hand, was an almost impossible undertaking. This changed with the invention of the optical frequency comb technology: an approach involving the measurement of optical frequencies using the comb spectrum of a mode-locked femtosecond laser.

In 2005, Theodor Hänsch and John Hall were awarded the Nobel Prize in Physics for their contributions to the development of high-precision laser spectroscopy, including frequency comb technology.

Already in 2001, Theodor Hänsch, Ronald Holzwarth and myself had founded Menlo Systems GmbH with the mission to commercialize the frequency comb technology. Today, Menlo Systems is one of the market leaders in high-precision measurement technology and employs over 160 people worldwide.

INNOVATION & TECHNOLOGY

Can you describe the core of your technology? What are the main scientific fields of application of your products?

By means of mode-locked femtosecond lasers, we were able to create frequency combs that could be used like a ruler to directly measure optical frequencies. The progress was enormous: previously, equipment filling a whole laboratory was required to measure a single optical frequency, whereas now we had a setup of approx. 1m^2 with which we could measure any frequency. This was a quantum leap for many applications. The first optical frequency combs were rather sensitive instruments, but over the years the technology has matured, and optical frequency combs nowadays are turn-key fiber-based laser systems designed for 24/7 operation.

Can you comment on the impact of optical frequency combs on science and technology?

The impact of optical frequency combs on science and technology can hardly be overestimated. While some of the early adopters predicted limited applications in traditional high-resolution spectroscopy only, over the course of the last 20 years the field of applications has widened and optical frequency combs are regarded as key enabling tools for many applications from optical clocks, quantum sensing and quantum computing, to detecting exoplanets in astronomy, and offering unmatched accuracies for tasks in industrial metrology.

MARKET & STRATEGY

Are you focusing your sales efforts in Europe or worldwide?

Menlo products all have in common that the optimal use is in applications where precision counts. From the very beginning we had customers from all over the world. From our headquarters in Martinsried, close to Munich, we serve the German and most of the European market, supported by local experts in selected countries like our regional sales engineer located in Bordeaux. In the US, China, and Japan we have sales and service offices, with the aim to be close to the applications and to our customers.

Is Europe a great place for photonics?

Europe has a long tradition in photonics. Many scientific discoveries and inventions have been made by its excellent scientists. The industry benefits from the continuous stream of graduates out of highly-ranked universities. In France, there are around 200 science labs with 13.000 scientists, and about 1000 companies with 50.000 jobs in optics and photonics (according to the French trade association AFOP). In Germany, the situation is excellent as well. So yes, we consider Europe a great place for photonics, with France and Germany both playing an important role.

How do you evaluate the evolution of photonics? How to increase the spread of photonic technologies and strengthen the companies and market?

With new strategic plans for quantum technologies in place we are observing the creation of several new companies and research projects with innovative quantum applications and technologies. In France, Menlo Systems already supports these initiatives by unlocking access to better laser metrology with optical frequency combs, and by providing customizable laser systems for demanding quantum applications. Menlo Systems will keep working closely with French actors of quantum technology to support this ambitious national plan.

VISION & PERSPECTIVES

How do you imagine the next 20 years for your company and for photonics? Have you identified promising scientific areas for photonic technologies?

Taking the optical frequency comb as an example, the evolution of scientific areas has rapidly grown from precision spectroscopy to very diverse fields including precision metrology, optical atomic clocks, astronomy, space applications, and the quantum technologies. We are convinced that we currently only see the tip of the iceberg. By means of integrated optics and chip based optical frequency combs our vision is that advanced spectroscopic tools will become available with any smartphone in 20 years from now.

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