Microscale laser techniques combined

Meas. Sci. Technol. **19,** 095403 (2008)

Two laser-based techniques — micrometre-resolution particle image velocimetry (μPIV) and optical tweezers (OT) — have been combined by researchers in the USA to make a new instrument for the manipulation and characterization of fluid-based microscale objects and their local environment. This instrument, the μPIVOT, enables a new realm of microscale studies, yet still maintains the individual capabilities of each optical technique, claim the researchers from the Portland State University and Oregon Health and Science University, Portland, USA.

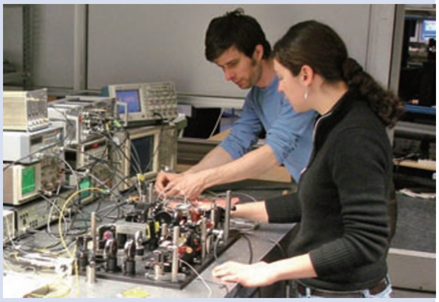
The μPIVOT system can manipulate an isolated particle or cell in a microfluidics environment without mechanical contact; image the isolated particle/cell; characterize the local environment surrounding the particles; and quantify applied stresses and induced strains. The researchers claim that the integrated technique will provide a unique perspective towards understanding microscale phenomena including single-cell biomechanics, non-Newtonian fluid mechanics and single-particle or particle–particle hydrodynamics.

Laser frequency comb calibrates telescope

Science **321,** 1335–1337 (2008)

A group of researchers from Germany and Australia has succeeded in using a laser frequency comb to calibrate the wavelength of an astronomical telescope with unprecedented precision. The calibration technique is important to astronomers because highly accurate observations of the cosmological redshift of distant objects in real time could potentially allow a direct measurement of the Universe's expansion history. However, to be feasible this requires measurements of Doppler velocity drifts of around 1 centimetre per second per year, and astronomical spectrographs have not yet been calibrated to this tolerance.

The experiments involved the Vacuum Tower Telescope solar instrument in Tenerife, Spain. Led by researchers at the Max Planck Institute for Quantum Optics in Germany, the team achieved absolute calibration with an equivalent Doppler precision of around 9 metres per second at a wavelength of about 1.5 micrometres. "We have already achieved beyond state-of-the-art accuracy," says team member Tilo Steinmetz, from Menlo Systems, a spin-off company from the Max Planck Institute. "Now we are going to make the system more versatile, and develop it even further."



CONSTANZA ARAUJO-HAUCKE

Terahertz probes deep

Opt. Express **16,** 11289–11293 (2008)

Researchers in Germany and the Netherlands have developed a terahertz profilometry system with a depth resolution of 0.5 μm. The technique can provide an alternative to conventional visible or near-infrared interferometry techniques, which can not cope with surfaces that have feature sizes of a tenth of the wavelength and more.

Bernd Hils, Torsten Löffler and colleagues from the University of Frankfurt together with researchers from the National Metrology Institute, Germany, and ESA/ESTEC in the Netherlands, used a femtosecond pulsed laser as a reference photonic local oscillator to enable stable phase measurements and thus improved depth resolution. Their terahertz heterodyne profilometer measures the phase shift of a continuous-wave terahertz beam, which is reflected from the object under test relative to the fixed reference beam. The radiation at 0.6 THz is generated electronically, but detected electro–optically at an intermediate frequency of around 10 MHz. The intermediate-frequency signal is obtained by mixing the THz radiation with the radiation of the high-repetition-rate femtosecond-pulse laser.

"When compared with traditional techniques terahertz profilometery has a reduced spatial resolution of maybe 0.5 mm, but it can achieve a depth resolution of about 1 μm even on rough, dirty, scratched and hidden surfaces," says Löffler. "Our new approach to terahertz profilometry avoids some limitations of our previous dark-field techniques for topography determination of fairly flat surfaces."

The development of the system was motivated by applications such as characterizing dish antennas for millimetre- and submillimetre-wave astronomical missions, but has much broader applicability. The group plans to commercialize a system through a spin-off company — Loeffler Technology — and hopes to have a system available at the end of this year.

A spectrometer fit for space

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The European Space Agency's Gaia mission, which launches in 2011, aims to determine how the Milky Way was formed. A key instrument will be the onboard radial velocity spectrometer (RVS). However, the optical components within the RVS need to be accurately characterized for operation at cryogenic temperatures and vacuum conditions. Researchers in Italy have now used a spectrometer to measure the refractive index of glass in these conditions.

They added a modified cryostat to their spectrometer and used a new method based on ray tracing to compute the refractive index. "The experimental set-up is modelled in detail, and the result is found by iteration of the ray-tracing sequence until the data observed in experiments are matched," explains Maurizio Vannoni from the National Institute for Applied Optics in Firenze. "The most important issue in our work is traceability. The results are intrinsically consistent and are validated step-by-step during the measuring procedure. Also, the system performance was previously verified for compliance over the course of an international inter-comparison exercise."

The researchers say that due to its simplicity and accuracy, this approach can be of interest for general use, not just for space missions. The accuracy requirement on the measurement of the refractive index was 10^{-4}. Although easily fulfilled under ambient conditions, this is quite a challenge in a vacuum at cryogenic temperatures.

Vannoni and his colleagues from the National Institute for Astrophysics, Firenze, and Galileo Avionica from Campi Bisenzio, now plan to further develop the use of ray tracing in this application. They also plan to use their approach to examine a series of vitreous materials (including fused silica) that are of interest for the Gaia space mission. "Hopefully, we will provide reference data for the optical design of the instruments to be carried on board, and for the analysis of the results that will be obtained from the experiments," says Vannoni.