Digital holography laboratory

(developed through the research contract "Capacities" no. 4/CP/I/2007 - National Plan RDI)

Research services offered:

- Image recording using digital holographic techniques (transmission and/or reflection):
  - material study (surface control, optical characterization)
  - samples investigation (micro and macroscopic).
- Image reconstruction of the objects from holograms and from the phase information obtained through processing.
- Fast and slow processes monitoring.
- Design of holographic gratings and devices and of diffractive optical elements

Purpose:

- Initiation and development of research projects and partnerships (private companies included)
- Experimental and theoretical studies for PhD, postdoctoral research and master studies.
- Student practice in optical engineering.

Location: Faculty of Applied Sciences , Physics Department I, room BN 139.

Address: „Politehnica" University of Bucharest, 060042, Spl. Independentei 313.

Team: Mona Mihailescu, Alexandru Preda, Constantin Cristescu, Ion M. Popescu, Dan Stefanoiu, Eugen Scarlat, Liliana Preda, Irina Paun, Cristina Stan, Aurel Toma.

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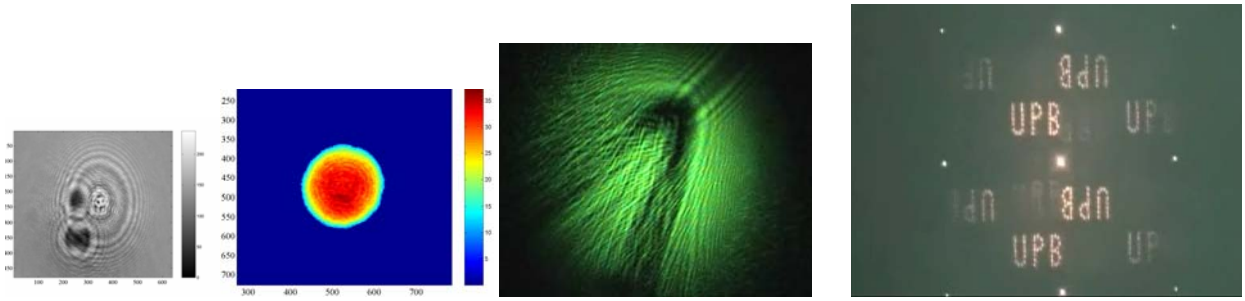
Schedule: daily, in agreement with all partners



Assets and facilities

We equipped this laboratory according to latest worldwide requirements in order to use this for various sample study, in-situ or in working regime. The holograms can be recorded using transmission or reflection mode, with many wavelegths, with simple or structured beams.

» Diode pumped solid-state laser Verdi V6 Coherent -

single diode pumped module, ultra-long-life AAA^{TM} laser diode material, continuum, diffraction limited, output power >6W, wavelength 532 nm, line width 5 MHz, beam diameter (1/e^2): 2,25±10%mm, beam divergence 0,5mrad, M^2 1,1, power stability (after 2 hrs): ±1%, pointing stability: <2 μrad / ^{0}C, noise (10Hz-1GHz): < 0,03% rms, polarization: vertical >100:1, cooling system, range of operating temperature: 15^{0}C-35^{0}C, operating voltage 100-240 VAC, power consumption: 13 kW maximum, 300 W typical.

» Ultra-short pulsed oscillator, Mantis Coherent

Ti:Saphire active medium, Avg. Modelocked power >300 mW, bandwidth <70 nm, central wavelength 800 nm, repetition rate 80 MHz, pulsewidth 20 fs with compressor and 100fs without it, beam divergence <2 mrad, beam diameter at output coupler 2mm, noise <0.5% rms, polarization >100:1 horizontal, beam height 120.8 mm (4.76 in.)

» Stabilized HeNe laser Spectra Physics

wavelength 632,8nm, linear polarized, TEM_{00} output power 1.5mW, frequency stability ±3 MHz, intensity stability (1 minute) ±0.02%, (1 hour) ±0.2%, beam diameter 0.6mm, beam divergence 1.6mrad.

» Laser diode

Temperature controller, Driver, beam diameter (1/e²) 0,95mm, beam divergence 1,2mrad, circular polarized, 2 heads: **(1)** wavelength 405nm output power 60mW **(2)** wavelength 445nm output power 50mW

» Inverted microscope Nikon Eclipse Ti-U

4 ports, Intermediate magnification included in all optical paths 1,5x, Halogen source 12V-100W with intensity control, Filters with different roles, Ocular 10x (100x2pcs), sextuple nosepiece, Focusing via nosepiece up/down movement with coarse stroke 5mm/rot. Fine stroke 0.1mm/rot. min Fine reading 1µm, Observation rectangular stage cross travel XY 50x70mm, Condenser lens NA 0.30 FOV 75mm for all types of examination, Objectives plan fluor ELWD DM 20XC NA 0.45 FOV 8.1-7.0mm, ELWD DM 40XC NA 0.6 FOV 3.7- 2.70mm, Correction system for the plate width (spherical aberation) 0-2mm
NIS-Elements Imaging Software - complete module
CCD - DS-Fi1 5megapixel color

equipped with module for:

- holographic studies

-phase contrast

-DIC

-fluorescence

» **Scientific video camera (2048x2048 pixel)**

CCD high resolution camera 2048x2048/14bit color, 16fps; transfer rate 100, 200, 400, 800 Mb/s, software for acquisition and image processing, Pentax objectives, firewire IEEE1394b

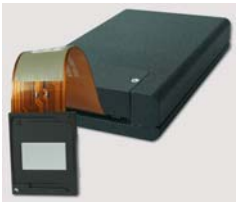
» **Matriceal sensor (CMOS) Photron Fastcam SA1 (675000fps)** - capture 12bit uncompressed data, 1024x1024pixels, pitch 20x20µm, data transfer: RS-422A or Gigabit Ethernet, variable ROI, global shutter 2 µs, with trigger

» **Spatial light modulators Holoeye**

Through transmission LC 2002

LCD display 800x600 pixels, pitch 32µm, computer addressable 8bit - 256 values, fill factor 55%, frame rate 60Hz, 2 π Phase Shift @ 532 nm

Through reflexion Pluto HES 6010 wavelength 420nm - 810nm, HDTV Developer phase kit, phase only panel display, resolution 1920 x 1200, pitch 8.1µm, fill factor: 90%, electronic driver, PCIe16 graphics card, frame rate 60 Hz



» software for holograms reconstruction off-axis (**Koala** produced by **Lynceetec,** Switzerland)

» software for image and hologram processing (**VirtualLab** produced by **LightTrans**, Jena)

» Actuator (**Physics Instruments**) piezoelectric commanded 100x100 µm, step 1µm

» Optical and mechanical components (lenses, beam-splitters, mirrors, objectives, filters, holographic tables, positioning stages, shutter)

Digital holography

The principal advantage of digital holography is that from a single hologram recorded on a video camera (CCD or CMOS) we can simultaneously reconstruct **(1)** amplitude and phase associated with the object **(2)** object details situated in planes at different distances along the propagation axis.

In classical holography the interference pattern between the reference wave and the one diffracted by the object is recorded on a holographic plate. This plate is chemically developed to obtain the hologram. The virtual image of the object are then experimentally reconstructed and viewed using complex setups.

In digital holography the hologram is recorded on a CCD or CMOS matrix; the chemical processes, which are time consuming, are avoided. Objects are digitally reconstructed, through an algorithm based on propagation simulation. The digital format of the image offers the possibility of software comparison with the same object images in different states.

Digital holographic microscopy purpose is to obtain microscopic sample images in coherent light, in which case the phase information is preserved and nm-range details are revealed.

Computer generated holograms purpose is to obtain holograms of virtual objects using specific algorithms, followed by experimental object reconstruction using a spatial light modulator.

The method implies many scientific and technical domains, including mechanical and optical complexity in experimental setups, iterative algorithms and specialized software in holograms and image filtering and processing. The method is complex, combining optics, electronics, information processing and transmitting (images, numerical data bases).