Optics in the Institute of Physics, Chinese Academy of Sciences
— from Terawatts to Single Photons

The Institute of Physics, Chinese Academy of Sciences, was established in 1950 through the merging of two older institutes dating back to 1928. Now also known as the Beijing National Laboratory for Condensed Matter Physics, with more than 200 research staff and 600 graduate students, it conducts basic and applied research on condensed matter, optics, atomic and molecular physics, plasma physics, and theoretical physics, with cross-disciplines related to materials, information, energy and life science. International collaboration, involving 400 visits/events annually, is a vital facet of the institute.

Research in the Key Laboratory of Optical Physics embraces novel optical materials, laser physics, photonic crystals, nonlinear optics, strong field physics, ultrafast processes, quantum optics, and applications to biological systems. Facilities include pulsed ns, ps and fs lasers, with powers up to terawatts, tunable cw lasers, and so forth, with wavelengths ranging from x-ray to THz. Light detection instruments include uv, ir, and visible spectrometers, boxcars, single-photon detectors, broadband oscilloscopes, and other electronic equipment.

Intense Laser-Matter Interactions

- High energy density physics
  - Generation of fast electrons and ions with solid targets
  - Laser wakefield electron acceleration
- Novel laser-based radiation sources (THz, X-rays, X-ray lasers)
- Propagation of fs laser pulses in air
- Laboratory astrophysics
- Future energy science

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http://highfield.iphy.ac.cn

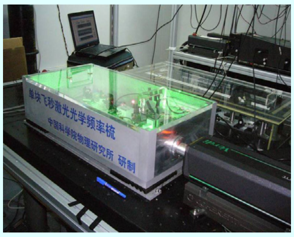
Ultrahigh Intensity fs Laser System Xtreme-Light (XL-III)

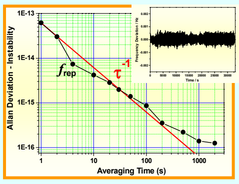
XL-III is a high power Ti:sapphire laser system based on chirped pulse amplification, capable of delivering 30fs pulses with an energy of 22J (= peak power 700TW)

Target Chamber

Monolithic Frequency Comb

A compact frequency comb based on difference frequency generation and our free fiber new design can run with long-term superstability and precision. It can be used for coherent control of atom and molecule dynamics, frequency metrology, optical clocks, measurement of fundamental constants, etc.



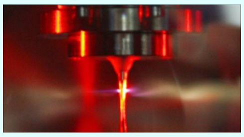


CEO fluctuations after locking

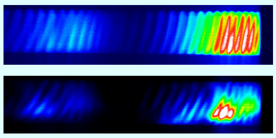
CEP Controlled fs Laser and Attosecond Science

The output pulse from an fs Ti:sapphire laser can be compressed to sub-5fs with an energy of about 0.5mJ, repetition rate 1kHz, and CEP locked within a fluctuation of <53mrad.

Coherent ultrafast X-rays of sub-10nm wavelengths can be generated for research on attsecond science and ultrafast X-ray spectroscopy.



Driving high order harmonics



Coherent X-rays with (upper) and without (lower) CEP locking

Supercomputer Facilities

Dawning-4000
CPU: 276GHz (31 nodes), Memory: 170GB

KLAP -1D, 2D, 3D PIC codes + field and collision ionization etc.
Laser beam transport code
Hydrodynamic code: Medusa
Radiation transport: NIMP
Ray tracing codes
Atomic data packages
Fokker-Planck code

Also available: Shenteng 6800: 1200CPU
Computation Center, CAS

International Collaboration

Country	Institution	Subject
UK	Rutherford Appleton Laboratory, CCLRC	Ultrashort intense laser interaction with matters
Italy	Dipartimento di Fisica "G.Occhialini", Università di Milano Bicocca	Generation and transport of fast electrons
Japan, Korea	Advanced Photon Research Center, JAERI, Japan Kwangju Institute of Science and Technology	China-Japan-Korea trilateral collaboration on ultrashort intense laser development and applications
Japan	Institute of Laser Engineering, Osaka University	Laboratory astrophysics by intense laser pulses.

8 international conferences, workshops and summer schools have been organized during the past 6 years

Quantum Optics

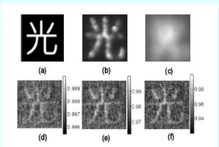
- Intensity correlation "ghost" imaging and interference with thermal light
- Generation and applications of entangled light
- Generation and applications of single photons
- Quantum cryptography

International Collaboration:
Previous collaboration with France, Russia, and USA

High-visibility high-order lensless ghost imaging with thermal light *

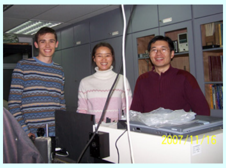
Xi-Hao Chen, Ivan N. Agafonov, Kai-Hong Luo, Qian Liu, Rui Xian, Maria V. Chekhova, and Ling-An Wu (to appear in *Optics Letters*)

High-visibility *N*-th-order ghost imaging with thermal light has been realized by only recording the intensities in two optical paths in a lensless setup. The visibility is dramatically enhanced as the order *N* increases



Reconstructed 2nd, 10th and 20th order ghost images
(b) and (c): Projection images obtained by CCD1 alone, averaged over 20,000 frames, for (b) z_3 = 20 mm, (c) z_3 = 70mm
(d) 2nd order (N = 2, n = 1)
(e) 10th order (N = 10, n = 9)
(f) 20th order (N = 20, n = 19), 140,000 frames

- Visibiilty improves as N increases
- Only 2 detectors required



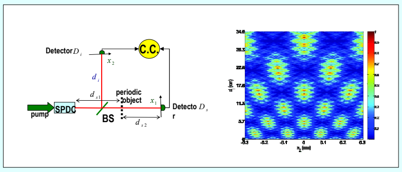
Russian student Ivan working in our lab

* Collaborative project with Russia, supported by a Joint Grant from NNSFC and RFBR

Second-order Talbot effect with entangled photon pairs *

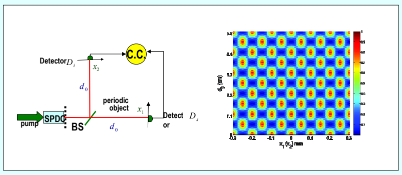
Kai-Hong Luo, Jianming Wen, Xi-Hao Chen, Qian Liu, Min Xiao, and Ling-An Wu, *Phys. Rev. A* 80, 043820 (2009)

The second-order Talbot effect for a periodic object illuminated by entangled photon pairs may be observed, without any focusing lens. Self-images of the object that may or may not be magnified can be observed nonlocally in the photon coincidences but not in the singles count rate. In the quantum lithography setup the second-order Talbot length is half that of the classical first-order case, thus the resolution may be improved by a factor of 2.



Talbot carpet in quantum imaging

D_s fixed, D_i scanned



Talbot carpet in quantum lithography

D_s or D_i fixed in the transverse direction
D_s and D_i scanned synchronously along the *z* direction

* Collaborative project with Arkansas Univ, USA