实验室概况/ Overview of the Laboratory of Optical Physics

光物理实验室最早是经中国科学院组织专家论证并批准成立的部门实验室，于 1994 年 12 月正式对国内外开放，2001 年 11 月按中科院的统一要求更名为中国科学院物理研究所光物理重点实验室。实验室为从事光物理基础研究及应用基础研究的实体，主要研究方向是光与物质相互作用的基础研究，同时开展新型人工结构和材料在光学，尤其是在光子学领域的应用基础研究，即一方面重视光物理本身的研究，另一方面将现代光学的方法和技术引入凝聚态物理和材料科学中去，开拓几种新材料在高技术产业中的可能应用。实验室瞄准国际科学前沿，在低维人工结构材料中的光科学、激光物理、光子晶体、非线性光学、量子光学、强场物理、高能量密度物理及超快过程研究等方面开展了在国内外有相当影响的基础和应用研究工作。在激光器件上也有较强的力量，能够研制并提供多种超短脉冲激光器件和全固态激光器件，并取得了具有国际先进水平的成果。此外将光学和物理学的方法、手段应用于生物系统也是目前正在发展的重点学科方向。与凝聚态物理与材料科学紧密结合是光物理实验室研究的重要特点。

光物理实验室拥有门类齐全的先进激光系统，如纳秒、皮秒、飞秒脉冲激光器，可调谐激光器，准分子激光器等，以及数字示波器、锁相放大器、Boxcar 积分器、单光子计数设备及工作在红外、可见和紫外波段的各类光谱仪等现代测量仪器，以及激光分子束外延薄膜设备，可以开展各类光物理的前沿研究工作。目前，在科技部和物理所的大力支持下，宽谱段、多功能基础研究光学平台正在建设中。

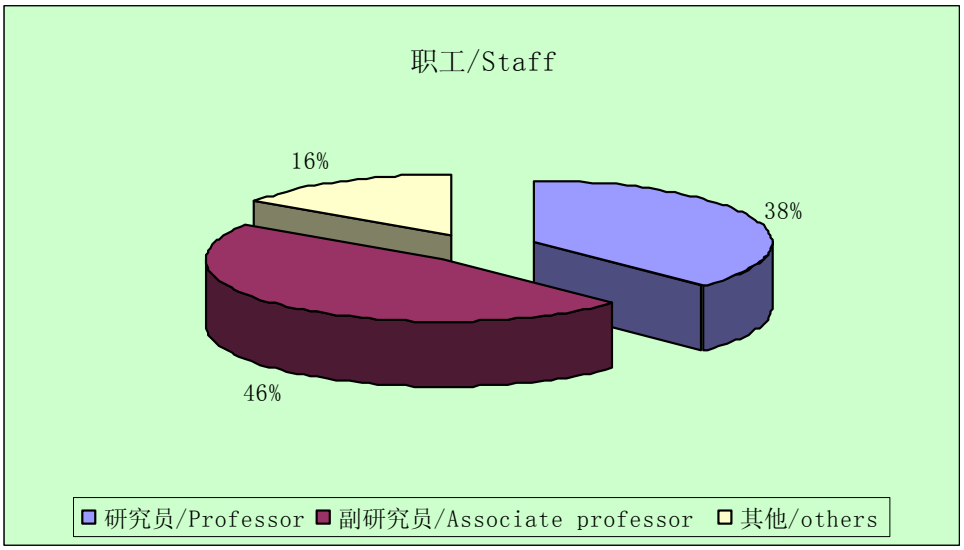
光物理实验室目前拥有三十四位研究人员，是一支具有一定综合实力的研究队伍，现为全国光学学科博士、硕士学位点和博士后流动站，有九十名在读研究生。目前实验室的研究工作大多数已进入国际竞争的前沿，承担多项国家和省部委的重大和重点研究课题。几年来，光物理实验室在光物理及其相关领域的研究中发挥了应有的作用。光物理实验室现与国内外十几个大学和研究所建立了良好的学术合作关系，对国内外科学家提出的优秀研究项目给予资助并开展合作研究。

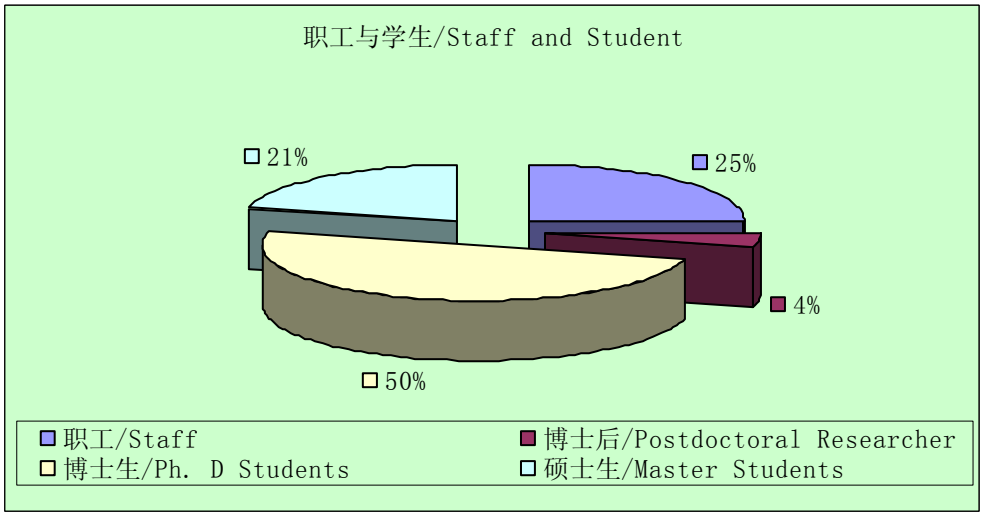
Optical physics was one of the earliest disciplines established in the Institute of Physics, Chinese Academy of Sciences (CAS). In December 1994 the Laboratory of Optical Physics was authorized as an Open Laboratory of CAS, and then renamed a CAS Key Laboratory in 2001. Its main focus is on the fundamental studies of laser interactions with matter, as well as applied basic research on novel materials in optics and photonics. That is, while emphasizing the physics of optics, at the same time modern optical methods and techniques are applied to condensed matter physics and material science for potential applications of new materials in high-tech industry. Current research topics include novel optical properties in low dimention perovskite oxide, pure and applied studies in laser physics, photonic crystals, nonlinear optics, quantum optics, high laser field physics, high energy density physics and ultrafast processes. Through persistent efforts the Laboratory is becoming more and more competitive academically, with a considerable number of publications in the major international journals. Important progress has also been achieved in the fabrication low dimension oxide materials and heterostructures by laser MBE, and many kinds of ultrashort pulsed lasers and all-solid-state lasers have been developed in-house, reaping in several national awards in science and technology. Meanwhile, the application of optical methods to biological systems has become an increasingly active research field, further demonstrating the close association of optics with condensed matter and material science in the Lab.

At present we have a whole range of advanced laser systems, such as pulsed lasers with nanosecond, picosecond and femtosecond pulse durations, as well as a tunable ring laser, excimer laser and widely tunable optical parametric amplifier (OPA). Modern detection instruments such as fast oscilloscopes, lock-in amplifiers, boxcars, single-photon detection counters, all types of autocorrelators, and different kinds of spectrometers covering the infrared, visible and ultraviolet regions are also available.

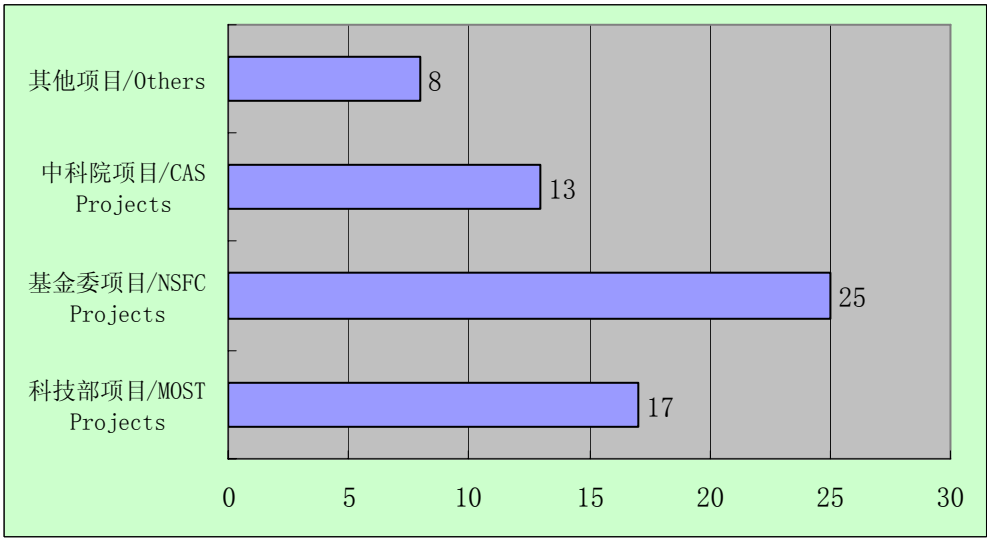
With a total of 34 research and administrative staff and 90 graduate students the Laboratory has emerged as a dynamic force at the forefront of research in optics, undertaking many major national programs. Successful collective projects are in progress with over a dozen external research groups both in China and abroad, and the Laboratory will continue to encourage and support such highly fruitful collaboration.

人事概况/General View of Personnel





在研项目概况/General View on Projects under Researching



人员结构/Organization

学术委员会/Academic Committee

杰出人才/Intelligent Staff

中国科学院院士/ Academician, CAS

1999 杨国桢 Yang Guozhen

2003 张 杰 Zhang Jie

国家杰出青年基金获得者/ National Science Fund for Distinguished Young Scholars

1997 李晓峰 Li Xiaofeng

1998 张 杰 Zhang Jie

2002 魏志义 Wei Zhiyi

2004 盛政明 Sheng Zhengming

2005 李志远 Li Zhiyuan

2008 金奎娟 Jin Kuijuan

2009 李玉同 Li Yutong

国家海外青年学者合作研究基金获得者/Laureates of the 'Joint Research Fund for Overseas Chinese Young Scholars'

2000 朱湘东/吕惠宾 Zhu Xiang-dong/Lu Hui-bin

2001 张希成/张 杰 Zhang Xi-cheng/Zhang Jie

2007 曹建明/张 杰 Cao Jian-ming/Zhang Jie

中科院"百人计划"入选者

1998 张 杰 Zhang Jie

1999 翁羽翔 Weng Yuxiang

2000 程波林 Cheng Bolin

2000 盛政明 Sheng Zhengming

2000 邹炳锁 Zou Bingsuo

2004 李志远 Li Zhiyuan

2009 陈黎明 Chen Liming

2011 许秀来 Xu Xiulai

中科院物理所"小百人计划"入选者

2010 尹 彦 Yin Yan

2011 丁 伟 Ding Wei

2011 贺新奎 He Xinkui

2011 左战春 Zuo Zhanchun

博士后/Post-doctoral Fellows

马海强	Ma Hai-qiang	张秋琳	zhang Qiu-lin
胡放荣	Hu Fangrong	陈基根	Chen Jigen
李　铭	Li Ming		

博士生/Ph. D Students

马冬莉	Ma Dong-li	刘　峰	Liu Feng
任明亮	Ren Ming-liang	张　蕾	Zhang Lei
凌　林	Ling Lin	周木林	Zhou Mu-lin
蒙自明	Meng Zi-ming	郝　彪	Hao Biao
王　晨	Wang Chen	刘　勋	Liu Xun
陈宇辉	Chen Yu-hui	毛婧一	Mao Jing-yi
刘思耘	Liu Si-yun	张　璐	Zhang Lu
王本立	Wang Ben-li	刘晓龙	Liu Xiao-long
钟晓岚	Zhong Xiao-lan	杜　飞	Du Fei
王　聪	Wang Cong	於陆勒	Yu Lu-le
王京义	Wang Jing-yi	江　淼	Jiang Miao
徐中堂	Xu Zhong-tang	胡志丹	Hu Zhi-dan
葛　琛	Ge Chen	苏鲁宁	Su Lu-ning
郭尔佳	Guo Er-jia	闫文超	Yan Wen-chao
金昱伶	Jin Yu-ling	袁大伟	Yuan Da-wei
王　乐	Wang Le	郑　轶	Zheng yi
赵瑞强	Zhao Rui-qiang	玄洪文	Xuan Hong-wen
戴　俊	Dai Jun	王　楠	Wang Nan
刘相波	Liu Xiang-bo	邹育婉	Zou Yu-wan
石洪菲	Shi Hong-fei	詹敏杰	Zhan Min-jie
周文佳	Zhou Wen-jia	叶　蓬	Ye Peng
曹　硕	Cao Shuo	郭淑艳	Guo Shu-yan
吴忠安	Wu Zhong-an	王　庆	Wang Qin
潘学聪	Pan Xue-cong	张　伟	Zhang Wei
翟　振	Zhai Zhen	沈忠伟	Shen Zhong-wei
裴丽娅	Pei Li-ya	汪礼峰	Wang Li-feng
吴晓君	Wu Xiao-Jun	张金伟	Zhang Jin-wei
李明飞	Li Ming-fei	张　龙	Zhang Long
赵　曦	Zhao Xi	张　静	Zhang Jing
李　春	Li Chun	黄　璐	Huang Lu
丁文君	Ding Wen-jun	邱康生	Qiu Kang-sheng
林晓宣	Lin Xiao-xuan		

硕士生/Master Students

廉　晋	Lian Jin
陈宝琴	Chen Bao-qin
史　哲	Shi Zhe
邱　柳	Qiu Liu
张　超	Zhang Chao
刘　菊	Liu Ju
何　旭	He Xu
刘　爽	Liu Shuang
冯雅晴	Feng Ya-qing
万　骞	Wan Qian
鄂轶文	E Yi-wen
银　珊	Yin Shan
张　奎	Zhang Kui
陈平平	Chen Ping-ping
崔云千	Cui Yun-qian
马　勇	Ma Yong
黄　开	Huang Kai
廖国前	Liao Guo-qian
赵倪婕	Zhao Ni-jie
陶孟泽	Tao Meng-ze
李明华	Li Ming-hua
范海涛	Fan Hai-Tao
侯　磊	Hou Lei
于子蛟	Yu Zi-jiao
钟诗阳	Zhong Shi-yang
刘家兴	Liu Jia-xing
江　曼	Jiang Man

仪器设备/Facilities

一、 激光器设备(Lasers)

1. 飞秒激光器(Femtosecond Lasers)

性能参数 Specifications	钛宝石激光振荡器 I Ti:sapphire Oscillator I	钛宝石激光振荡器 II Ti:sapphire Oscillator II	钛宝石激光振荡器 III Ti:sapphire Oscillator III
生产厂家 Manufacturer	美国 Spectra-Physics	本室研制 Home-made	本室研制 Home-made
型号 Model	Tsunami 3941-X1BB		
输出波长 Output Wavelength	700 ~ 1000nm	750 ~ 850nm	600~ 1000nm
平均功率 Average Power	1.4W（790nm）	1W（790nm）	400mW
脉冲宽度 Pulse Width	<100fs	~ 30fs	5~ 8fs
重复频率 Repetition Rate	82MHz	82MHz	100 ~ 300MHz
联系部门 Contact Department	光物理公共技术	L07 组	L07 组

性能参数 Specifications	钛宝石激光放大器 I Ti:sapphire Amplifier I	钛宝石激光放大器 II Ti:sapphire Amplifier II	钛宝石激光放大器 III,IV Ti:sapphire Amplifier III,IV
生产厂家 Manufacturer	美国 Spectra-Physics	奥地利 Femtolasers Inc	本室研制 Home-made
型号 Model	TSA – 10	FemtoPower-Pro	极光 II, III（XL II, III）
输出波长 Output Wavelength	750 ~ 850nm	~790nm	790nm, 810 nm
单脉冲能量 Pulse Energy	5mJ（790nm）	0.8mJ	640mJ, 11 J
脉冲宽度 Pulse Width	<200fs	~ 25fs(自加压缩后 5fs)	30fs, 30fs
重复频率 Repetition Rate	10Hz	1kHz	10Hz, 20 分钟/发
联系部门 Contact Department	光物理公共技术	L07 组	L05 或 L07 组

性能参数 Specifications	飞秒镁橄榄石激光振荡器 femtosecond Cr:forsterite laser	同步飞秒钛宝石激光器 Synchronized fs Ti:sapphire Laser
生产厂家 Manufacturer	本室研制 Home-made	本室研制 Home-made
输出波长 Output Wavelength	1250 ~1350nm	750~ 850nm
平均功率 Average Power	150mW（1280nm）	>1W
脉冲宽度 Pulse Width	29fs	30~80fs
同步精度 Timing Jiter		<1fs
重复频率 Repetition Rate	82MHz	82MHz
联系部门 Contact Department	L07 组	L07 组

2. 皮秒激光器（Picosecond lasers）

性能参数 Specifications	皮秒 Nd:YAG 激光器 ps Nd:YAG laser	皮秒光参量放大器 ps Optical Parametric Amplifier
生产厂家 Manufacturer	立陶宛 EKSPLA 公司	本室研制 Home-made
型号 Model	PL2143B	
输出波长 Output Wavelength	1064 532 355nm	430 ~ 2000nm
单脉冲能量 Pulse Energy	80 40 20mJ	3mJ
脉冲宽度 Pulse Width	25ps (1064nm)	~ 20ps
重复频率 Repetition Rate	10Hz	10Hz
联系部门 Contact Department	光物理公共技术	光物理公共技术

3. 纳秒激光器（Nanosecond laser）

性能参数 Specifications	倍频 Nd:YAG 激光器 SHG Nd:YAG laser	倍频 Nd:YAG 激光器 SHG Nd:YAG laser	倍频钕玻璃激光器 SHG Nd:glass laser
生产厂家 Manufacturer	美国 Positive Light	美国 Spectra-Physics	
型号 Model	Evolution 30	Pro-230	Powelite-100
输出波长 Output Wavelength	527nm	532nm	527nm
单脉冲能量 Pulse Energy	~20mJ (2W)	~1.4J	100J
脉冲宽度 Pulse Width	>100ns	~7ns	~25ns
重复频率 Repetition Rate	1kHz	10Hz	3pph
联系部门 Contact Department	L07 组	L05 或 L07 组	L05 或 L07 组

性能参数 Specifications	准分子激光器 Excimer Laser	纳秒 Nd:YAG 激光器 ns Nd:YAG laser	纳秒光参量振荡器 ns Optical Parametric Oscillator
生产厂家 Manufacturer	德国 Lambda Physik	立陶宛 EKSPLA 公司	本室研制 Home-made
型号 Model	COMPexPro 201	NL303G	
输出波长 Output Wavelength	308nm	1064 532 355nm	430 ~ 2000nm
单脉冲能量 Pulse Energy	500mJ	500 210 135mJ	10mJ
脉冲宽度 Pulse Width	~ 25ns	3 ~ 6 ns (1064nm)	3 ~ 6 ns
重复频率 Repetition Rate	10Hz	10Hz	10Hz
联系部门 Contact Department	光物理公共技术	光物理公共技术	光物理公共技术

4．连续波输出激光器（CW lasers）

性能参数 Specifications	CW 钛宝石激光器 CW Ti:sapphire laser	倍频 Nd:YVO_4 激光器 SHG Nd:YVO_4 laser	倍频 Nd:YVO_4 激光器 SHG Nd:YVO_4 laser
生产厂家 Manufacturer	美国 Spectra-Physics	美国 Spectra-Physics	美国 Coherent Inc
型号 Model	3900S	Millennia X	Verdi 10
输出波长 Output Wavelength	700 ~ 950nm	532nm	532nm
平均功率 Average Power	750mW（790nm）	10W	10W
线宽 Linewidth	< 40GHz		<5MHz
联系部门 Contact Department	光物理公共技术	L07 组	L07 组

二、分析测试仪器

光栅光谱仪/Spectrometer	**微型光纤光谱仪/Mini-Spectrometer**
美国 Princeton Instruments 公司	美国 Ocean Optics 公司
型号 Model：SpectraPro-500i	型号 Model：HR-2000
波长扫描范围 Scan Range：200 ~ 1400nm	波长测量范围 Wavelength Range：200 ~ 1100nm
分辨率 Resolution：0.05nm	分辨率 Resolution：1.8nm
用于材料透射谱、吸收谱，光波长测量等	用于光波长测量、荧光测量等
联系部门 Contact Department：光物理公共技术	联系部门 Contact Department：光物理公共技术

脉冲干涉自相关仪/Interfermeter autocorrelator	**SPIDER**
本室研制 Home-made	本室研制 Home-made
测量波长范围 Wavelength Range：600 ~ 1000nm	测量波长范围：Wavelength Range：600～1000nm
测量脉宽范围 Measurable Range：3fs ~ 100fs	测量脉宽范围：Measurable Range：3fs ~ 100fs
用于低重复频率超短激光脉冲脉宽测量	
联系部门 Contact Department：L07 组	联系部门 Contact Department：L07 组

SPM100 型近场扫描光学显微镜	
美国 RHK 公司	
扫描范围 Scan range：30um × 30um	
激光源 Laser sources：465, 488, 514nm	
工作模式 Modes：接触和敲打透射模式	
近场探针 Near filed Probe：悬臂式光纤 Fiber	
分辨率 Resolution：<100 nm	
联系部门 Contact Department：光物理公共技术	

注：除开放基金外，所有仪器设备均为有偿使用

获奖情况/Award

2011 年度中国科学十大进展：利用强激光成功模拟太阳耀斑的环顶 x 射线源和重联喷流

获奖单位：中科院国家天文台赵刚研究组、中科院物理所李玉同研究组，上海交通大学张杰研究组以及其他合作者联合完成

中国人民解放军总装备部军队科技进步奖

获奖者：滕浩，魏志义，赵环

获奖个人：

中国物理学会谢希德物理奖：金奎娟

中国物理学会王淦昌物理奖：李玉同

中国物理学会胡刚复物理奖：魏志义

中国光学学会王大珩光学奖：李志远

获奖研究生 /Award for excellent graduate students

中科院物理所所长奖学金优秀奖：任明亮，陈宇辉，徐中堂，刘晓龙，王庆

中科院物理所所长奖学金表彰奖：蒙自明，凌林，刘思耘，王晨，王京义，葛琛，金昱伶，王乐，赵瑞强，戴俊，刘相波，翟振，吴晓君，裴丽娅，张璐，杜飞，毛婧一，江淼，闫文超，郑轶，王楠，邹育婉，詹敏杰，叶蓬，郭淑艳，张伟，张金伟，张静，黄璐

研究工作报告/Scientific Report

光子晶体及其应用／ Photonic crystal and its applications

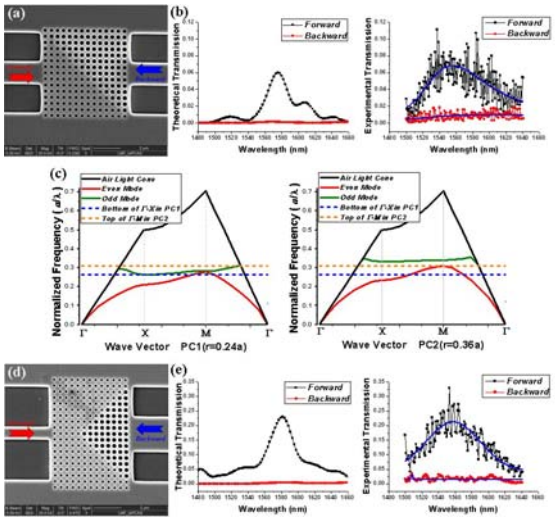
组长：李志远 Group Leader: Li Zhi-yuan
成员：郭红莲 李家方 刘荣鹃 Members: Guo Hong-lian, Li Jia-fang, Liu Rong-juan
丁伟 甘霖 Ding Wei, Gan Lin

◆利用光子晶体的方向带隙不匹配特性，设计并制备了尺寸为波长量级的硅基光子晶体异质结全光二极管，无需磁场，易于集成。成功制备了品质因子超过 70, 000 的硅光子晶体纳米共振微腔，达到了与量子态强耦合的水平。

◆提出了超级准相位匹配的概念，并在周期极化铌酸锂超晶格结构上演示并验证了该概念的正确性和有效性。提出了有效非线性系数的理论模型，获得了任意非线性光学过程的解析解。

◆提出了表面波全息术的概念，设计了能够对表面等离子体波散射和传输进行调控的亚波长金属表面结构。理论上提出增益复合的金纳米棒有优异的表面等离子体共振放大性质，实验上利用棱镜耦合技术实现了染料分子泵浦激发的表面等离子体波的自发辐射放大。

◆利用磁表面等离子体共振传输能够实现电磁波的单向传输，不仅对缺陷、杂质等外界干扰免疫，而且对光子晶体自身的结构无序具有高度的免疫力。



设计并制造了基于硅光子晶体异质结的全光二极管(a)。实验测量发现该器件有明显的单向传播的特性，与理论计算符合很好(b)。能带图(c)分析表明单向传播性是由不同晶格光子晶体方向带隙差别造成的。通过改进异质结的界面设计(d)，在保持反向高截止的情况下，正向透过率理论计算及实验测量最高达到 32.8%(e)；信号对比度达到 0.885，接近电路二极管的水平。该全光二极管尺寸为几个光波长量级，集成度高，不需要磁性和非线性，将为实现全光集成和光计算机提供有益的思路。

(a) Scanning electron microscope images, (b) theoretical (left) and experimental (right) transmission spectra of original optical diode structures based on silicon photonic crystal heterojunctions. (c) Calculated modal dispersion curve for PC1 (r=0.24a) and PC2 (r=0.36a) showing directional bandgap mismatch and different mode transitions. (d) Scanning electron microscope images, (e) theoretical (left) and experimental (right) transmission spectra of optimized optical diode structures, which have better performance of higher forward transmission and signal contrast. The experimental realization of on-chip wavelength-scale optical diodes would open up a road towards optical integration and photonic computers.

◆We design and build all-optical diodes based on directional bandgap mismatch of silicon photonic crystal heterojunction, which are of wavelength size, magnetism free, and easy for integration. We make silicon photonic crystal high-Q nanocavities with a Q-factor over 70,000 that allows for strong coupling with quantum states.

◆We present the concept of super-quasi-phase matching to enhance nonlinear conversion efficiency and confirm it experimentally in periodically-poled lithium niobate superlattice structures, and present an effective nonlinear susceptibility model to analytically evaluate nonlinear conversion efficiency in nonlinear photonic crystals.

◆We present the concept of surface wave holography that allows for direct design of subwavelength metallic structures without complicated inverse problem solution to engineer scattering and transport of surface plasmonic waves. We show theoretically gain-assisted gold nanorods have superior property of surface plasmon amplification and demonstrate experimentally spontaneous emission amplification of surface plasmon polaritons.

◆We show experimentally that one-way waveguides working within the magnetic-resonance induced band gap in a gyromagnetic photonic crystal are magnetically tunable, robust against back scattering, and highly immune to lattice disorders.

低维氧化物体系的设计、激光法制备及其物理研究/ Designing and manufacturing low dimension Oxide materials by Laser and studying their properties

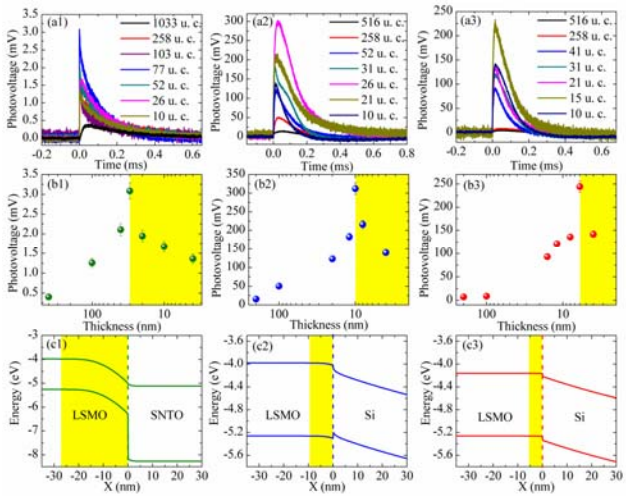
组长：金奎娟 Group Leader: Jin Kui-juan
成员：杨国桢（院士） 吕惠宾 王 灿 何 萌 郭海中 许秀来 左占春
Members: Yang Guo-zhen (Academician), Lü Hui-bin, Wang Can He Meng, Guo Hai-zhong, Xu Xiu-lai, Zuo Zhan-chun

◆利用激光分子束外延方法成功地生长了 BiFeO3 外延薄膜，研究了 BiFeO3 薄膜的可反转二极管特性和铁电电致电阻效应。

◆应系统研究了在不同氧压下制备的 LSMO/Si 和 LSMO/SNTO 异质结的光电效应，实验表明随着 LSMO 薄膜从厚变薄，在某一特定膜厚下，这些异质结的光电压分别都增强了一个量级。

◆为了深入的研究金属/铁电/金属结构中发现的可反转二极管效应，我们通过自洽计算，得到了和实验数据符合得很好的反转二极管效应的理论结果，揭示了铁电极化能改变界面势垒高度是导致可反转二极管效应的主要机制。

◆用斜入射光反射差法，实现了无标记和高通量检测生物芯片与实时监测生物分子的反应动力学过程，检测的灵敏度和分辨率达到目前无标记高通量检测的国际最高水平。



系统研究了在不同氧压下制备的 LSMO/Si 和 LSMO/SNTO 异质结的光电效应，实验表明随着 LSMO 薄膜从厚变薄，在某一特定膜厚下，这些异质结的光电压分别都增强了一个量级。
Through systematic investigation on photovoltaic effects in the heterostructures of LSMO/SNTO and LSMO/Si by varying film thicknesses and oxygen pressures, an enhancement of one order of magnitude of photovoltages in these heterojunctions was observed with the decreasing film thickness. An ultimate value of photovoltage was found in the heterostructures with the film thickness consistent with the calculated thickness of the depletion layer in LSMO films for heterostructures of LSMO/SNTO and LSMO/Si fabricated under different oxygen pressures.Appl. Phys. Lett. 98, 181101 (2011)

◆We have grown epitaxial BiFeO3 thin films successfully by using laser molecular beam epitaxy, and have investigated their switchable diode effect and ferroelectric resistive switching behaviors.

◆Through systematic investigation on photovoltaic effects in the heterostructures of LSMO/SNTO and LSMO/Si by varying film thicknesses and oxygen pressures, an enhancement of one order of magnitude of photovoltages in these heterojunctions was observed with the decreasing film thickness. An ultimate value of photovoltage was found in the heterostructures with the film thickness consistent with the calculated thickness of the depletion layer in LSMO films for heterostructures of LSMO/SNTO and LSMO/Si fabricated under different oxygen pressures.

◆We have carried out a self-consistent calculation to further study the switchable diode effect in metal/ferroelectrics/metal structures. The calculated results are in good agreement with the experimental data, theoretically demonstrating the important role played by the polarization-modulated barrier.

◆We have realized the label-free and high-throughput detection of biomolecular microarrays and the real-time measurement of dynamic processes of biomolecular interactions. The sensibility and resolution reached the international peak for label-free and high-throughput detection.

太赫兹和超快光谱学/ Terahertz and ultrafast spectroscopy

组长：汪　力　　Group Leader: Wang Li

成员：傅盘铭 王兵兵 尹　彦 徐新龙　Members: Fu Pan-ming, Wang Bing-bing, Yin Yan, Xu Xin-long

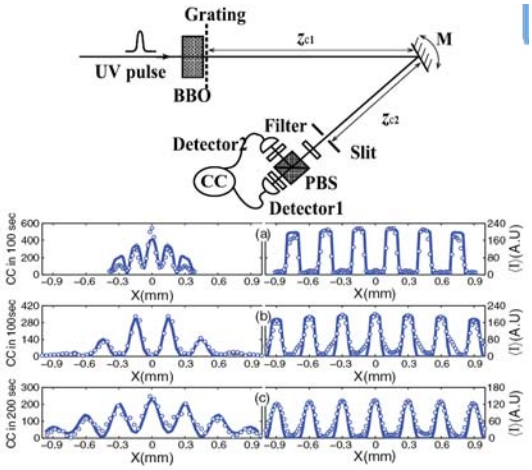
◆在乳糖颗粒水合形成的 Core－shell 结构的 THz-TDS 透射测量中，发现这种亚波长介电随机体系由于相干耦合导致的新型传播效应；发现铂类抗癌药物和鼠肝 DNA 水溶液相互作用过程中存在巨大太赫兹旋光效应的证据。

◆提出利用理德堡原子和超短脉冲实现优化高次谐波产生的方案；解释了超短脉冲的实验中产生的高次谐波复杂结构；利用外加磁场对非序列电离轨道的选择条件，证明非序列电离中激光辅助碰撞机制在强激光场区域起主要作用。

◆在多普勒系统中提出基于缀饰模型宏观效应产生的 AT 效应；从理论和实验上研究共振受激拉曼散射和电磁感应透明之间的关系。

◆以参量下转换产生的纠缠光子对首次演示了非经典的二阶 Talbot 效应，证实了量子的 Talbot 鬼成像可被放大,但因为是近场衍射所以量子光刻的成像距离是经典 Talbot 距离的两倍；探讨强度关联机制下直接产生正负图像的对应成像方法，和基于压缩感知的单像素成像，均已成功实验演示；开发了一种用于量子密钥分发的新真随机数源的软硬件；筹建冷原子量子存储的实验。

◆继续纳米碳管的拉曼光谱的研究，测量了 G 模式的电子声子耦合并解释了 1700 波数模式的物理起源。同时开展了石墨烯器件的光电混合测量研究。



量子光刻方案的二阶 Talbot 自成像。左图为光栅的双光子符合计数 Talbot 像，右图为相干光源的一阶自成像。圆圈为实测数据，对应不同有效衍射距离：(a) Zc = 1/2 zT =11.25 cm, (b) Zc = zT = 22.5 cm, (c) Zc = 2zT = 45 cm, 其中 zT 为经典一阶 Talbot 距离。实线为理论曲线。

Second-order Talbot self-imaging in the quantum lithography scheme. Left and right parts correspond, respectively, to the two-photon coincidence count Talbot images of a grating using an entangled photon source, and the first-order self-images using a coherent light source. Open circles are experimental data observed for effective diffraction lengths of (a) Zc = 1/2 zT =11.25 cm, (b) Zc = zT = 22.5 cm, and (c) Zc = 2zT = 45 cm, where zT is the classical first-order Talbot distance. Solid lines are theoretical curves.

◆Find a new propagation effect in subwavelength-sized lactose random particle system due to the strong coherent coupling and the evidence of the giant THz optical activity existing in interaction of oxaliplatin and DNA solution.

◆It is demonstrated that high harmonic generation with both high cutoff frequency and high conversion efficiency can be realized in a Rydberg atom using a ultrashort laser pulse. The complex structure of high harmonic spectrum by a few cycle laser pulse has been explained based on the mechanism involving a static electric field; The NSDI mechanism of laser-assisted collision ionization is proposed in a high intensity region.

◆Using the dressed-state model, a novel type of Autler-Townes (AT) effect on a macroscopic phenomenon in a Doppler broadened system is proposed. We also study the interrelation between resonant stimulated Raman scattering and electromagnetically induced transparency (EIT) both theoretically and experimentally.

◆We performed the first demonstration of quantum Talbot effects with single photons and entangled photon pairs, verifying that Talbot ghost images may be magnified, but in quantum lithography the Talbot distance is twice that of classical self-imaging due to the near-field condition. New mechanisms of intensity correlation imaging are being explored, such as what we call correspondence imaging can directly obtain positive and negative images, and compressive sensing has been used to realize single-pixel imaging. The hardware and software for a new true random number generator for use in quantum key distribution are being developed. A magneto-optical trap is being set up for quantum information storage in cold atoms.

◆We measured the G mode electron-phonon coupling and gave the assignment for a mode at 1700cm-1. We also started the optical and electrical combined measurements on graphene devices, and obtained the primary data.

超强激光与物质相互作用/ Ultra-Intense Laser Interaction with Matter

组长：李玉同 Group Leader: Li Yu-tong
成员：张杰（院士）盛政明 鲁欣 董全力 陈黎明 马景龙 王伟民 Wang Wei-min
Members: Zhang Jie (Academician), Sheng Zheng-ming, , Lu Xin, Dong Quan-li, Chen Li-ming, Ma Jing-long,

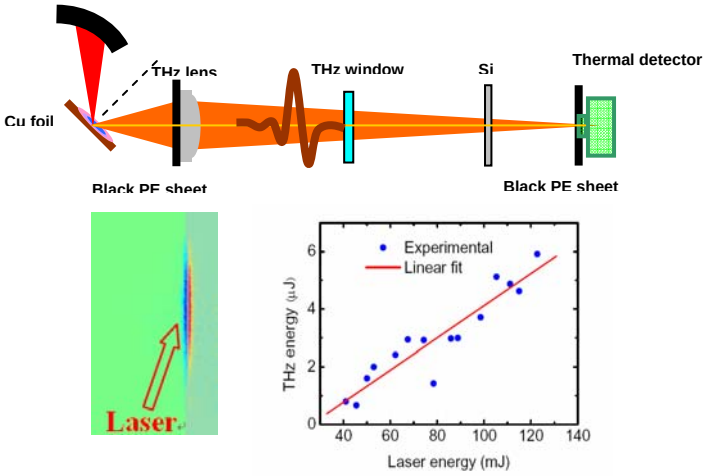
◆在与快点激光核聚变相关的研究中，首次发现了靶晶格结构对超热电子输运的重要影响［Phys. Rev. Lett. 106, 185004 (2011)］

◆提出了利用中红外和周期量级飞秒激光与等离子体相互作用增强太赫兹辐射的新方案，在实验上获得了>微焦量级的太赫兹辐射及其与激光预脉冲的关系[Opt. Lett. 36, 2608 (2011); Phys. Plasmas 18, 073108 (2011); Physical Review E 84, 036405 (2011)].

◆利用高能激光与等离子体相互作用产生了类超新星爆发激发的无碰撞冲击波，文章发表后 12 天就被下载 250 次[New J. Phys., 13, 093001 (2011)]。

◆通过增加等离子体通道长度和优化团簇尺寸，大幅度提升了 K 壳层 X 射线的流强，实现了单发激光脉冲 X 射线透视成像[optics Express 19, 25812(2011)]。

◆首次利用团簇得到能量大于 600MeV 的电子加速，高能电子总电荷量大于 3nC，有望作为一种新的加速器注入种子[Appl. Phys. Lett. (Accepted)]



利用相对论强激光与固体靶相互作用，产生了能量~50 微焦/sr 的强太赫兹辐射。利用强太赫兹辐射不仅可以开展太赫兹波段的非线性物理问题研究，而且还可以用来诊断等离子体中强超热电子束流。

A plasma-based strong THz source with energies up to 50 μJ/sr has been generated in relativistic laser interaction with solid targets. Such a source allows potential applications in THz nonlinear physics and provides a new diagnostic of transient currents generated in intense laser-solid interactions.

◆We demonstrated the effect of lattice structure on energetic electron transport in solids irradiated by ultraintense laser pulses [Phys. Rev. Lett. 106, 185004 (2011)]

◆We proposed new schemes to genererate GW strong THz radiation with midinfrared or few-cycle laser pulses, and experimetnally produced > μJ THz pulses[Opt. Lett. 36, 2608 (2011); Phys. Plasmas 18, 073108 (2011); Physical Review E 84, 036405 (2011)].

◆We excited collisionless shockwaves by counter-streaming laser-produced plasmas in laboratory, which could be scaled to the astronimical phonomena[New J. Phys., 13, 093001 (2011)].

◆K-shell x-ray flux is greatly improved. Single-laser-shot x-ray radiography is achieved [optics Express 19, 25812(2011)].

◆Energetic electron beam with energy higher than 600MeV is obtained using laser interacting with atomic clusters. Beam charge of 3 nC leads to the possibility as a injector for traditional accelerators[Appl. Phys. Lett. (Accepted)]

超短脉冲激光与精密测量物理研究/ Ultrafast Laser Technology and Precision Measurement Physics

组长：魏志义 Group Leader: Wei Zhi-yi
成员：李德华 滕浩 王兆华 韩海年 贺新奎 Members: Li De-hua, Teng Hao, Wang Zhao-hua, Han Hai-nian He Xin-kui

◆建成峰值功率 1.16PW 的高对比度超强飞秒钛宝石激光装置，结果突破了原有的世界纪录。

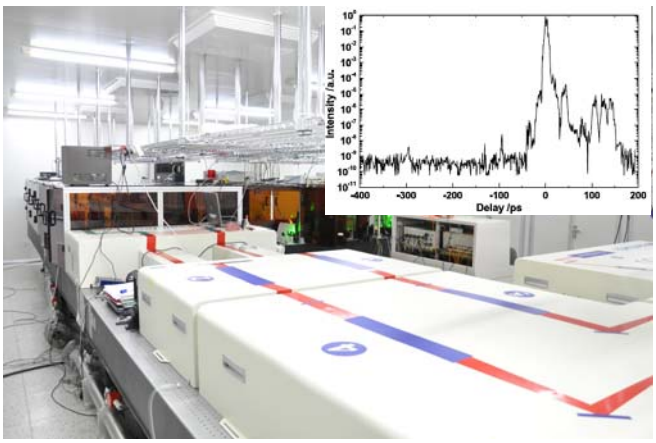
◆提出了参量置换放大的新技术，实现了 CEP 相位自稳定的可调谐飞秒参量激光。

◆首次实现了差频不同波长激光产生中红外超短脉冲的方法，首次在国内实现腔内倍频的飞秒参量激光振荡。

◆压缩飞秒放大激光得到 3.8fs 的极短脉冲，成为新的国内最短脉冲结果。

◆研制成功系列 Yb、Nd 及 Tm 掺杂的新型全固态连续及锁模陶瓷激光器，实现多种 1um 及 2um 波段的高效率激光输出。

◆利用自建的飞秒激光与相关研究组合作，在国内首次实现了基于光学整流 Cherenkov 辐射的宽带 THz 产生及薄膜靶的质子加速。



升级到 PW 峰值功率的高对比度激光装置。我们在利用新的方案提高基于 CPA 放大技术的飞秒钛宝石激光脉冲对比度的基础上（Opt Lett, Vol.35, 3096(2010)），将“极光 III”装置的最高峰值功率推进到了 1.16PW（Opt Lett，Vol.36, 3194 (2011)）。
Based on a new scheme to increase the contrast ratio of femtosecond Ti:sapphire laser pulse with chirped pulse amplification (CPA) technology (Opt Lett, Vol. 35, 3096 (2010)), we obtained an ultrahigh laser peak power up to 1.16PW from the XL-III (Extreme Light) facility. (Opt Lett, Vol. 36, 3194(2011)).

◆Intense laser power up to 1.16PW was generated from the home-made XL-III facility, which broken the world record in high power laser.

◆A new CPA technology with exchanging waves was proposed, tunable femtosecond infrared laser pulse with self-stabilized CEP was realized.

◆We demonstrated a novel way to generate the ultrafast infrared laser by DFG between two synchronized laser branches, an intracavity SHG-OPO was domestically realized for the first time.

◆Compress amplified laser to 3.8 fs, which is the shortest laser pulse domestically.

◆Novel all solid state CW and mode-locking ceramics lasers with Yb, Nd and Tm doping were realized, efficient lasers around 1um and 2 um were generated.

◆Collaborated with some groups, we realized the broad bandwidth THz radiation and accelerated protons based on the home-made femtosecond laser facilities

专利/Patents

申请专利/Patents Applied

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[2] 201110192059.1；制备半导体和热塑性有机物复合微纳结构的方法；发明；李志远 秦飞 蒙自明

[3] 201110218950.8；一种在有机溶剂中制备金属纳米颗粒的装置；发明；石洪菲 王灿 周岳亮

[4] 201110371868.9；一种静电驱动微悬臂梁结构太赫兹频段可调超吸收体；发明；胡放荣 汪力 吴忠安

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授权专利/Patents Approved

[1] ZL200810227104.0; 一种实时标定四象限探测器的方法; 发明; 郭红莲、屈娥、凌林、黄璐、李兆霖、张道中、李志远

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[5] ZL200810222553.6; 一种产生强太赫兹辐射的装置和方法; 发明; 王伟民、盛政明、张杰

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[19]. **Li Yutong** "Studies of Secondary sources driven by intense laser pulses at the Intitute of Physics, CAS", **Invited talk** on Laser and Plasma accelerators Workshop 2011, 2011.6.20-6.24, Shanghai, China.

[20]. **Wei Zhiyi** "Development of PW laser facility and attosecond laser source for the researches on frontier sciences", **Invited talk** on the JSPS Asian CORE Workshop on Next Generation Ultra-Short Pulse Lasers for High Field and Ultrafast Science, 2011.3.2-3.4, Hirosawa, Japan.

[21]. **Wei Zhiyi** "Ultrafast laser research at Institute of Physics", **Invited talk** on the Inauguration workshop schedule of MaxPlanck Center-Attosecond ScienceA, 2011.7.11-7.12, Puhang, Korea.

[22]. **Wei Zhiyi** "100 TW TI: Sapphire Laser system at 0.1 Hz", **Invited talk** on the International Conference on Inertial Fusion Sciences and Applications(IFSA)2011, 2011.9.12-9.16, Bordeaux-Lac, France.

[23]. **Wei Zhiyi** "Overview and prospect on petawat laser researches in China", **Invited talk** on the Ultrafast Optics, 2011.9.26-9.30, Monterey, USA.

[24]. **Wei Zhiyi** "Diode-Pumped Transparent Tm:YAG Ceramic Laser", **Invited talk** on the 7th Laser Ceramics Symposium: International Symposium on Transparent Ceramics for Photonic Applications, 2011.11.14-11.17, Singapore.

主办会议/Conference Sponsored by the Laboratory

第九届全国光学前沿问题讨论会

由中国物理学会光物理专业委员会和中国光学学会基础光学专业委员会主办, 中国科学院物理研究所光物理实验室承办的第九届全国光学前沿问题讨论会于 2011 年 10 月 10 日—11 月 14 日在江西九江市举行。来自全国科研院所、大专院校等 20 多个单位的 3 位院士、60 余位专家、学者和研究生代表参加了会议。

会议开场，主持人物理学会光物理专业委员会主任金奎娟研究员代表两个委员会对参会代表表示热烈欢迎。然后由中科院物理研究所杨国桢院士代表老一辈会议组织者讲话。杨国桢院士简要讲述了会议的起源，介绍了会议的开创者，经过多年的沿袭，现在交给中科院物理研究所金奎娟研究员和北京大学龚旗煌教授两位进行组织领导。会议的主旨是国内光学领域的学术交流，互相启发，特别是对年轻科学家的帮助很大。杨院士还提出了现在国内的光学研究发展很快，数量很多，但质量有待提高，所以希望通过此会大家能够互相启发，强强合作，若干年后能够有开创性的研究领域出现。

会议从收到的论文中选出 46 篇作为会议报告，其中 14 篇为大会特邀报告，经录用的论文摘要将在《量子电子学报》汇编成会议论文集发表。这些报告不仅对了解光学前沿领域的新进展有较大参考价值，而且对同行的工作也颇有启发。会议报告内容新颖丰富、学术气氛浓厚而热烈。与会代表对学术报告所函盖的光学前沿热点研究以及光学科研进展进行了深入的分析和探讨，形成生动活泼的学术气氛。不少与会代表反映，该讨论会为国内光学科研工作者提供了学术交流的讲坛，增强了相互之间的了解，有助于及时了解和把握光学科研领域的最新进展和未来的发展趋势，对促进光学在国内的深入发展起到积极的作用。

会议期间，中国物理学会光物理专业委员会和中国光学学会基础光学专业委员会召开了组委会会议，讨论了 2012 年的工作计划和下次开会的地点，决定 2012 年由两专业委员会共同主办，北京大学物理学院承办第十五届全国基础光学与光物理学术讨论会。

学位论文/Dissertations

1．博士学位论文

[1] 傅晋欣，磁光光子晶体和表面等离子体中单向波导的研究； 导师：李志远

[2] 甘 霖，光子晶体中光传输特殊效应的研究；导师：李志远

[3] 周 飞，光与金属纳米结构的表面等离子体相互作用的理论研究； 导师：李志远

[4] 周长柱，二维平板光子晶体器件的设计与应用研究； 导师：李志远

[5] 秦 飞，复合结构非线性光子晶体的设计和制备； 导师：李志远

[6] 张莉莉，氧化物低维结构光辐射—热离子制冷效应的理论研究； 导师：金奎娟

[7] 冯 辉，太赫兹系统和功能器件的研究； 导师：汪力

[8] 罗开红，光子关联的性质和应用； 导师：吴令安,傅盘铭

[9] 赵建领，量子保密通信的理论和实验研究； 导师：吴令安

[10]王首钧，激光等离子体 X 射线光谱研究； 导师：张杰

[11]朱鹏飞，基于超快电子衍射的铝晶格结构动力学研究； 导师：张杰

[12]林晓宣，超短超强激光与固体靶相互作用中超热电子输运和能量沉积以及 X 射线诊断技术的研究； 导师：张杰,李玉同

[13]郝 彪，高能粒子在稠密等离子体中输运不稳定性的动理学研究； 导师：盛政明，张杰

[14]杨 杰，具有碳纳米管微结构温稠密等离子体的理论研究；导师：张杰,董全力

[15]李芳琴，高功率高效率全固态皮秒激光器及非线性光学晶体的三阶非线性光学性质研究；导师：许祖彦

[16]谢仕永，高功率全固态第二代钠信标激光技术研究； 导师：许祖彦

[17]徐一汀，高平均功率高光束质量准连续波全固态激光技术研究；导师：许祖彦

[18]刘 成，飞秒激光脉冲放大过程中对比度及光束质量提高的研究，导师：魏志义

[19]运晨霞，周期量级超短脉冲激光的载波包络相位控制及与气体相互作用产生亚飞秒激光脉冲的研究； 导师：魏志义

[20]张 青，飞秒掺钛蓝宝石激光重复频率扩展及腔外共振增强的研究，导师：魏志义

[21]张永东，新型全固态超快激光的产生及其放大技术研究，导师：魏志义

[22]钟 欣，飞秒激光脉冲的频率变换研究，导师：魏志义

光物理系列学术报告／ Optical Physics Series Academic Report

光物理系列学术报告（五十九）

题　目：Quantum Optical Metrology -- The Lowdown on High-N00N States

报告人：Prof. Jonathan P. Dowling（Dept. of Physics & Astronomy, Louisiana State University, USA）

光物理系列学术报告（六十）

题　目：Fiber Lasers Using Specialty Glasses

报告人：Dr. Shibin Jiang（President of AdValue Photonics Inc. and Adjunct Research Professor at College of Optical Sciences, University of Arizona, USA）

光物理系列学术报告（六十一）

题　目：Femtosecond-laser-written optical waveguides for optical communications and biophotonic applications

报告人：Prof. Ajoy K Kar（School of Engineering and Physical Sciences, David Brewster Building, Heriot-Watt University, Edinburgh, EH14 4AS, Scotland.）

光物理系列学术报告（六十二）

题　目：Resistive switching in heterostructures of complex oxides

报告人：Dr. Tom Wu（School of Physical and Mathematical Science, Nanyang Technological University, Singapore.）

光物理系列学术报告（六十三）

题　目：Metal-Insulator Transitions in Ferroelectrics

报告人：Prof. Gerald D. Mahan（Pennsylvania State University, USA）

光物理系列学术报告（六十四）

题　目：THz Photonics: The Synergy of Ultrafast Optics, Electronics, Micro-Microwaves, and Quasi-Optics

报告人：Prof. Daniel R. Grischkowsky（School of Electrical and Computer Engineering, Oklahoma State University, Stillwater, Oklahoma 74078, United States of America）

光物理系列学术报告（六十五）

题　目：时间分辨 X 射线散射、衍射和反射的应用与发展

报告人：王焕华 副研究员（中科院高能所，北京同步辐射实验室）

光物理系列学术报告（六十六）

题目：Break up an atom or break down the vacuum with laser forces ?

报告人：Prof. Q. Charles Su（Illinois State University in the US）

学术组织与期刊任职/Academic Service

国际学术组织任职/Service to the International Professional Societies

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吴令安 Lingan Wu	英国物理学会北京代表处 顾问, 英国物理学会 会士 Beijing Office Consultant, Institute of Physics (UK), Fellow, Institute of Physics (UK)
魏志义 Zhiyi Wei	国际纯粹与应用物理委员会 C2 常数物理名词第二专业委员会 委员 Member, Commission on Symbols, Units, Nomenclature, Atomic Masses & Fundamental Constants, International Union of Pure and Applied Physics (IUPAP) C2 Max Planck Centre for Attosecond Science, 亚洲组成员 The 3rd International Conference on Attosecond Physics (ATTO3)， International committee number
盛政明 Zhengming Sheng	亚洲先进加速器指导委员会 委员,中日核心大学计划(中方)协调人 OECD(全球经合会组织)超短超强激光委员会委员 欧洲超强激光设施（ELI）国际顾问委员会委员 Member, Asian Advanced Accelerator Community Member, Organisation for Economic Co-operation and Development Member, Advisory Committee of the European Project Extreme Light Intrastructure

国际期刊任职/Service to International Journals

张杰 Jie Zhang	Associate Editor, Optics Express Associate Editor, Physics of Plasmas Member of Editorial Board, High Energy Density Physics Member of Editorial Board, Chemical Physics Letters Member of Editorial Board, Journal of Plasma and Fusion Research
金奎娟 Jin Kuijuan	Associate Editor, International Journal of Modern Physics B Associate Editor, Modern Physics Letters B
魏志义 Zhiyi Wei	Member of International Advisory Board, Measurement Science and Technology
盛政明 Zhengming Sheng	Member of Editorial Board, Plasma and Fusion Research (Japan) Member of Editorial Board, Communication in Computational Physics Member of Editorial Board, Plasma Science and Technology

国内学术组织任职/Service to the Domestic Professional Societies

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金奎娟	中国科学院“百人学者论坛”理事会理事（2011-至今） 中国物理学会常务理事（2011-至今） 中国物理学会光物理专业委员会 主任（2009-至今） 全国凝聚态物质光学性质学术会议学术委员会委员兼组织委员会委员（2007-至今） 中国物理学会秋季学术会议电介质分会 主席（2007-至今）
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汪　力	中国物理学会光物理专业委员会 委员
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国内期刊任职/Service to the Domestic Journals

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魏志义	《Chinese Optics Letters》常务编委 《量子电子学报》第六届编委会委员 《Journal of Measurement Science and Instrumentation》编委 《红外与激光工程》第十四届编委会编委
汪力	《光谱学和光谱分析》常务编委
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客座人员名单及客座研究课题/ Visitors List & Open Subjects

客座人员名单/Visitor List

序号	姓名	性别	专业	职称	工作单位
1	张希成	男	激光物理	教　授	美国 Rensselaer Polytechnic Institute
2	朱湘东	男	物理	教　授	美国加洲大学戴维斯分校
3	郁明阳	男	光学	教　授	德国鲁尔大学
4	俞　进	男	光学	教　授	法国里昂大学
5	曹建明	男	光学	教　授	美国佛罗里达州立大学
6	张坚地	男	材料学	教　授	美国路易斯安那大学
7	余　玮	男	光学	研究员	中科院上海光学精密机械研究所所
8	赵　刚	男	天文学	研究员	中科院国家天文台
9	李英骏	男	光学	教　授	中国矿业大学
10	张佳莹	女	激光医学	副教授	中国人民解放军总医院
11	李兆霖	男	光学	研究员	中国科学院物理研究所
12	陈正豪	女	光学	研究员	中国科学院物理研究所
13	张泽渤	男	光学	研究员	中国科学院物理研究所
14	张治国	男	光学	研究员	中国科学院物理研究所
15	顾本源	男	光学	研究员	中国科学院物理研究所
16	周岳亮	男	光学	研究员	中国科学院物理研究所
17	盛政明	男	光学	研究员	上海交通大学

实验室资助的客座研究课题/Open Subjects

序号	课题名称	负责人	职称	单位	起止时间
1	有机无机电荷转移化合物的合成及三阶非线性光学性质研究	周云山	教授	北京化工大学	2011.9-2011.12

选录论文/Selected Papers

1. A Resistive Memory in Semiconducting BiFeO3 Thin-FilmCapacitors, An Quan Jiang , Can Wang , Kui Juan Jin , Xiao Bing Liu , James F. Scott , Cheol Seong Hwang , Ting Ao Tang , Hui Bin Lu , and Guo Zhen Yang, **Advanced Materlals 23** (2011) 1277

2. Experimental Observation of Quantum Talbot Effects, Song XB, Wang HB, Xiong J, Wang K, Zhang X, Luo KH, Wu LA, **Physical Review Letters 107** (2011) 033902

3. Effect of lattice structure on energetic electron transport in solids irradiated by ultraintense laser pulses, P. McKenna, A. P. L. Robinson, D. Neely, M. P. Desjarlais, D. C. Carroll, M. N. Quinn, X. H. Yuan, C. M. Brenner, M. Burza, M. Coury, P. Gallegos, R. J. Gray, K. L. Lancaster, Y. T. Li, X. X. Lin, O. Tresca, and C.-G. Wahlström, **Physical Review Letters** 106 (2011) 185004

4. Collisionless shockwaves formed by counter-streaming laser-produced plasmas, X. Liu, Y. T. Li, Y. Zhang, J. Y. Zhong, W. D. Zheng, Q. L. Dong, M. Chen, G. Zhao, Y. Sakawa, T. Morita, Y. Kuramitsu, T. N. Kato, L. M. Chen, X. Lu, J. L. Ma, W. M. Wang, Z. M. Sheng, H. Takabe, Y-J Rhee, Y. K. Ding, S. E. Jiang, S. Y. Liu, J. Q. Zhu, and J. Zhang, **New Journal of Physics 13** (2011) 93001

5. Numerical investigation into the switchable diode effect in metal-ferroelectric-metal structures, Chen Ge, Kui-Juan Jin, Can Wang, Hui-Bin Lu, Cong Wang, and Guo-Zhen Yang, **Applied Physics Letters 99** (2011) 63509

6. Surface wave holography on designing subwavelength metallic structures, Yu-Hui Chen, Jin-Xin Fu, and Zhi-Yuan Li, **Optics Express 19** (2011) 23908

7. On-chip optical diode based on silicon photonic crystal heterojunctions, Chen Wang, Chang-Zhu Zhou, Zhi-Yuan Li, **Optics Express 19** (2011) 26948

8. High-contrast 1.16 PW Ti:sapphire laser system combined with a doubled chirped-pulse amplification scheme and a femtosecond optical-parametric amplifier, Wang ZH, Liu C, Shen ZW,Zhang Q,Teng H, and Wei ZY, **Optics Letters 36** (2011) 3194

9. Diode-pumped efficient continuous-wave Yb:Y3Ga5O12 laser at 1035nm, Zhang YD, Wei ZY, Wang Q, Li DH, Zhang ZG, Yu HH, Zhang HJ,Wang JY, and Lv L, **Optics Letters 36** (2011) 472

10. High-order harmonic generation with Rydberg atoms by using an intense few-cycle pulse, Z. Zhai, Q. Zhu, J. Chen, Z. Yan, P. Fu, B. Wang, **Physical Review A 83** (2011) 43409