European Satellite Technology Covers China in Dragon Program

The Dragon program, a new bilateral collaboration between the European Space Agency (ESA; Paris, France) and the Chinese Ministry of Science and Technology (MOST; Beijing, China), will exploit European remote sensing space-borne resources to assist China with land and resources management while fostering increased scientific cooperation between Europe and China.

“There are a multitude of issues where Earth observation has the potential to aid Chinese management of the territory they deal with, including development planning and resource mapping,” explains professor Jose Achache, ESA director for Earth observations programs. Thematic areas covered in the program include rice monitoring, forest mapping, water resource assessment, flood forecasting, and air quality measurements. China covers about 9.6 million square miles, ranging from the Himalayas to tropical lowlands. Zhang Guocheng, deputy director-general of the National Remote Sensing Center of China (Beijing, China), is also optimistic about the opportunities in the Dragon program. “Remote sensing technology has a wide range of potential applications, including evaluating resources and responding to natural disasters,” he says.

The program will utilize the Envisat and European Remote Sensing (ERS) satellites in targeted investigations covering terrestrial, oceanographic, and atmospheric topics. Envisat includes the medium-resolution imaging spectrometer (MERIS) that can study coastal zones by measuring the solar radiation reflected from the Earth’s surface and from clouds in the visible and near-IR range from 390 nm to 1040 nm. This is a push-broom-style instrument that collects an image of the Earth’s surface that is 1150-km wide, using five identical cameras focused onto the entrance slit of an optical grating spectrometer. The entrance slit is imaged through the spectrometer onto a 2-D CCD array, which provides spatial and spectral information simultaneously. Data will be processed on the ground to generate large-scale maps of things like vegetation status and distribution, coastal water monitoring, and phytoplankton biomass production.

Envisat’s Advanced Synthetic Aperture Radar (ASAR), which compliments the SAR systems onboard the two ERS satellites, is a high resolution, wide swath, imaging radar technique that can monitor environmental issues such as deforestation, disaster monitoring of floods and earthquakes, wetlands, and land surface properties. The primary advantage of this instrument is the ability to take images independent of weather conditions. This is critical during severe weather disasters or during key parts of the agricultural season. “The probability of acquiring cloud-free optical remote sensing data is only about 1% during the crop-growing season in Southern China,” says professor Tan Bingxiang of the Chinese Academy of Forestry (Beijing, China). “This makes it very difficult to carry out real-time monitoring of crop growth and estimate rice yields.” The SAR systems on ERS-1 and ERS-2 will enable Synthetic Aperture Radar Interferometry, which involves combining two or more radar images of the same spot to provide very precise ground measurements.

These capabilities and more are part of the Dragon program, which was kicked off by more than 100 leading European and Chinese scientists in late April. The size of China makes satellites particularly useful due to their large coverage areas and abundance of useful data. China is home to one in five humans and is the world’s fastest growing economy. Through this association with China, the ESA hopes to improve the life of a large segment of the world’s population. —Michael Brownell

Femtosecond Shockwave Isolates Single Cells for Researchers

Laser trapping has been shown as a nondestructive way to manipulate individual cells, but what if the cell is still attached to living tissue? Creating enough laser power to disassociate the cell from the tissue sample can lead to overheating of the tissue and cellular death. A recent experiment highlighting the nonlinear effects caused by intense ultra-short laser pulses on biological material has led to the discovery of a new nondestructive optical method to isolate single cells from living tissue without damaging the cell from excess pressure or heat.
A team of researchers from Osaka University (Osaka, Japan), Kyoto University (Kyoto, Japan), and Japan Science and Technology Agency (Saitama, Japan) used shockwaves produced in culture media by nonlinear absorption of femtosecond laser pulses to disassociate single mouse cells from a prepared matrix.

The team’s setup included a 20-Hz regeneratively amplified Ti:Sapphire laser with a center wavelength of 800 nm and a pulse duration of 120 fs connected to a microscope’s optical port. “For our biological cells, we chose mouse NIH3T3 fibroblasts,” says group spokesman Yoichiroh Hosokawa. “We plated them onto plastic coverslips coated with type-I collagen, and cultured them in a Dulbecco’s modification of Eagle’s medium (DMEM) containing 5% fetal bovine serum at 37°C.” During the experiment, the chamber plate holding the cultured coverslips was also kept at 37°C, with a Peltier element and temperature controller. The team monitored cell appearance and locomotion via a CCD camera.

“Cells attach [to each other] with arms and legs called lamellipodia and filopodia,” explains Hosokawa. “So to move a single cell, its ‘podia must be severed. To do that, we gave each one a single laser shot of 0.26-μJ pulse energy.” The shots caused the cell’s filopodia to contract, but the cell did not exhibit the random motion expected of small particles suspended in gas or liquid (Brownian motion)—in other words, the cell body was still attached.

The team then upped the laser pulse energy to 0.51 µJ, focused 20 µm from the ventral side of the cell, and fired. The laser shot’s shockwave pushed the cell away, causing the cell to voluntarily detach from the matrix. The team was

**EYE on technology**

**PLANET EXPLORATION**

**NASA Expands Search for Planets beyond our Solar System**

The Bush administration’s new vision for space exploration is setting the pace for the National Aeronautic Space Agency’s (NASA; Washington, D.C.) activities well into the next decade. NASA recently announced plans to search for life beyond our solar system by backing two multibillion-dollar missions, where each associated spacecraft is tasked with searching for Earth-sized planets in nearby habitable zones, and obtaining spectra to detect biomarkers such as methane or oxygen. NASA and the European Space Agency (ESA; Paris, France) will collaborate to launch these respective missions—terrestrial planet finder and Darwin—before 2020, and it is anticipated that both missions could be combined in the future for a launch as early as 2015.

ESA’s Darwin mission concept calls for a multispacecraft system carrying a free-flying interferometer that exploits the wave nature of light in order to uncover and analyze the faint light emanating from exoplanets. Light collected by several telescope mirrors flying in formation is combined to form a single IR image, while the distance between the mirrors helps to eliminate glare from the central star and capture light coming from an angle, which could represent a planet.

In addition to free-flying interferometers, NASA is investigating a single-spacecraft interferometer with several mirrors arrayed along a truss. As a viable alternative, an optical light coronagraph may also be employed to block light from a bright star in order to detect faint, nearby objects. The occluding spot is placed at the focal plane of the telescope and prevents light from striking any optical elements further down in the optical path. The removal of the diffraction pattern is a major advantage when trying to image faint sources near a bright star. Monitoring both the visible and IR spectra increases the probability and reliability of identifying planets outside our solar system. NASA’s current plans call for the creation and launch of the smaller coronagraph by 2014, followed by the free-flying interferometer several years later. —Phillip Espinasse
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able to observe the Brownian motion of an isolated cell and determine that the cell was not damaged. A few hours after it detached, the cell regenerated its filopodia and once again adhered to the matrix. The team used a dye exclusion test to confirm the cell’s viability.

Shockwave pressure is key to any damage to the living cell. Hosokawa says the force in nanonewtons of the shockwave, \( F_0 \), can be estimated as a function of the pulse energy of the laser, \( I \), in microjoules. The relevant equation, an experimentally determined law, is:

\[
F_0 = 6.99 \times 10^{-3} \times I^{2.17}
\]

The team assumes that \( F_0 \) propagates uniformly in all directions from the laser focal point. That means the shockwave pressure, \( p \), at the distance the cell is from the laser focal point, \( R_0 \), is shown as:

\[
p = F_0/4\pi R_0^2 = \frac{(6.99 \times 10^{-3} \times I^{2.17})}{(4\pi R_0^2)}
\]

Using this equation, when \( I = 0.51 \) μJ per pulse and \( R_0 = 20 \) μm, the shockwave pressure on the cell should be 0.32 μN per μm². “This force is much larger than that coming to bear on cells during conventional optical laser trapping,” says Hosokawa. “However, we tried to move a cell with optical trapping, using 2 W of IR laser power, and it didn’t work. What’s more, the powerful laser irradiation raised the temperature of the culture medium, and could possibly cause critical damage. As our method causes no damage during cell detachment when the proper pressure pulses are generated at the fixed distance from the target cell, we feel it is definitely superior to laser trapping,” says Hosokawa.

Hosokawa adds that a cell isolated by the team’s nondestructive method can then be manipulated by conventional laser trapping, using a 400-mW IR laser. The research team feels that a combination of laser trapping and femtosecond laser-induced shockwave methodology will result in new possibilities in the single cell analysis of differentiation and tissue formation.

Saulius Juodkazis, researcher at the Research Institute for Electronic Science of Hokkaido University (Sapporo, Japan), says he is familiar with the work of Hosokawa’s team. “I think that it really deserves attention. The method really works and holds excellent prospects in the field of cell research.” —Charles Whipple

UV LASER

Silicon-based Microdisk UV Laser Detects Molecules

Lasin in silicon still eludes us today due to the material’s electronic structure. However, integrating a different gain medium directly onto silicon can provide a viable alternative for taking advantage of the mass production techniques used in consumer electronics. Researchers at Northwestern University (Evanston, IL) fabricated and used a silica-based microdisk laser to detect molecules of nitrobenzene by measuring the laser frequency shift when the gas is introduced to the sensor.

Optically pumped by 355-nm, 20-ps pulses from a mode-locked neodymium-doped yttrium aluminum garnet laser, the structure consists of a 55-nm zinc oxide (ZnO) layer as the gain medium deposited atop of a silicon dioxide (SiO₂) disk (see figure 1). The team grew a 320-nm-thick SiO₂ layer on a silicon wafer, defined disk patterns with diameters less than 10 μm by optical lithography, and transferred the patterns from the photoresist to the SiO₂ layer by a two-step carbon tetrafluoride-based reactive ion etching process. After selectively wet-etching the silicon with tetramethyl ammonium hydroxide solution to form a silicon pedestal underneath each SiO₂ disk, the team deposited the ZnO film by metalorganic chemical vapor deposition in a pulsed organometallic beam epitaxy system.

The group’s end goal is to deliver a highly sensitive, chemically selective sensor of small size (1–10 μm), which is compatible with current silicon technology. Future work will look at lowering the lasing threshold, making electrically pumped microdisk lasers, and changing the sensing layer material such that the device will be sensitive to different types of molecules. “Our dream is to make an array of microdisk laser sensors on a single chip, each one having a different sensing layer so that it can sense different molecules,” explains Hui Cao of the research group. While the current application targets gas sensors, this device has the potential to be used in other chemical sensing and data storage applications.

—Phillip Espinasse