

杨红，女，博士，海南师范大学物理与电子工程学院教授，博士生导师。海南省拔尖人才，海南师范大学榕树青年学者，海南师范大学第二届巾帼能手，中国民主促进会会员。主持及参与国家自然科学基金 5 项、海南省自然科学基金 9 项，发表 SCI 论文近 40 篇。指导硕士研究生人均两篇 SCI 论文，且多次获得优秀毕业生、优秀毕业生干部和省级优秀硕士毕业论文荣誉，主要从事量子光学以及量子信息交叉学科领域的研究工作，具体包括：以电磁感应光透明为基础相干操控探测光增益，一维光晶格系统中动力学调控光子带隙，基于缺陷原子晶格和均匀原子介质中破坏极化率的空间对称性实现非互易光传播、放大及非互易激光的调控等。研究成果在领域内具有重要学术影响力。同时，她牵头组建了一支综合能力强、创新潜力足的量子光学与量子信息领域科研团队，带领团队在集成光子器件研发、量子纠缠机制探索及量子计算技术突破等方向持续攻关，取得一系列具有突破性的研究进展，为该领域的发展注入强劲动力。

1. 2026 年 6 月在读研究生情况

陈端富	202412070200003	2024 级硕士研究生
彭晨	202511070201001	2025 级博士研究生
杨薏	202512070200019	2025 级硕士研究生
刘凤粉	202512070200009	2025 级硕士研究生

2. 2024 年 6 月--2026 年 6 月毕业研究生情况（三届）

李观荣	20212070200011	2021 级硕士研究生	2024 届硕士毕业生
耿玥	20212070200014	2021 级硕士研究生	2024 届硕士毕业生
林新宇	20212070200013	2021 级硕士研究生	2024 届硕士毕业生
徐琼怡	202212070200016	2022 级硕士研究生	2025 届硕士毕业生
郑怡婷	202312070200001	2023 级硕士研究生	2026 届硕士毕业生
郑鑫福	202312070200013	2023 级硕士研究生	2026 届硕士毕业生

杨红老师开设研究生课程情况（近三年）

学年、学期	课程名称	班级名称	课堂教学时数
2024-2025（一）	量子光学	24 级物理学硕士	36
2025-2026（一）	高等量子光学	25 级物理学博士	72
2025-2026（二）	科学研究方法与论文写作	25 级物理学硕士	18

国家自然科学基金 资助项目准予结题通知

杨红 同志：

您承担的国家自然科学基金项目：（基于缺陷原子晶格的非互易光传播动力学调控与应用研究），批准号：（12204137）按有关规定已审核完毕，准予结题。

与本项目资助有关的后续成果，请您继续及时报送。

祝您在研究工作中取得更好的成绩！





项目批准号	12564048
申请代码	A2205
归口管理部门	
依托单位代码	57115808A0360-0697



125640481002907

国家自然科学基金 资助项目计划书 (预算制项目)

资助类别: 地区科学基金项目

亚类说明:

附注说明:

项目名称: 基于晶格缺陷和相干增益原子系统的非互易光子激光研究

直接费用: 31万元 执行年限: 2026.01-2029.12

负责人: 杨红 BRID: 03182.00.20021

通讯地址: 海南省海口市琼山区龙昆南路99号

邮政编码: 571158 电话: 13034920596

电子邮件: yang_hongbj@126.com

依托单位: 海南师范大学

联系人: 韩晓龙 电话: 0898-65808048

填表日期: 2025年08月31日

国家自然科学基金委员会制

Version: 1.002.907



国家自然科学基金资助项目计划书填报说明

（预算制项目）

- 一、项目负责人收到《国家自然科学基金资助项目批准通知》（以下简称《批准通知》）后，请认真阅读本填报说明，参照国家自然科学基金相关项目管理办和《国家自然科学基金资助项目资金管理办法》（以下简称《资金管理办法》，请查阅国家自然科学基金委员会门户网站首页“政策法规”栏目），按《批准通知》的要求认真填写和提交《国家自然科学基金资助项目计划书》（以下简称《计划书》）。
- 二、填写《计划书》时要科学严谨、实事求是、表述清晰、准确。《计划书》经国家自然科学基金委员会相关项目管理部门审核批准后，将作为项目研究计划执行、检查和验收的依据。
- 三、《计划书》各部分填写要求如下：
 - （一）简表：由系统自动生成。
 - （二）摘要及关键词：各类获资助项目都应当填写中、英文摘要及关键词。
 - （三）项目组主要成员：计划书中列出姓名的项目组主要成员由系统自动生成，与申请书原成员保持一致，不可随意调整。如果《批准通知》所附“项目评审意见及修改意见表”中“修改意见”栏目有调整项目组成员相关要求的，待项目开始执行后，按照项目成员变更程序另行办理。
 - （四）资金预算表：根据批准的项目资助额度，按规定调整项目预算，并按照《国家自然科学基金项目计划书预算表编制说明》填报资金预算表和预算说明书。
 - （五）正文：
 1. 面上项目、地区科学基金项目：如果《批准通知》所附“项目评审意见及修改意见表”中“修改意见”栏目没有修改要求的，只需选择“研究内容和研究目标按照申请书执行”即可；如果《批准通知》中上述栏目明确要求调整研究期限或研究内容等的，须选择“根据研究方案修改意见更改”并填报相关修改内容。
 2. 重点项目、重点国际（地区）合作研究项目、重大项目、重大研究计划重点支持项目、重大研究计划集成项目、国家重大科研仪器研制项目、联合基金项目、原创探索计划项目、重大科学基础设施国际合作研究计划专项：须选择“根据研究方案修改意见更改”，根据《批准通知》的要求填写研究（研制）内容，不得自行降低、更改研究目标（或仪器研制的技术性能与主要技术指标、验收技术指标等）或缩减研究（研制）内容。此外，还要突出以下几点：
 - （1）研究的难点和在实施过程中可能遇到的问题（或仪器研制风险），拟采用的研究（研制）方案和技术路线；
 - （2）项目主要参与者分工，合作研究单位（如有）之间的关系与分工，重大项目还需说明课题之间的关联；
 - （3）详细的年度研究（研制）计划。
 3. 创新研究群体项目：须选择“根据研究方案修改意见更改”，按下列提纲撰写：

- (1) 研究方向；
 - (2) 结合国内外研究现状，说明研究工作的学术思想和科学意义（限两个页面）；
 - (3) 研究内容、研究方案及预期目标（限两个页面）；
 - (4) 年度研究计划；
 - (5) 研究队伍的组成情况。
4. 卓越研究群体项目：须选择“根据研究方案修改意见更改”，卓越研究群体项目根据《批准通知》的要求和现场考察专家组的意见和建议，进一步完善并细化研究计划。卓越研究群体项目（延续资助）根据《批准通知》的要求填写计划书即可。
- 卓越研究群体项目（含延续）按下列提纲撰写：
- (1) 五年拟开展的研究工作（包括主要研究方向、关键科学问题与研究内容）；
 - (2) 研究方案（包括骨干成员之间的分工及合作方式、学科交叉融合研究计划等）；
 - (3) 年度研究计划；
 - (4) 五年预期目标和可能取得的重大突破等；
 - (5) 研究队伍的组成情况。
5. 数学天元基金项目：天元前沿重点专项项目和数学与其他学科交叉联合资助项目，参照重点项目的方式进行选择和填写；其他类型项目，参照面上项目的方式进行选择和填写。
6. 对于其他类型项目，参照面上项目的方式进行选择和填写。

四、其他事项

- (一) 根据有关要求，国家自然科学基金资助项目研究形成的代表性论文中发表在我国科技期刊上的应占20%以上。
- (二) 国家自然科学基金资助项目研究形成的专利申请应按照《建立财政资助科研项目形成专利的声明制度实施方案》要求进行声明。

简表

项目负责人信息	姓 名	杨红	性 别	女	出生年月	1985年07月	民 族	汉族
	学 位	博士			职称	副教授		
	是否在站博士后	否		电子邮件	yang_hongbj@126.com			
	电 话	13034920596		个人网页				
	工 作 单 位	海南师范大学						
	所 在 院 系 所	物理与电子工程学院						
依托单位信息	名 称	海南师范大学					代码	57115808A0360
	联 系 人	韩晓龙		电子邮件	215304651@qq.com			
	电 话	0898-65808048		网站地址	http://www.hainnu.edu.cn			
合作单位信息	单 位 名 称							
项目基本信息	项 目 名 称	基于晶格缺陷和相干增益原子系统的非互易光子激光研究						
	资 助 类 别	地区科学基金项目				亚 类 说 明		
	附 注 说 明							
	申 请 代 码	A2205:光量子物理和量子光学						
	执 行 年 限	2026.01-2029.12						
	直 接 费 用	31万元						

项目摘要

中文摘要:

集成化、高性能非互易光子器件对量子计算和信息处理领域的发展异常重要,因此,如何在一个物理系统中同时实现非互易和激光输出是迫切要解决的问题。本项目旨在将非互易、光放大和激光震荡巧妙的在一个物理系统中实现,并对该系统中非互易激光的物理原理和特征进行深入分析和讨论。具体研究内容如下:首先,基于自发辐射相干、四波混频以及微波场作用建立相干增益原子系统,使探测光被放大。然后,利用晶格缺陷打破极化率的空间对称性,同时也能使放大的光信号在晶格中多次反射,进一步通过合理调制使探测光达到阈值条件输出非互易激光。最后,通过优化参数和设置,实现高性能、低阈值非互易激光的灵活操控;分析不同增益原子系统中耦合场强度和失谐、相干场相位以及缺陷晶格结构变化等带来的影响;探讨如何产生多模非互易激光等。该项研究在集成芯片及长距离量子通信中具有重要的应用前景,深入开展非互易激光的研究对推动当下量子科技发展具有重要意义。

Abstract:

The integrated and high-performance nonreciprocal photonic devices are extremely important in quantum computing and information processing. Therefore, how to achieve optical non-reciprocity and laser output simultaneously in one physical system is an urgent problem to be solved. The aim of this project is to ingeniously implement optical non-reciprocity, light amplification, and laser oscillation in one physical system, to analyse and discuss the physical principles and characteristics of nonreciprocal lasers deeply in this system. Detailed contents of our research plan are: Firstly, the coherent active atomic system are established based on spontaneously generated coherence, four wave mixing, and microwave field effects to amplify the probe light. Then, by utilizing lattice defects to break the spatial symmetry of probe susceptibility, the amplified light signal can also be reflected multiple times, and further modulated to achieve threshold conditions for probe light and outputting nonreciprocal laser. Finally, the flexible control of high-performance, low threshold nonreciprocal lasers can be achieved by optimizing parameters and settings; while the effects of coupling field strength and detuning, coherent field phase, and the variation of defect lattice structure in different active atomic system are also analysed; and we will explore how to generate multi-mode nonreciprocal lasers, etc. This study has important applications in integrated chips and long-distance quantum communications, which is of great significance for promoting the development of current quantum technology to research on nonreciprocal lasers in-depth.

关键词(用分号分开): 量子相干; 晶格缺陷; 非互易激光; 四波混频; 自发辐射相干

Keywords(用分号分开): Quantum coherence; lattice defect; nonreciprocal laser; four wave mixing; spontaneously generated coherence

项目组主要成员

编号	姓名	出生年月	性别	职称	学位	单位名称	电话	证件号码	项目分工	每年工 作时间 (月)				
1	杨红	1985. 07	女	副教授	博士	海南师范大学	13034920596	23230219850724 3029	项目负责人	10				
2	张廷桂	1983. 02	男	副教授	博士	海南师范大学	0898-65883210	37132619830220 641X	数学指导	5				
3	朱瑜	1994. 09	男	讲师	博士	海南师范大学	0898-65861468	33082419940916 701X	程序指导	5				
总人数			高级		中级		初级		博士后		博士生		硕士生	
10			2		1						2		5	

国家自然科学基金预算制项目预算表

项目批准号：12564048

项目负责人：杨红

金额单位：万元

行次	科目名称	金额
(1)	1. 科学基金资助项目直接费用合计	31.0000
(2)	1.1 设备费	0.0000
(3)	其中：设备购置费	0.0000
(4)	1.2 业务费	12.0000
(5)	1.3 劳务费	19.0000
(6)	2. 直接费用中合作研究外拨资金	0.0000
(7)	3. 其他来源资金	0.0000

注：1. 请按照项目研究实际需要合理填写各科目预算金额。

2. $(1) = (2) + (4) + (5)$ 。

3. 如果不存在外拨资金的情形，(6) 请填“0”。

4. 如果无其他来源资金，(7) 请填“0”。

预算说明书

1. 科学基金资助项目直接费用

请按照《国家自然科学基金项目计划书预算编制说明》等有关要求,按照政策相符性、目标相关性和经济合理性原则,实事求是编制项目预算。填报时,每个科目应结合科研任务按支出用途进行基本测算说明。

1.1 设备费(是指在项目实施过程中购置或试制专用仪器设备,对现有仪器设备进行升级改造,以及租赁外单位仪器设备而发生的费用。计算类仪器设备和软件工具可在设备费科目列支。填报时,应对设备费支出的必要性和测算的合理性等内容进行说明,并按照设备购置费、试制改造费和租赁使用费的分类提供基本测算依据。单价大于50万元(含50万元)的设备需补充说明设备的主要性能指标、主要技术参数等内容。)

无

1.2 业务费(是指项目实施过程中消耗的各种材料、辅助材料等低值易耗品的采购、运输、装卸、整理等费用,发生的测试化验加工、燃料动力、出版/文献/信息传播/知识产权事务、会议/差旅/国际合作交流等费用,以及其他相关支出。填报时,应按照支出大类进行基本测算说明。)

业务费共计12万元。其中文献/信息传播/知识产权事务费1.6万元;会议/差旅/国际合作交流等费用10.4万元。具体预算如下:

一、文献/信息传播/知识产权事务费1.6万元。

1) 文献检索、图书资料费:0.2万元/年 $\times$ 4年=0.8万元。

2) 复印、打印、装订、邮寄费合计:0.2万元/年 $\times$ 4年=0.8万元。

二、会议/差旅/国际合作交流等费用10.4万元。

1) 项目组成员访问国内专家、参加学术会议等8人次约5.6万元。预算标准:平均每次4天,每天食宿费约0.05万元,交通费约0.4万元/人次,会议费0.1万元/人次。费用约:(4天 $\times$ 0.05万元/天+0.4万元+0.1万元)/人次 $\times$ 8人次=5.6万元。

2) 国际合作与交流费4.8万元:用于课题成员到国外进行科学研究、合作交流等所需费用预算标准:计划一次45天,每天食宿费用约0.08万元,国际国内交通费约1.2万元/人次。费用约(45天 $\times$ 0.08万元/天+1.2万) $\times$ 1人次=4.8万元。

1.3 劳务费(是指在项目实施过程中支付给参与项目研究的研究生、博士后、访问学者以及项目聘用的研究人员、科研辅助人员等的劳务性费用,以及支付给临时聘请的咨询专家的费用等。填报时,应综合考量劳务费支出对象所承担研究任务的必要性、投入本项目的工作时长、费用标准的合理性等因素,按照人员类别进行基本测算说明。专家咨询费应按照国家有关规定执行。)

劳务费共计19.0万元:其中学生劳务费14.4万元,专家咨询报告费4.6万元。具体预算如下:

一、学生劳务费14.4万元。

1) 硕士生按照平均0.08万元/人/月,每年发放6个月计算,平均每年约5个在籍硕士。

费用:0.08万元/人/月 $\times$ 6个月 $\times$ 5人 $\times$ 4年=9.6万元。

2) 博士生按照平均0.1万元/人/月,每年发放6个月计算,平均每年约2个在籍博士。

费用:0.1万元/人/月 $\times$ 6个月 $\times$ 2人 $\times$ 4年=4.8万元。

二、专家咨询报告费4.6万元。

1) 咨询费按照0.08万元/人次 $\times$ 5人次/年 $\times$ 4年=1.6万元。

2) 专家报告费,预计聘请专家报告15人次,每次预算标准0.2万元/人次,0.2万元/人次 $\times$ 15人次=3.0万元。

2. 直接费用中合作研究外拨资金

需对合作研究单位承担研究任务及协商一致后确定的直接费用资金外拨情况进行必要说明。如存在多个合作研究单位,需逐一说明。

无

3. 其他来源资金

对其他来源资金的经费来源、资金具体开支用途做简要说明。

无

报告正文

研究内容和研究目标按照申请书执行。

本项目研究形成的代表性论文中发表在我国科技期刊上的将占 20%以上。

本项目研究形成的专利申请将按照《建立财政资助科研项目形成专利的声明制度实施方案》要求进行声明。

国家自然科学基金项目负责人、依托单位承诺书

国家自然科学基金项目负责人承诺书

本人郑重承诺：我接受国家自然科学基金的资助，严格遵守中共中央办公厅、国务院办公厅《关于进一步加强科研诚信建设的若干意见》《关于进一步弘扬科学家精神加强作风和学风建设的意见》《关于加强科技伦理治理的意见》《科技伦理审查办法（试行）》等规定，和国家自然科学基金委员会关于资助项目管理、项目资金管理等各项规章制度，在《计划书》填写及项目执行过程中：

（一）按照《批准通知》《国家自然科学基金资助项目计划书填报说明》的要求填写《计划书》，未自行降低、更改目标任务或约定要求，或缩减研究（研制）内容；

（二）树立“红线”意识，严格履行科研合同义务，按照《计划书》负责实施本项目（批准号：12564048），切实保证研究工作时间，按时报送有关材料，及时报告重大情况变动，不违规将科研任务转包、分包他人，不以项目实施周期外或不相关成果充抵交差；

（三）遵守科研诚信、科技伦理规范和学术道德，认真开展研究工作，对资助项目发表的论著和取得的研究成果按规定进行标注，不在非本项目资助的成果或其他无关成果上标注本项目批准号，反对无实质学术贡献者“挂名”，不在成果署名、知识产权归属等方面侵占他人合法权益，并如实报告本人及项目组成员发生的违背科研诚信要求的任何行为；

（四）尊重科研规律，弘扬科学家精神，严谨求实，追求卓越，反对浮夸浮躁、投机取巧，不人为夸大学术或技术价值，不传播未经科学验证的现象和观点；

（五）将项目资金全部用于与本项目研究工作相关的支出，并结合科研活动需要，科学合理安排项目资金支出进度；

（六）做好项目组成员的教育和管理，确保遵守以上相关要求。

如违背上述承诺，本人愿接受国家自然科学基金委员会和相关部门做出的各项处理决定。

项目负责人（签字）：

2025年9月10日

依托单位科研管理部门：

负责人（签章）：
2025年9月18日

依托单位财务管理部门：

负责人（签章）：
2025年9月9日

国家自然科学基金项目依托单位承诺书

我单位同意承担上述国家自然科学基金项目，将保证项目负责人及其研究队伍的稳定和研究项目实施所需的条件，严格遵守中共中央办公厅、国务院办公厅《关于进一步加强科研诚信建设的若干意见》《关于进一步弘扬科学家精神加强作风和学风建设的意见》《关于加强科技伦理治理的意见》《科技伦理审查办法（试行）》等规定，和国家自然科学基金委员会有关资助项目管理、项目资金管理、科研诚信管理和科技伦理管理等各项规定，并督促实施。

依托单位（公章）

2025年9月18日



国家自然科学基金资助项目签批审核表

科学处审查意见：

同意按计划执行

负责人（签章）
年 月 日



2025年 10月 23日

科学部审查意见：

同意按计划执行

负责人（签章）：
年 月 日



2025年 10月 23日

本栏目由自然科学基金委填写

项目名称：基于晶格缺陷和相干增益原子系统的非互易光子激光研究
 资助类型：地区科学基金项目
 申请代码：A2205. 光量子物理和量子光学

国家自然科学基金项目申请人和参与者承诺书

为了维护国家自然科学基金项目评审公平、公正，共同营造风清气正的科研生态，本人在此郑重承诺：严格遵守《中华人民共和国科学技术进步法》《国家自然科学基金条例》《关于进一步加强科研诚信建设的若干意见》《关于进一步弘扬科学家精神加强作风和学风建设的意见》《关于加强科技伦理治理的意见》以及科技部、自然科学基金委关于科研诚信建设有关规定和要求；申请材料信息真实准确，不含任何涉密信息或敏感信息，不含任何违反法律法规或违反科研伦理规范的内容；在国家自然科学基金项目申请、评审和执行全过程中，恪守职业规范和科学道德，遵守评审规则和工作纪律，杜绝以下行为：

- (一) 抄袭、剽窃他人申请书、论文等科研成果或者伪造、篡改研究数据、研究结论；
- (二) 购买、代写申请书；购买、代写、代投论文，虚构同行评议专家及评议意见；违规购买实验数据；
- (三) 违反成果发表规范、署名规范、引用规范，擅自标注或虚假标注科技计划等资助；
- (四) 项目计划书中故意篡改降低项目申请书中相应指标；
- (五) 以任何形式打听或散布尚未公布的评审专家名单及其他评审过程中的保密信息；
- (六) 通过各种方式和途径联系有关专家进行请托、游说、“打招呼”，违规到评审会议驻地窥探、游说、询问等干扰评审或可能影响评审公正性的行为；
- (七) 向工作人员、评审专家等提供任何形式的礼品、礼金、有价证券、支付凭证、商业预付卡、电子红包，或提供宴请、旅游、娱乐健身等任何可能影响评审公正性的活动；
- (八) 违反财经纪律和相关管理规定的行为；
- (九) 危害国家安全、损害社会公共利益、危害人体健康、违背科研诚信和科技伦理的科学技术研究开发和应用活动；
- (十) 其他弄虚作假行为。

如违背上述承诺，本人愿接受国家自然科学基金委员会和相关部门做出的各项处理决定，包括但不限于撤销科学基金资助项目，追回项目资助经费，向社会通报违规情况，取消一定期限国家自然科学基金项目申请资格，记入科研诚信严重失信行为数据库以及接受相应的党纪政务处分等。

申请人签字：

杨红

编号	主要参与者姓名 / 工作单位名称 (应与加盖公章一致) / 证件号码	签字
1	张廷桂 / 海南师范大学 / 3*****X	张廷桂
2	朱瑜 / 海南师范大学 / 3*****X	朱瑜
3		
4		
5		
6		
7		
8		
9		



项目名称： 基于品格缺陷和相干增益原子系统的非互易光子激光研究
资助类型： 地区科学基金项目
申请代码： A2205. 光量子物理和量子光学

国家自然科学基金项目申请单位承诺书

为了维护国家自然科学基金项目评审公平、公正，共同营造风清气正的科研生态，**我单位就做好国家自然科学基金申请工作做出以下承诺。**

一、认真贯彻《关于进一步加强科研诚信建设的若干意见》《关于进一步弘扬科学家精神加强作风和学风建设的意见》《关于加强科技伦理治理的意见》等文件精神。

严格遵守《国家自然科学基金条例》《科技部自然科学基金委关于进一步压实国家科技计划（专项、基金等）任务承担单位科研作风学风和科研诚信主体责任的通知》要求，建立和完善科研诚信教育、管理监督制度。

二、切实贯彻《国家自然科学基金委员会关于进一步加强依托单位科学基金管理工作的若干意见》《国家自然科学基金依托单位基金工作管理办法》，认真履行管理主体责任，加强和规范科学基金项目管理工作。认真组织项目申请工作，注重提高项目申请质量，避免通过“全民动员”、设置硬性指标、实施与是否申请项目挂钩的奖惩措施等方式盲目追求项目申请数量。

三、严格按照《2025年度国家自然科学基金项目指南》《国家自然科学基金资助项目资金管理办法》有关申请的通知通告和相关类型项目管理办法等文件要求，认真审核所有申请材料，确保本单位所有申请材料的真实性、完整性和合法性；确保在申请材料中不出现任何违反法律法规、违反科研伦理的内容；确保申请材料中没有任何涉密信息或敏感信息；确保申请人符合相应项目的申请资格；确保依托单位、合作研究单位、申请人及主要参与者不在限制申报、承担或参与财政性资金支持的科技活动的期限内。

四、在项目申请和评审活动全过程中，遵守有关评审规则和工作纪律，杜绝以下行为：

（一）以任何形式打听未公开的项目评审信息、评审专家信息及其他评审过程中的保密信息，干扰评审专家的评审工作；

（二）组织、协助或纵容申请人或参与者向评审工作人员、评审专家等提供任何形式的礼品、礼金、有价证券、支付凭证、商业预付卡、电子红包等；宴请评审工作人员、评审专家，或向评审工作人员、评审专家提供任何可能影响科学基金评审公正性的活动；

（三）支持申请人采取任何不正当手段获取国家自然科学基金项目申请资格；

（四）支持申请人或参与者虚假申报项目，甚至骗取国家自然科学基金项目；

（五）支持申请人或参与者采取“打招呼”“围会”等方式影响科学基金项目评审的公正性；

（六）拖延、包庇、阻碍、干扰请托案件等不端行为调查；

（七）其他违反财经纪律和相关管理规定的行为。

五、不从事危害国家安全、损害社会公共利益、危害人体健康、违背科研诚信和科技伦理的科学技术研究开发和应用活动。

如违背上述承诺，本单位愿接受自然科学基金委和相关部门做出的各项处理决定，包括但不限于停拨或核减经费、追回项目已拨经费、取消本单位一定期限国家自然科学基金项目申请资格、记入科研诚信严重失信行为数据库以及主要责任人接受相应党纪政务处分等。

依托单位公章：

日期：2025年9月18日

合作研究单位公章：

日期： 年 月 日

合作研究单位公章：

日期： 年 月 日

代表性论文说明

15 篇代表作第一作者均为学生，导师为通讯作者，故导师论文和研究生论文佐证材料为同一份

具体如下：

1. **Xinfu Zheng**, Chen Peng, Duanfu Chen, Tinggui Zhang, Hanxiao Zhang, Dong Yan, Jinhui Wu and **Hong Yang***, Modulation of unidirectional reflection lasing via the dual mechanisms of destructive interference and asymmetric distributed feedback, **Phys. Rev. App.**, **25**, 064011 (2026).

第一作者：郑鑫福（2023级硕士研究生）

2. **Duanfu Chen**, Xinfu Zheng, Chen Peng, Yiting Zheng, Dong Yan, Hanxiao Zhang and **Hong Yang***, Unidirectional reflection lasing via microwave modulation in defective atomic lattice, **Opt. Express**, **34** (10): 17440-17460 (2026). 第一作者：陈端富（2024级硕士研究生）

3. **Chen Peng**, Xinfu Zheng, Duanfu Chen, Hanxiao Zhang, Dong Yan, Jinhui Wu and **Hong Yang***, Unidirectional spectral singularity lasing in a defective atomic lattice, **Opt. Express**, **34** (9): 17320-17333 (2026). 第一作者：彭晨（2025级博士研究生）

4. **Yiting Zheng**, Chen Peng, Guanrong Li, Xinfu Zheng, Duanfu Chen, Dong Yan, Hanxiao Zhang, Yan Zhang and **Hong Yang***, Unidirectional reflection amplification without inversion, **Phys. Rev. A**, **113**, 033112 (2026). 第一作者：郑怡婷（2023 级硕士研究生）

5. **Qiongyi Xu**, Chen Peng, Duanfu Chen, Hanxiao Zhang, Dong Yan and **Hong Yang***, Amplified nonreciprocal and unidirectional reflection in a defective atomic lattice via spontaneously generated coherence, **Optics Continuum**, **5** (4), 1184-1197 (2026). 第一作者：徐琼怡（2022级硕士研究生）

6. **Yiting Zheng**, Xinfu Zheng, Chen Peng, Duanfu Chen, Hanxiao Zhang, Dong Yan and **Hong Yang***, Multicolored unidirectional reflection amplification based on two-photon resonance in the defective atomic lattice, **Opt. Express**, **33** (23): 49639-49651 (2025). 第一作者：郑怡婷（2023级硕士研究生）

7. Xu Qiong -Yi, Zhang Jin, Zheng Yi-ting, Yan Dong, Zhang Han-xiao, **Yang Hong***, Nonreciprocal reflection in one-dimensional quasi-periodic defective atomic lattice, *Acta Phys. Sin.*, **74** (11), 116402 (2025). 第一作者：徐琼怡（2022级硕士研究生）

8. **Yue Geng**, Chen Peng, Xinfu Zheng, Dong Yan, Han-xiao Zhang, Jinhui Wu and **Hong Yang***, Unidirectional amplified reflections based on four-wave mixing and spontaneously generated coherence, *Phys. Lett. A*, **534**, 130241 (2025). 第一作者：耿玥（2021级硕士研究生）

9. **Qiongyi Xu**, Guangrong Li, Yiting Zheng, Dong Yan, Hanxiao Zhang, Tinggui Zhang, and **Hong Yang***, “Broadband unidirectional reflection amplification in a one-dimensional defective atomic lattice” **Phys. Rev. A**, **110**, 063724 (2024). 第一作者: 徐琼怡 (2022级硕士研究生)

10. **Tian-ming Li**, **Hong Yang***, Mao-hua Wang, Chen-ping, Yin, Ting-gui Zhang *, and Yan Zhang *, “Unidirectional photonic reflector using a defective atomic lattice” **Phys. Rev. Research**, **6**, 023122 (2024). 第一作者: 李天明 (2016级本科生)

11. **Xin-yu Lin**, Xinfu Zheng, Yue Geng , Guanrong Li, Qiongyi Xu, Jinhui Wu, Dong Yan *, and **Hong Yang ***, Amplified Nonreciprocal Reflection in a Uniform Atomic Medium with the Help of Spontaneous Emissions, **Photonics** , **11**, 389 (2024). 第一作者: 林新宇 (2021级硕士研究生)

12. **Li Guang-Rong**, Zheng Yi -Ting, Xu Qiong -Yi, Pei Xiao -Shan Geng Yue Yan Dong **Yang Hong***; Perfect non-reciprocal reflection amplification in closed loop coherent gain atomic syste, *Acta Phys. Sin.*, **73**(12), 126401 (2024). 第一作者: 李观荣 (2021级硕士研究生)

13. **Guan-rong Li**, Yue Geng, Xiao-shan Pei, Jin-hui Wu, Xin-Yu Lin, Dong Yan, Han-xiao Zhang, and **Hong Yang***, Phase and detuning control of the unidirectional reflection amplification based on the broken spatial symmetry, *Opt. Express*, **32** (7): 12839-12851 (2024). 第一作者: 李观荣 (2021 级硕士研究生)

14. **Yue Geng**, Xiao-shan Pei, Guan-rong Li, Xin-Yu Lin, Han-xiao Zhang, Dong Yan, and **Hong Yang***, spatial susceptibility modulation and controlled unidirectional reflection amplification via four-wave mixing, **Opt. Express**, **31** (23): 38228-38239 (2023). 第一作者: 耿玥 (2021 级硕士研究生)

15. **Xiao-shan Pei**, Han-xiao Zhang, Meng-mei Pan, Yue Geng, Tian-ming Li, and **Hong Yang***, Two-color unidirectional reflections by modulating the spatial susceptibility in a homogeneous atomic medium, **Opt. Express**, **31** (9): 14694-14704 (2023). 第一作者: 裴笑山 (2020 级硕士研究生)

Modulation of unidirectional reflection lasing via the dual mechanisms of destructive interference and asymmetric distributed feedback

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(Received 7 January 2026; revised 18 March 2026; accepted 11 May 2026; published 3 June 2026)

The ingenious scheme we propose for achieving unidirectional reflection lasing (URL) onset involves integrating a one-dimensional defective atomic lattice with a coherent-gain atomic system. Its physical essence lies in the fact that the right-side reflectivity is drastically reduced due to the destructive interference between direct and secondary reflections, whereas on the left-side direct reflection is effectively suppressed and the secondary reflection is efficiently enhanced, ultimately reaching the lasing threshold. Through numerical results and further analyses, we have elucidated how to precisely tailor the lattice parameters and coupling fields to control the destructive-interference point, thereby enabling the onset and active modulation of URL. Our scheme not only effectively circumvents the stringent structural-parameter tuning process required to directly reach the URL onset, but also benefits the integration of active photonic devices into compact quantum networks and may improve the efficiency of optical information transmission.

DOI: [10.1103/ws6v-b98c](https://doi.org/10.1103/ws6v-b98c)

I. INTRODUCTION

In the past decade or so, optical nonreciprocity has garnered extensive research attention. From the irreversible manipulation based on the magneto-optical Faraday effect [1,2] to the establishment of magnet-free optical nonreciprocal systems [3–15], and further from the perfect nonreciprocity of unidirectional light propagation [16–20] to the realization of unidirectional light amplification [21–25] and unidirectional lasing [26–28], research in this field has been steadily advancing toward integrated high-performance photonic devices. In particular, magnet-free unidirectional lasing not only protects lasers to ensure their stable operation but also isolates backscattered light [29–33], avoids unnecessary reflections and crosstalk, and safeguards fragile light sources. As the foundation of nonreciprocal photonic networks, it further promotes the development of integrated photonic devices [34–39].

So far, achieving higher precision in chip-integrated all-optical controlled nonreciprocal devices has remained a significant challenge. Nevertheless, substantial progress has been made in the research of nonreciprocal lasing

across diverse physical systems; for example, the nonreciprocal Brillouin lasing within silicon waveguides [40–43], the nonreciprocal magnon lasing in a hybrid-cavity optomagnonic system [44–46], and the nonreciprocal phonon lasing in coupled optomechanical and nonlinear-optical resonators [47,48]. However, the unidirectional lasing that can be an indispensable component of photonic integrated circuitry requires more ingenious design and precise control. Unidirectional lasing modes associated with the frozen-mode regime of nonreciprocal slow-wave structures have been proposed, which can only exist in cavities with broken time-reversal and space-inversion symmetries [22,49]. Stable unidirectional lasing in ring resonators has been investigated by adding an S-shaped waveguide element to the ring resonator to form a so-called “Taiji” resonator (TJR) [50,51]. Evidently, the combination of nonreciprocity and optical cavities is the core mechanism for achieving nonreciprocal lasing or unidirectional lasing [52,53]. However, cavity losses induced by factors such as diffraction effects and mode competition, coupled with mode-stability issues, represent critical bottlenecks limiting the performance enhancement of cavity-based lasing. Despite continuous technological innovations driving devices to constantly break physical limits in terms of output power and beam quality, developing a system capable

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Unidirectional reflection lasing via microwave modulation in defective atomic lattice

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Abstract: Unidirectional lasing is highly desirable for practical high-performance quantum information processing platforms, while most existing schemes still rely on the combination of resonant cavities and nonreciprocal mechanisms. Here, we propose a cavity-free scheme for achieving the onset of narrowband unidirectional reflection lasing (URL) in a single physical system by introducing a coherent gain atomic medium into a one-dimensional defective atomic lattice, where the former amplifies the probe field and the latter provides spatial symmetry breaking and a distributed-feedback mechanism. We show that the threshold condition for URL, characterized by $\lambda_+^{-1} \simeq \lambda_-^{-1} \rightarrow 0$, can be tuned from single-mode to dual-mode by varying the microwave field and the lattice structure. Its underlying mechanism lies in the constructive or destructive interference between the reflections from both sides under distinct Bragg conditions.

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1. Introduction

Optical nonreciprocity has important applications in unidirectional quantum information transfer and integrated photonic networks because of the unique characteristics of nonreciprocal light propagation [1–8]. Driven by the crucial applications of nonreciprocity, extensive experimental and theoretical studies have been carried out in diverse physical systems in recent years. Examples include parity-time (PT)-symmetric systems [9–12], space symmetry breaking systems [13–15], cavity optomechanical systems [16–22] and the self-induced isolation of optical signals without any external bias field, which is based on a nonlinear nonreciprocal susceptibility mechanism in optical media and has been experimentally realized [23]. Different physical systems exhibit distinct characteristics and advantages, yet the shared objective of researchers is to realize tunable, miniaturized, and high-efficiency nonreciprocal photonic devices. Therefore, further exploration of nonreciprocal optical amplification based on the integration of gain media and nonreciprocal mechanisms remains highly desirable. For instance, the amplified unidirectional reflection has been realized in coherent active atomic systems with spatially varying coupling fields [24,25]; unidirectional amplification has also been demonstrated in the hot atom system due to the Doppler shifts [26,27]. Specifically, based on the reflection effect of resonant cavities, nonreciprocal optical amplification has developed more rapidly in cavity optomechanical systems [28–30], including whispering-gallery microcavities [31,32], ring resonators [33,34] and Taiji resonators [35].

Compared with nonreciprocal optical amplification, unidirectional lasing (UL) exhibits ultrahigh spatial coherence, excellent directional consistency, and superior beam quality. In addition, UL based on exceptional points (EPs) provides a useful platform for investigating the mode evolution and topological phase transitions in non-Hermitian systems, serving as an ideal platform for exploring what we believe to be new principles of nonreciprocal photonic devices [36–38]. At present, research on UL is mainly focused on resonant cavity systems, since single-mode, narrow-linewidth lasing can typically be achieved via the mode selection of resonant cavities [39–41]. Stable UL has been demonstrated in Taiji resonators—structures formed by integrating an S-shaped waveguide element into a conventional ring resonator—and is



Unidirectional spectral singularity lasing in a defective atomic lattice

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Abstract: We propose an efficient scheme for achieving mode-tunable unidirectional reflection lasing (URL) by establishing a coherent gain atomic system to amplify the probe field and ingeniously designing a one-dimensional (1D) defective atomic lattice. This lattice not only replaces the resonant cavity to provide a distributed feedback mechanism but also breaks the spatial symmetry of the probe susceptibility. Correspondingly, the URL can be characterized by a non-Hermitian degenerate spectral singularity (NHDSS), where the two eigenvalues of the inverse scattering matrix are engineered to satisfy $\lambda_{S-1}^+ \approx \lambda_{S-1}^- \rightarrow 0$. This intriguing NHDSS depends on the probe susceptibility and the Bragg condition, both of which can be modulated by adjusting the external driving fields and lattice structure, rendering the scheme experimentally feasible. Our approach achieves both nonreciprocity and lasing oscillation in a single system, significantly enhancing the efficiency of optical information transmission and facilitating the integration of active photonic devices into compact quantum networks.

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1. Introduction

The nonreciprocal laser, which is usually based on nonreciprocal amplification, has significant applications in quantum networks and optical information processing due to its high efficiency, high density, and narrow linewidth [1–3]. Nonreciprocal amplification [4–6] enables the amplification of sensitive and fragile weak signals in quantum systems, while isolating them from external noise induced by backscattering [7–10], a phenomenon that has been extensively investigated in numerous active systems [11–15]. However, the realization of nonreciprocal lasers requires not only a gain medium but also an optical resonator. For instance, in a system composed of a spinning microwave resonator coupled to a magnetic material, a nonreciprocal phonon laser can be realized by leveraging the Fizeau light-dragging effect [16]. Alternatively, the optical Sagnac effect can be exploited in a coupled cavity system consisting of an optomechanical resonator and a spinning resonator, to achieve the same result [17]. Besides, directional phonon lasers can be realized by coupling optomechanical resonators to nonlinear optical resonators [18]. This type of nonreciprocal phonon device, characterized by directionally amplified phonon flow, can be applied to chiral phonon transport, phonon isolation, unidirectional mechanical networks, and invisible acoustic sensing, among others [19–22]. Similar to the rapid development of phonon lasers, magnon lasers utilizing magnon-induced Brillouin scattering have also seen rapid progress. The manipulation of nonreciprocal magnon lasers can be effectively achieved through the Fizeau light migration effect in both optical cavity [23–26] and parity-time (PT)-symmetric cavities optomagnonic systems [3,27], where the effect is caused by resonator rotation.

It can be seen that the resonator cavity plays a crucial role in both phonon lasers and magnon lasers. Similarly, the realization of nonreciprocal photonic lasers is generally based on resonator cavity systems, where optical signals achieve the threshold condition through repeated oscillation

Unidirectional reflection amplification without inversion

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(Received 20 October 2025; accepted 2 March 2026; published 27 March 2026)

Unidirectional reflection amplification is a desirable functionality for nonreciprocal photonic components. We propose an inversionless route to this effect in a homogeneous ensemble of a three-level Λ -type atomic system using a spatially graded coupling field. The linear position dependence of the coupling strength breaks the spatial symmetry of the optical susceptibility, enabling strong reflection from one side while suppressing the counterpropagating reflection channel. With the assistance of spontaneously generated coherence and a weak incoherent pumping field, the medium provides coherent gain without population inversion, resulting in essentially unidirectional reflection amplification, including the emergence of dual amplification bands. Moreover, both the magnitude and spectral location of the amplification can be reconfigured by tuning the relative phase, detuning, and intensity of the coupling field, offering flexible control over the nonreciprocal response. These results establish a simple, nonmagnetic, and highly tunable platform for realizing reflection-type nonreciprocal amplifiers and related functionalities, with potential applications in quantum optics and integrated photonic devices.

DOI: [10.1103/1lhc-srq7](https://doi.org/10.1103/1lhc-srq7)

I. INTRODUCTION

Optical nonreciprocal transmission aims to enable light to behave as electrons in a circuit diode, allowing only one-way propagation. With the rapid advancement of quantum information technology, optical nonreciprocal devices such as all-optical diodes, isolators, and circulators have been extensively studied as fundamental components of quantum circuits. Traditionally, reciprocity is broken by disrupting time-reversal symmetry through the Faraday magneto-optical effect, but such devices rely on strong magnetic fields and are bulky, making them incompatible with integrated circuits and limiting their practical applications. To address these limitations, numerous nonmagnetic nonreciprocal solutions have been proposed, such as spatial-temporal refractive-index modulations [1–6], optical nonlinearity effects in media [7–14], asymmetric coupling of atomic states [15–20], optomechanical systems [21,22], and the Doppler effect [23–26].

In quantum information systems, amplifying optical signals is essential to enhance the robustness of quantum systems against interference. In recent years, researchers have developed various nonreciprocal amplification schemes in diverse systems, such as Josephson circuits [27,28], non-Hermitian time Floquet systems [29,30], and even-odd time symmetric structures [31,32]. Additionally, in silicon photonic device technologies, nonreciprocal amplification based on Brillouin scattering within silicon waveguides has become

central to the development of high-performance photonic devices [33–36]. Cavity optomechanics has also emerged as a critical platform for designing on-chip high-performance nonreciprocal devices, including microwave amplification using cavity magnonic systems [37,38], unidirectional amplification in whispering-gallery cavities [39,40], and nonreciprocal phonon lasing in coupled cavity systems involving optomechanical and spinning resonators [41–43], as well as other innovative approaches [44–48].

Spontaneously generated coherence (SGC) [49–53], also referred to as vacuum-induced coherence [54–56], induces destructive quantum interference between multiple quantum pathways and has been experimentally demonstrated in atomic ensembles. Studies on SGC-induced absorption dispersion characteristics under various models [57–63] have shown that while absorption is significantly reduced, spontaneous radiation coherence alone cannot generate gain in the system. Although pumping can excite particles from lower- to higher-energy levels, low-power pumping fails to achieve population inversion and thus cannot produce sufficient gain. Therefore, the synergistic effect of the SGC and incoherent pumping field has been widely applied, e.g., in the manipulation of optical vortex field and optical switching [64,65].

In this work, we propose a three-level Λ -type atomic system that leverages low-power incoherent pumping and the SGC effect to achieve atomic coherent gain, enabling reflected light amplification. The coherent gain mechanism is driven by the combined influence of the pumping field and SGC. By engineering a position-dependent coupling field, we demonstrate nonreciprocal amplification in the left and right reflection channels of the probe light, achieving significant amplification within specific frequency ranges.

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Amplified nonreciprocal and unidirectional reflection in a defective atomic lattice via spontaneously generated coherence

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Abstract: Simultaneously realizing nonreciprocity and signal amplification in the same physical system cannot only greatly enhance the efficiency of nonreciprocal photonic devices but also facilitate their integration. We propose a scheme to achieve gain-assisted nonreciprocal or even unidirectional reflection amplification by exploring spontaneously generated coherence (SGC) activated by a weak incoherent pump in a defective atomic lattice. The numerical results show that the monochromatic to two-color nonreciprocal reflection amplification (the maximum of reflectivities $R_l \approx 10^4$ and $R_r \approx 10^2$), and even unidirectional reflection amplification ($R_l \approx 10^2$ and $R_r \approx 10^{-4}$) can be modulated freely by adjusting the relative phase ϕ , the dipole moment angle θ and the parameters of defective atomic lattice, e.g., the number and period of vacant lattice cells, the period of filled lattice cells, and so on. This indicates that nonreciprocal reflection amplification can be enhanced and modulated via the SGC effect and multiple reflections within the atomic lattice. Such efficient nonreciprocal amplification can be effectively applied to integrated chips, thereby advancing the development of quantum information technology.

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1. Introduction

Optical nonreciprocity refers to the phenomenon where the transmission path's response is no longer symmetric when the source and observation points are swapped during the light propagation. This characteristic is crucial in designing nonreciprocal optical devices, such as optical isolators, circulators, and phase shifters [1–6]. These devices have boosted the development of optical signal processing, optical communication, and quantum networks [7–9]. However, optical signals may weaken or even disappear due to the interaction with the environment during propagation. The amplified nonreciprocal transmission can more efficiently protect coherent information processing against noise and backscattering benefiting from the advantages of signal amplification and optical nonreciprocity [10–13], which have attracted a great deal of research interest and demonstrated in various systems [14–16]. The physical essence is mainly based on the magneto-optical Faraday effect, optical nonlinearity, and time-reversal symmetry breaking, chiral materials, and topological photonics systems [17–23]. For instance, nonreciprocal amplification has been achieved in silicon waveguides through Brillouin scattering [24–26], active optomechanics systems [27–31], atomic systems [32–36], and parity-time (PT) symmetry systems [37,38]. It is believed that the above systems are powerful tools for the development of nonreciprocal optical amplification. However, each system has its own advantages and limitations, e.g., Faraday effect in magneto-optical medium is incompatible with integrated circuit technology, optical nonlinearity requires high power that is typically suitable for pulse systems, PT-symmetry system often requires complex external driving fields and so on. Therefore, more effective nonreciprocal optical amplification schemes need to be studied.



Multicolored unidirectional reflection amplification based on two-photon resonance in the defective atomic lattice

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Abstract: Improving the performance of non-reciprocal photonic devices is one of the key factors for promoting the development of quantum networks. To achieve this goal, we propose a scheme to realize multicolored unidirectional reflection amplification in the defective atomic lattice, with all atoms trapped in each filled lattice cell being driven into a four-level diamond-type coherent gain atomic system by two coupling fields and two probe fields. Therefore, this scheme simultaneously achieves light amplification (resulting from the joint effect of the coherent gain atomic system and the distributed feedback mechanism of the atomic lattice) and non-reciprocity (arising from the symmetry-breaking effect of the defective atomic lattice) in a single physical system. Furthermore, we propose a reasonable scheme for obtaining equivalent results by reducing the energy level structure, and through numerical simulations and calculations, it is concluded that perfect unidirectional reflection amplification requires that the two-photon resonance is not only located in the gain region, but also satisfies the Bragg condition. This scheme can be used to design non-reciprocal photonic devices that are easily integrable, high-efficiency, and capable of flexible multi-channel manipulation.

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1. Introduction

Non-reciprocity is an exotic property of certain materials, e.g., time crystals, chiral materials and magnetic materials, etc [1–5]. However, establishing different physical systems to manipulate the non-reciprocity of light propagation [6–10] has greater degrees of freedom and adjustability, that can be widely used to design new photonic devices such as diodes and isolators, which plays an important role in the fields of quantum networks and quantum information processing [11–15]. High-performance nonreciprocal light propagation can simultaneously amplify the weak signal output by the quantum system and isolate the sensitive quantum system from the backscattered external noise, this requires more perfect non-reciprocity of amplified light signal, that is, unidirectional optical amplification, has aroused widespread research interest in recent years [16–18].

The purpose of achieving unidirectional optical amplification is to improve the efficiency of photonic devices. This can be achieved by completely suppressing the propagation of light signal on one side and amplifying the light signal on the other side. Our recent works have focused on studying unidirectional light amplification (on one side, the reflectivity is suppressed as low as 10^{-2} , while on the other side, it reaches as high as 10^2 .) in a uniform cold atomic medium, based on the spatial symmetry breaking effect and skillfully designed coherent active atomic system [19–21]. However, in the hot atomic system by exploiting Doppler shifts, a high transmissivity of 400 on one side and almost zero transmissivity on the other side have been achieved [12,22–24]. Especially, the whispering-gallery cavity [25,26], ring resonator [25,27] and other optical cavities [28–33] play an important role in unidirectional light propagation. In addition, photonic crystals [34], Josephson circuit [35,36], and non-Hermitian time Floquet systems [37] and other systems

一维准周期缺陷原子晶格中非互易光反射*

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(2025 年 3 月 3 日收到; 2025 年 3 月 25 日收到修改稿)

光学非互易性因其能够有效地用于全光二极管、隔离器等新型光子器件的设计, 近年来相关研究备受关注. 本研究组在 2024 年利用晶格缺陷打破极化率空间对称性实现了非互易光反射, 该工作中缺陷是由固定数量空晶格周期性调制的. 为了进一步展开缺陷原子晶格中非互易光传播特性的研究, 我们提出用斐波那契数列调控空晶格的排布规律, 构成准周期缺陷原子晶格系统, 实现了探测光左右反射非互易的操控. 分析了单个准周期中满晶格数量、斐波那契数列和准周期数对非互易反射的优化过程以及产生影响的物理实质, 并讨论了耦合场失谐对非互易频率域和带宽的调制. 这些结果为宽频、对比度高的非互易光反射调控提供了更多的自由度, 在量子计算和信息处理领域具有潜在的应用.

关键词: 非互易反射, 缺陷原子晶格, 空间对称破缺**PACS:** 64.70.Tg, 03.67.-a, 03.65.Ud, 75.10.Jm**DOI:** 10.7498/aps.74.20250270**CSTR:** 32037.14.aps.74.20250270

1 引言

一般来讲, 基于时间反演对称性, 光波在介质中传播也具有对称性, 这是厄米物理系统的基本性质. 然而, 在某些实际应用中需要打破这种时间反演对称性, 例如, 当信号发射端和接收端连接在同一信道、信号源需要与负载隔离时等. 基于对称破缺效应, 实现光传播的非互易性可用于设计全光二极管、隔离器、循环器等新型光子器件. 这些器件具有单向导通性, 在光信息处理和量子网络等方面具有重要应用^[1-5]. 因此, 光传播非互易性的研究在信息科学、工程科学等领域具有重要意义^[6-8]. 破坏时间反演对称性的机制主要是基于线性磁光法拉第效应, 在外加磁场作用下, 介质的电磁参数在时间反演操作下发生变化. 但该机制往往需要庞大的

磁体, 不易集成^[9-12]. 近年来, 随着对集成化需求的增大, 人们对无磁材料非互易性的研究取得重大进展. 基于光学非线性效应破坏时间反演对称性, 调节微腔和波导之间的距离, 使得耦合效率呈现非互易特性^[13,14]. 在回音壁模式微腔中, 通过调节两个耦合腔的增益和吸收建立非厄米系统实现光场的非互易传输^[15,16]. 利用介电常数的时空调制, 实现了宽带的非互易光隔离^[17,18], 并进一步在带间跃迁中获得波长可调的非互易光信号^[19,20]. 在光机系统中, 通过打破光学微腔与光子偏振态耦合的对称性能够实现经典光以及单光子水平的光学非互易^[21-26]. 此外, 空间对称破缺效应主要影响光在空间的传播特性, 能够在不破坏时间反演对称性的情况下实现光传播的非互易性. 例如, 基于多普勒效应的原理, 将热原子嵌入环形腔中, 原子的随机热运动产生了极化率动量锁定, 建立一种新型的非互易光学系统,

* 国家自然科学基金 (批准号: 12204137) 和海南省研究生创新科研课题 (批准号: Qhys2023-394) 资助的课题.

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Discussion

Unidirectional amplified reflections based on four-wave mixing and spontaneously generated coherence

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ARTICLE INFO

Communicated by S. Khonina

ABSTRACT

The ability to realize unidirectionality and signal amplification in the same device has become an urgent demand, with the increasingly high requirements for integrating signal processing devices. We propose a feasible scheme to achieve amplified unidirectional reflection in a coherent active atomic system via four-wave mixing (FWM) and spontaneously generated coherence (SGC), based on symmetry breaking caused by the spatially linear modulation of coupling on symmetry breaking caused by the spatially linear modulation of coupling fields. Specifically, a narrowed and amplified unidirectional reflection band can be generated in the weak-coupling regime of light-atom interactions with the combination of FWM and SGC, which can be modulated by the relative phase ϕ and dipole angle θ . This high and narrow band yields low out-of-band noise, which can prove more advantageous for many on-chip functionalities.

1. Introduction

All-optical diodes, isolators and circulators, serve as fundamental elements in integrated quantum circuits have attracted intensive research, for its important potential applications in quantum information technology [1–5]. High-performance nonreciprocal amplification is an essential functionality in integrated photonic circuits, which can simultaneously amplify the weak signal output by the quantum system and isolate the sensitive quantum system from the backscattered external noise [6,7]. However, under normal conditions, the nonreciprocal and amplified devices are independent of each other in the information network, each performing its own function separately. It is an urgent demand to simultaneously manipulate optical nonreciprocity and signal amplification in the same device, for the increasingly high requirements of integrating signal processing devices.

Up to now, various promising physical systems have been proposed for nonreciprocal optical amplification. Such as Josephson circuit [8,9], non-Hermitian time Floquet systems [10,11], and parity-time symmetric structures [12,13], and these seem to be the intensively studied fields in nonreciprocal amplification and asymmetric lasing of active systems.

Additionally, in silicon photonic device technologies, the nonreciprocal amplified light signal within silicon waveguides based Brillouin scattering is central to the development of high-performance photonic devices [14–17]. Cavity optomechanics is also playing an increasingly important role in making and steering on-chip high-performance nonreciprocal devices, including microwave amplification using a cavity magnonic system [18,19], the unidirectional amplification in whispering-gallery cavity [20,21], the nonreciprocal phonon lasing in a coupled cavity system composed of an optomechanical resonator and a spinning resonator [22–24], and others [25–29]. The optical cavity plays an important role in nonreciprocal amplification for its feedback effect, and atoms coupled with the optical cavity are also a feasible regime [30]. However, it is promising to explore more functions and applications by manipulating nonreciprocal amplification in atomic system. The nonreciprocal amplification based on four-level hot atoms by exploiting atomic Doppler shifts opens up a new avenue towards realistic devices based on nonreciprocal amplification [31,32].

Recently, our two works have focused on studying nonreciprocal reflection amplification in a uniform atomic medium, based on the spatial symmetry breaking effect and skillfully designed coherent active

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<https://doi.org/10.1016/j.physleta.2025.130241>

Received 29 November 2024; Received in revised form 3 January 2025; Accepted 6 January 2025

Broadband unidirectional reflection amplification in a one-dimensional defective atomic latticeQiongyi Xu,¹ Guangrong Li,¹ Yiting Zheng,¹ Dong Yan[✉],¹ Hanxiao Zhang,¹ Tinggui Zhang,² and Hong Yang^{1,*}¹*School of Physics and Electronic Engineering, Hainan Normal University, Haikou 571158, People's Republic of China*²*School of Mathematics and Statistics, Hainan Normal University, Haikou 571158, People's Republic of China*

(Received 21 August 2024; accepted 10 December 2024; published 27 December 2024)

Assisted by the probe gain, we propose a scheme to realize the amplified unidirectional broadband reflection in a one-dimensional defective atomic lattice. In this system, some lattice cells are intentionally designed to prevent atom trapping and exhibit a periodic distribution, in order to break the spatial symmetry of light propagation and form a well reflection band. While the filled lattice cells of ^{87}Rb atoms are driven into the closed three-level Δ -type configuration, which can realize the amplification of the probe field. By optimizing parameters and reasonable settings, it is obvious that our scheme not only yields a flexible and adjustable broadband unidirectional reflection amplification, but also has reduced the requirement for probe gain and greatly shortened the length of defective atomic lattices.

DOI: [10.1103/PhysRevA.110.063724](https://doi.org/10.1103/PhysRevA.110.063724)**I. INTRODUCTION**

The optical nonreciprocity refers to allowing the one direction transmission or reflection and prohibits the opposite direction, which can be used to design all optical diodes, isolators, and other nonreciprocity devices [1–5]. Optical nonreciprocal devices need to both transmit information in the desired direction while isolating the backscattered noise. Therefore, they play an important role in optimizing system performance by suppressing undesired signal paths, noises, and spurious modes [6–8]. However, every quantum system inevitably interacts with its environment, and the quantum properties e.g., coherence, entanglement, etc. could be lost. It is an urgent demand to manipulate optical nonreciprocity amplification in photonic circuits, which can amplify the optical signals and reducing noise.

In general, it is relatively easy that the nonreciprocal and gain devices are performing their own function separately. Thus, that the nonreciprocity and signal amplification are realized in one device has been the central goal in many works, with the increasingly high requirements of integrated devices. In recent years, significant progress has been made in the nonreciprocal, even unidirectional amplification of a signal, including electromagnetic wave radiation, transmission, and reflection in various specific physical systems [9–11]. For example, the unidirectional signal amplification is mainly achieved in silicon waveguides based on Brillouin scattering [12–14], and it can also be realized by adding non-Hermiticity into time-varying systems [15–17]. In addition, Josephson circuit [18,19], parity-time symmetric structures [20–22], whispering-gallery microcavities [23,24], fiber-guided system [25,26], and atomic ensembles [27,28] are also the intensively studied fields in nonreciprocal amplification. Specifically, extensive research on nonreciprocal amplification has been conducted on optomechanical systems [29–32]. For the transmission behavior of a weak signals

can be enhanced significantly assisted by another strong control field [33–35], or a strong input field based on the nonlinear interaction without introducing the additional strong control field [36,37] based on optomechanical systems. The optical cavity plays an important role in nonreciprocal amplification for its feedback effect. Therefore, high-quality resonant cavities are needed. However, our recent works have achieved amplified unidirectional reflection in the coherent active atomic system, based on a symmetry breaking caused by the spatially linear variation of coupling fields [38–40]. Thus uniform atomic schemes are able to be implemented in experiments.

Nonreciprocal amplification in a uniform atomic medium requires a relatively strong gain, as there is no assistance of optical cavity. However, one-dimensional (1D) atomic lattices, like an optical cavity, can serve as a good distributed feedback mechanism, in which the probe light can form wide photonic bandgaps [41–46]. In addition, it has been used to fabricate non-Hermitian optical materials satisfying (anti-) parity-time symmetry [47–50] or spatial Kramers-Kronig modulation [51], and achieve the manipulation of optical nonreciprocity under appropriate modulation of standing wave fields. Recently, we found that the defects of atomic lattices can disrupt the symmetry of probe light propagation, which leads the nonreciprocity of left and right reflections [52]. In further, under the specifically designed and optimized parameters, a unidirectional photonic reflector can be achieved in a defective atomic lattices, with all atoms in the filled lattice cells driven into a three-level Λ type [53].

In this paper, we propose a well designed scheme to achieve and modulate a unidirectional amplified broadband reflection, utilizing the coherent driven three-level Δ -type active atomic system for amplifying a weak probe field, 1D defective atomic lattices (DALs) for destroying the symmetry of left and right reflections, and provide a distributed feedback mechanism. To be more specific, the DAL we used was comprised of both filled lattice cells (trapping atoms) and vacant lattice cells (not trapping atoms), which is different from the parity-time symmetry [47–50] and the spatial symmetry broken of probe susceptibility [38–40]. The symmetry

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Article

Amplified Nonreciprocal Reflection in a Uniform Atomic Medium with the Help of Spontaneous Emissions

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Abstract: It is important to elaborate on versatile strategies for achieving the perfect nonreciprocal reflection amplification, which is the key technology of high-quality nonreciprocal photonic devices. In this work, we ingeniously design a coherent four-level N -type atomic system to harness the nonreciprocal light amplification, in which the uniform distribution of atoms is driven by two strong coupling fields and a weak probe field. In our regime, the strength of the two control fields is designed with linear variation along the x direction to destroy the spatial symmetry of the probe susceptibility, leading to the nonreciprocity of the reflection. In particular, the closed-loop transitions to amplify the probe field are due to the combined effect of the control fields and spontaneous emissions. The numerical simulation indicates that the perfect nonreciprocal reflection amplification can be realized and modulated by the appropriate settings of the control fields and the detuning, Δ_c . Our results will open a new route toward harnessing nonreciprocity, which can provide more convenience and possibilities in experimental realization.

Keywords: nonreciprocal reflection amplification; spontaneous emission; symmetry breaking



Citation: Lin, X.; Zheng, X.; Geng, Y.; Li, G.; Xu, Q.; Wu, J.; Yan, D.; Yang, H. Amplified Nonreciprocal Reflection in a Uniform Atomic Medium with the Help of Spontaneous Emissions.

Photonics **2024**, *11*, 389. <https://doi.org/10.3390/photonics11040389>

Received: 22 March 2024

Revised: 15 April 2024

Accepted: 18 April 2024

Published: 22 April 2024



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1. Introduction

Reciprocal optical responses need to be broken if a source has to be isolated from one side or is unwanted. Thus, nonreciprocal optical responses have been widely studied, especially magnetic-free optical nonreciprocity for its potential applications in optical communications and technology [1–5]. Optical diodes and chip isolators based on magnetic-free optical nonreciprocity [6–9] do not need bulky magnets and are thus compatible with integrated circuit technology [10,11]. A number of schemes based on different physical principles have been proposed that avoid the need for the integration of magneto-optical elements. For example, the nonreciprocal quantum optical system induced by the thermal motion of atoms [12,13], the optomechanical system operating on a few photons or single-photon bands in one-dimensional coupled-resonator optical waveguides [14–20], and moving atomic lattices [21,22], even without broken parity or time-reversal symmetry to demonstrate chirality, an asymmetric property widely found in nature [23]. Some of the above schemes have been experimentally verified. In addition, most, though still far from practical realization, include periodic structures with spatial asymmetry [24,25], a parity-time (PT) symmetric or antisymmetric system with standing-wave coupling fields based on time-reversal symmetry breaking [26–28]. Owing to the complex atom-light coupling configuration, precise light-field arrangement in space, and many other factors, the implementations of these schemes are confronted with significant challenges.

In order to avoid difficulties in most systems, research on optical nonreciprocity has shifted toward uniform atomic systems. Recently, perfectly asymmetric reflection has been achieved in a homogeneous continuous medium, with a refractive index of the plane

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(2024 年 3 月 11 日收到; 2024 年 4 月 15 日收到修改稿)

高性能非互易光子器件能够有效地提升光量子操控、信息处理以及量子模拟的效率. 放大的光信号可以增强并隔离量子系统输出的微弱信号, 避免敏感量子系统受反向散射噪声等影响, 是高性能光子器件的核心技术. 在我们先前的工作 (2023 *Opt. Express* **31** 38228) 中, 基于四波混频增益并利用耦合场强度随位置线性变化实现了单向反射光放大的动力学调控. 本文巧妙地设计了简单的三能级闭合回路相干增益原子系统, 创新性地设置耦合场强度随位置阶梯型变化来破坏极化率空间对称性实现了完美非互易反射光放大. 相比之下, 耦合场强度阶梯型变化在实验上更容易调节, 大大地降低了实验难度. 特别地, 该系统引入了相位调制. 通过改变相位能够切换探测光增益和吸收的频率域, 对反射光放大的调节更具灵活性.

关键词: 完美非互易, 反射光放大, 相对相位**PACS:** 64.70.Tg, 03.67.-a, 03.65.Ud, 75.10.Jm**DOI:** 10.7498/aps.73.20240347

1 引言

量子科技的发展将给人类生活带来崭新的篇章, 量子计算和信息处理作为量子科技的核心已成为当前的研究热点. 其中, 引领科技的关键是芯片处理技术. 基于光学非互易性的全光二极管、隔离器等新型光子器件能够隔离噪声、稳定光信号且具有体积小、兼容性好等优点, 是高性能集成芯片不可或缺的元件^[1,2]. 因此, 非互易光传输在光量子操控、信息处理以及量子模拟等量子科技中具有重要的应用^[3-5]. 传统的方法一般是基于法拉第磁光效应破坏时间反演对称性. 然而, 基于法拉第磁光效应的不可逆操控系统总是需要庞大的磁体, 这与集成电路技术不兼容, 大大地限制了实际应用性^[6]. 因此, 无磁材料非互易性及不可逆光子传输器件的

研究具有重要的意义.

根据洛伦兹互易性, 光子在介电常数各向同性的介质中传输是互易的. 人们试图通过打破介质介电常数时间和空间反演对称性 (即, 破坏洛伦兹互易性) 在硅片、半导体以及光子晶体等材料中实现了光学非互易性^[7-13]. 随着光腔电动力学的快速发展, 基于时间反演对称破缺的光学非互易效应在光力系统中取得了重要成果^[14-19], 基于光力诱导的光学非互易性, 还可以根据不同配置的要求在环形、球形以及回音壁等模式微腔中设计隔离器、非相干相移器等^[20-22]. 在手性量子光学系统中, 基于光子发射和吸收的特征可利用原子内态的非对称耦合实现非互易^[23-26]. 近年来, 基于宇称-时间 (parity-time, PT) 反演对称性使光子结构极化率在空间上满足 $\chi(z) = \chi^*(-z)$, 在一维光晶格中利用驻波相干耦合实现了非互易光反射的调制^[27,28]. 随后, 在

* 国家自然科学基金 (批准号: 12204137, 12126314, 12126351)、海南省榕树基金 (批准号: RSYH20231165828X, RSYH20231165827X) 和海南省院士创新平台 (批准号: YSPTZX202215, YSPTZX202207) 资助的课题.

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Phase and detuning control of the unidirectional reflection amplification based on the broken spatial symmetry

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Abstract: In order to achieve the tunable unidirectional reflection amplification in a uniform atomic medium that is of vital importance to design high-quality nonreciprocal photonic devices, we propose a coherent closed three-level Δ -type atomic system by applying a microwave field, and a strong coupling field of linear variation along the x direction to control a probe field. In our scheme, the linearly increased coupling field destroys the spatial symmetry of probe susceptibility and effectively suppresses the reflection of one side; the microwave field constructs closed loop transitions to amplify the probe field and causes phase changes. The numerical simulation indicates that the unidirectional reflection amplification is sensitive to the relative phase ϕ and the coupling detuning Δ_c . Our results will open a new route toward harnessing optical non-reciprocity, which can provide more convenience and possibilities in the experimental realization.

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1. Introduction

It is important to realize optical components that photons are only allowed to propagate in one direction, namely non-reciprocal photonic device, similar to diodes in electronic information science [1–4]. The magnetic-free optical diodes and chip isolators [5–7] controlling the flow of light are of principal significance for information processing and quantum networks, because it doesn't need bulky magnets and is thus compatible with integrated circuit technology [8–10]. Versatile strategies have been Elaborated to achieve optical nonreciprocity, such as chiral quantum optical systems by asymmetric coupling of atomic internal states [11–15], optomechanically induced non-reciprocity on a few photon or even single-photon level has reported in theory and experiment [16–21], even at room temperature [22]. A similar effect can also be investigated in nonlinear regimes [23], giant-atom systems [24] or a chip by quantum squeezing one of two coupled resonator modes [20]. In particular, the perfect non-reciprocity reflection (unidirectional reflection) has been studied in a moving atomic lattice based on time reversal symmetry breaking [25–27], or in a stationary atomic lattice with applying standing-wave coupling fields based on parity-time (PT) symmetric or antisymmetric [28–30]. In addition, the unidirectional perfect reflection or reflectionless have been guaranteed to occur in PT-symmetric system of double-lattice photonic crystals or two-dimensional periodic structures [31,32].

The above physical systems have made significant progress in optical nonreciprocity photonic device. However, high performance optical amplification is an essential functionality in integrated photonic circuits. Therefore, harnessing non-reciprocal light amplification is more important, which can simultaneously amplify the weak signal output by the quantum system and isolate the sensitive quantum system from the backscattered external noise, and it is promising to explore more functions and applications [33–36]. Up to now, unidirectional amplification or

Spatial susceptibility modulation and controlled unidirectional reflection amplification via four-wave mixing

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Abstract: Control of unidirectional light propagation is of paramount importance to optical signal processing and optical communication. Especially, the amplified optical signal can isolate noise well that may provide more applications. In this work, we propose a dynamically modulated regime to realize unidirectional reflection amplification in a short and dense uniform atomic medium, and all atoms are driven into four-level double- Λ type by two coupling fields with linearly varied intensities along x direction and two weak probe fields. Based on four-wave mixing resonance and the broken spatial symmetry, the complete nonreciprocal reflection (unidirectional reflection) can be amplified with reflectivity more than 2.0, even to 6.0. In addition, the width, height, and position of the unidirectional reflection bands can be tunable. Thus, our regime is feasible and may inspire further applications in all-optical networks that require controllable unidirectional light amplification.

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1. Introduction

Optical non-reciprocity is widely used to design novel photonic devices, such as all-optical diodes and chip isolators [1,2], which can isolate noise, stabilize signals on integrated chips and protection of sensitive laser equipment from unwanted reflections [3–6]. Efficient and stable integrated chips are the key in quantum computing and information processing [7–11]. Therefore, it is of great significance to carry out research on non-reciprocal light propagation to promote current quantum technology. The conventional route to optical nonreciprocity is mainly based on the Faraday effect in magneto-optical medium [12–14], which leading to the materials' permittivity becoming an asymmetric anisotropic tensor. However, the bulky magnets is always required in order to achieve high external magnetic field, in addition, the inevitable loss inherent to magneto-optical materials are also significant limiting factors, especially at optical frequencies. Thus, the mechanism depending on magneto-optical Faraday effect to realize symmetry-breaking effect is incompatible with integrated circuit technology.

Recent researches show that optical nonreciprocity of non-magnetic has made great progress. In chiral quantum optical systems, nonreciprocity can be realized by asymmetric coupling of atomic internal states [15–18]; Such a nonreciprocal light manipulation has achieve important results in optomechanical systems, that on a few photon or even single-photon level [19–22]; It has also been widely studied in nonlinear optical systems, *e.g.*, a parity-time (PT) symmetric or antisymmetric system as standing-wave coupling fields are applied in a one-dimensional atomic lattice [23–25], or a moving atomic lattices which based on time reversal symmetry breaking [26–28], even in the hot atom system with considering Doppler shifts [29]. It is then justified, the above physical systems have made significant progress in studying optical nonreciprocity. However, the challenge in these schemes is the requirement of precise modulation, including achieving a balance of gain and loss within a single period, precisely arranging the spatial

Two-color unidirectional reflections by modulating the spatial susceptibility in a homogeneous atomic medium

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Abstract: Non-reciprocal reflections of optical signals are unusual yet fascinating to achieve the imminent applications of non-reciprocal photonic devices and circuits. The complete non-reciprocal reflection (unidirectional reflection) was recently found to be achievable in a homogeneous medium, if the real and imaginary parts of the probe susceptibility satisfy the spatial Kramers-Kronig (KK) relation. We propose a coherent four-level tripod model for realizing dynamically tunable two-color non-reciprocal reflections by applying two control fields with linearly modulated intensities. We found that, the unidirectional reflection can be obtained if the non-reciprocal frequency regions are located in the electromagnetically induced transparency (EIT) windows. This mechanism is to break the spatial symmetry by the spatial modulation of susceptibility to induce unidirectional reflections, the real and imaginary parts of the probe susceptibility are no longer required to satisfy the spatial KK relation.

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1. Introduction

In the past few decades, progress has been made in the study of nonreciprocal optical propagation in optical systems [1–5]. Especially in atomic systems, the non-reciprocal response have been investigate theoretically and experimentally [6,7]. The momentum locking of susceptibility can not only be generated by the random thermal motion of atoms to achieve a non-reciprocal optical system and an irreversible transmission-light amplification based on the Doppler effect [8,9]. However, the non-reciprocal light propagation can also be realized by using the parity-time (P-T) symmetric system combined with the one-dimensional (1D) atomic lattice and standing wave [10–13], so that the incident light signal from one side in the medium is suppressed while that on the other side is strengthened. Moreover, rapid progress has been made in designing optical non-reciprocity, and it may also be achieved in optomechanical and optical cavity systems [14–18]. In addition, an all-optical approach to achieve optical non-reciprocity on a chip has been attempted by the quantum squeezing of two coupled resonator modes. This protocol creates a new pathway to achieving integrable all-optical non-reciprocal devices, permitting chip-compatible optical isolation and non-reciprocal quantum-information processing [19]. lately, the nontrivial single-photon scattering properties of giant atoms has been investigated, which being an effective platform to realize nonreciprocal and chiral quantum optics [20].

Recently, it has been found that non-reciprocal optical propagation can also be realized in an homogeneous medium, which requires that the refractive index, susceptibility or permittivity of plane electromagnetic waves are complex analytic functions, their real and imaginary parts satisfy the KK relation of spatial distribution [21–23]. The advantage of realizing unidirectional light propagation based on the spatial KK relation is that, there is no strict requirement for the incident-light angle, which is simpler and more controllable in experiments [24–28]. Furthermore,

文章（如下所示）发表日期较新，为2026年6月3日，因此无法提供检索证明，特此说明：

1.Xinfu Zheng, Chen Peng, Duanfu Chen,Tinggui Zhang, Hanxiao Zhang, Dong Yan, Jinhui Wu and **Hong Yang***, Modulation of unidirectional reflection lasing via the dual mechanisms of destructive interference and asymmetric distributed feedback, **Phys. Rev. App**, **25**, 064011 (2026).

文献收录证明

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检索数据库: 科学引文索引 Science Citation Index-Expanded 《SCI-E》(1900-2026 年)、期刊引证报告 Journal Citation Reports 《JCR》(1997-2025 年)、中国科学院文献情报中心期刊分区表在线平台(2005-2023 年, 2025 年)

检索结果:

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标题: Unidirectional reflection lasing via microwave modulation in defective atomic lattice

作者: Chen, DF (Chen, Duan-Fu); Zheng, XF (Zheng, Xin-Fu); Peng, C (Peng, Chen); Zheng, YT (Zheng, Yi-Ting); Yan, D (Yan, Dong); Zhang, HX (Zhang, Han-Xiao); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 34 期: 10 页: 17491-17505 DOI: 10.1364/OE.591668 Published Date: 2026 MAY 18

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001766297600001

文献类型: Article

地址: [Chen, Duan-Fu; Zheng, Xin-Fu; Peng, Chen; Zheng, Yi-Ting; Yan, Dong; Zhang, Han-Xiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engr, Haikou 571158, Peoples R China.

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IDS 号: HZ3UI

ISSN: 1094-4087

2025 年 JCR 影响因子: 3.4

2025 年中科院分区 (升级版):

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标题: Unidirectional spectral singularity lasing in a defective atomic lattice

作者: Peng, C (Peng, Chen); Zheng, XF (Zheng, Xinfu); Chen, DF (Chen, Duanfu); Zhang, HX (Zhang, Hanxiao); Yan, D (Yan, Dong); Wu, JH (Wu, Jinhui); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 34 期: 9 页: 17320-17333 DOI: 10.1364/OE.591667 Published Date: 2026 MAY 4

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001767479500028

文献类型: Article

地址: [Peng, Chen; Zheng, Xinfu; Chen, Duanfu; Zhang, Hanxiao; Yan, Dong; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

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IDS 号: IB1EW

ISSN: 1094-4087

2025 年 JCR 影响因子: 3.4

2025 年中科院分区 (升级版):

大类 物理与天体物理 2 区

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标题: Unidirectional reflection amplification without inversion

作者: Zheng, YT (Zheng, Yiting); Peng, C (Peng, Chen); Li, GR (Li, Guanrong); Zheng, XF (Zheng, Xinfu); Chen, DF (Chen, Duanfu); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); Zhang, Y (Zhang, Yan)*; **Yang, H (Yang, Hong)***

来源出版物: PHYSICAL REVIEW A 卷: 113 期: 3 文献号: 033122 DOI: 10.1103/1lhc-srq7 Published Date: 2026 MAR 27

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001736420200001

文献类型: Article

地址: [Zheng, Yiting; Peng, Chen; Li, Guanrong; Zheng, Xinfu; Chen, Duanfu; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

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IDS 号: GH3NR

ISSN: 2469-9926

eISSN: 2469-9934

2025 年 JCR 影响因子: 3

2025 年中科院分区 (升级版):

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根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红 (*为通讯作者), 署名单位为海南师范大学的以下论文被 ESCI 收录, 详细信息如下:

标题: Amplified nonreciprocal and unidirectional reflection in a defective atomic lattice via spontaneously generated coherence

作者: Xu, QY (Xu, Qiong-Yi); Peng, C (Peng, Chen); Chen, DF (Chen, Duan-Fu); Zhang, HX (Zhang, Han-Xiao); Yan, D (Yan, Dong); **Yang, H (Yang, Hong)***

来源出版物: OPTICS CONTINUUM 卷: 5 期: 4 页: 1184-1197 DOI: 10.1364/OPTCON.592284
Published Date: 2026 APR 15

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001745200200018

文献类型: Article

地址: [Xu, Qiong-Yi; Peng, Chen; Chen, Duan-Fu; Zhang, Han-Xiao; Yan, Dong; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

通讯作者地址: Xu, QY (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

IDS 号: GU2UQ

eISSN: 2770-0208

2025 年 JCR 影响因子: 1.5

2025 年中科院分区 (升级版):

大类 物理与天体物理 4 区

小类 OPTICS 光学 4 区

检索员 (签字): 李一萍 技术职务: 副研究员

检索单位 (签章): 中国热带农业科学院科技信息研究所



文献收录证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 科学引文索引 Science Citation Index-Expanded 《SCI-E》(1900-2026 年)、期刊引证报告 Journal Citation Reports 《JCR》(1997-2025 年)、中国科学院文献情报中心期刊分区表在线平台(2005-2023 年, 2025 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红 (*为通讯作者), 署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Multicolored unidirectional reflection amplification based on two-photon resonance in the defective atomic lattice

作者: Zheng, YT (Zheng, Yiting); Zheng, XF (Zheng, Xinfu); Peng, C (Peng, Chen); Chen, DF (Chen, Duanfu); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 33 期: 23 页: 49639-49651 DOI: 10.1364/OE.577334 Published Date: 2025 NOV 17

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001625970300006

文献类型: Article

地址: [Zheng, Yiting; Zheng, Xinfu; Peng, Chen; Chen, Duanfu; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: H8608

ISSN: 1094-4087

2025 年 JCR 影响因子: 3.4

2025 年中科院分区 (升级版):

大类 物理与天体物理 2 区

小类 OPTICS 光学 2 区

检索员 (签字): 李一萍 技术职务: 副研究员

检索单位 (签章): 中国热带农业科学院科技信息研究所



文献收录证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 科学引文索引 Science Citation Index-Expanded《SCI-E》(1900-2026 年)、期刊引证报告 Journal Citation Reports《JCR》(1997-2025 年)、中国科学院文献情报中心期刊分区表在线平台(2005-2023 年, 2025 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红(*为通讯作者), 署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Nonreciprocal reflection in one-dimensional quasi-periodic defective atomic lattice

作者: Xu, QY (Xu, Qiongyi); Zhang, J (Zhang, Jin); Zheng, YT (Zheng, Yiting); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); **Yang, H (Yang, Hong)***

来源出版物: ACTA PHYSICA SINICA 卷: 74 期: 11 文献号: 116402 DOI: 10.7498/aps.74.20250270

Published Date: 2025 JUN 5

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001512025200019

文献类型: Article

地址: [Xu, Qiongyi; Zheng, Yiting; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

[Zhang, Jin] South China Normal Univ, Coll Optoelect Sci & Engn, Guangzhou 510631, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: 3YM2U

ISSN: 1000-3290

2025 年 JCR 影响因子: 1

2025 年中科院分区 (升级版):

大类 物理与天体物理 3 区

小类 PHYSICS, MULTIDISCIPLINARY 物理: 综合 3 区

检索员 (签字): 李一萍 技术职务: 副研究员

检索单位 (签章): 中国热带农业科学院科技信息研究所



文献收录证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 科学引文索引 Science Citation Index-Expanded (SCI-E) (1900-2026 年)、期刊引证报告 Journal Citation Reports (JCR) (1997-2025 年)、中国科学院文献情报中心期刊分区表在线平台 (2005-2023 年, 2025 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 共同通讯作者为杨红 (*为共同通讯作者), 署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Unidirectional amplified reflections based on four-wave mixing and spontaneously generated coherence

作者: Geng, Y (Geng, Yue); Peng, C (Peng, Chen); Zheng, XF (Zheng, Xinfu); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); Wu, JH (Wu, Jinhui)*; **Yang, H (Yang, Hong)***

来源出版物: PHYSICS LETTERS A 卷: 534 文献号: 130241 DOI: 10.1016/j.physleta.2025.130241 Early Access Date: JAN 2025 Published Date: 2025 FEB 28

Web of Science 核心合集中的 "被引频次": 2

被引频次合计: 2

入藏号: WOS:001400456100001

文献类型: Article

地址: [Geng, Yue; Peng, Chen; Zheng, Xinfu; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

[Wu, Jinhui] Northeast Normal Univ, Ctr Quantum Sci, Changchun 130024, Peoples R China.

[Wu, Jinhui] Northeast Normal Univ, Sch Phys, Changchun 130024, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

Wu, JH (通讯作者), Northeast Normal Univ, Ctr Quantum Sci, Changchun 130024, Peoples R China.

Wu, JH (通讯作者), Northeast Normal Univ, Sch Phys, Changchun 130024, Peoples R China.

电子邮件地址: jhwu@nenu.edu.cn; yang_hongbj@126.com

IDS 号: S8D2R

ISSN: 0375-9601

eISSN: 1873-2429

2025 年 JCR 影响因子: 2.7

2025 年中科院分区 (升级版):

大类 物理与天体物理 3 区

小类 PHYSICS, MULTIDISCIPLINARY 物理: 综合 3 区

检索员 (签字): 李一萍 技术职务: 副研究员

检索单位 (签章): 中国热带农业科学院科技信息研究所



编号: JS2025181

文献收录检索证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 科学引文索引 Science Citation Index-Expanded 《SCI-E》(1900 年-2025 年)、期刊引证报告 Journal Citation Reports 《JCR》(1997 年-2023 年)、中国科学院文献情报中心期刊分区表在线平台 (2005 年-2023 年, 2025 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红 (*为通讯作者), 署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Broadband unidirectional reflection amplification in a one-dimensional defective atomic lattice

作者: Xu, QY (Xu, Qiongyi); Li, GR (Li, Guangrong); Zheng, YT (Zheng, Yiting); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); Zhang, TG (Zhang, Tinggui); **Yang, H (Yang, Hong)***

来源出版物: PHYSICAL REVIEW A 卷: 110 期: 6 文献号: 063724 DOI: 10.1103/PhysRevA.110.063724
Published Date: 2024 DEC 27

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001389473100011

文献类型: Article

地址: [Xu, Qiongyi; Li, Guangrong; Zheng, Yiting; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

[Zhang, Tinggui] Hainan Normal Univ, Sch Math & Stat, Haikou 571158, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: R1X8F

ISSN: 2469-9926

eISSN: 2469-9934

2023 年 JCR 影响因子: 2.6

2023 年中科院分区 (升级版):

大类 物理与天体物理 2 区

小类 **PHYSICS, ATOMIC, MOLECULAR & CHEMICAL** 物理: 原子、分子和化学物理 2 区

小类 **OPTICS** 光学 3 区

检索员 (签字): 李一萍 技术职务: 副研究员

检索单位 (签章): 中国热带农业科学院科技信息研究所



文献收录检索证明

委托人: 杨红 (Yang, Hong)
委托单位: 海南师范大学
检索数据库: 《科学引文索引》(SCI-E)、《期刊引证报告》(JCR)、中国科学院文献情报中心期刊分区表在线平台(升级版 2019-2023 年)
检索结果:
根据委托人的检索要求, 查询了相关数据库。经检索, 共同通讯作者为杨红(*为共同通讯作者), 第一署名为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:
标题: Amplified Nonreciprocal Reflection in a Uniform Atomic Medium with the Help of Spontaneous Emissions
作者: Lin, XY (Lin, Xinyu); Zheng, XF (Zheng, Xinfu); Geng, Y (Geng, Yue); Li, GR (Li, Guanrong); Xu, QY (Xu, Qiongyi); Wu, JH (Wu, Jinhui); Yan, D (Yan, Dong)*; **Yang, H (Yang, Hong)***
来源出版物: PHOTONICS 卷: 11 期: 4 文献号: 389 DOI: 10.3390/photonics11040389 Published Date: 2024 APR
Web of Science 核心合集中的 "被引频次": 0
被引频次合计: 0
入藏号: WOS:001210322000001
文献类型: Article
地址: [Lin, Xinyu; Zheng, Xinfu; Geng, Yue; Li, Guanrong; Xu, Qiongyi; Yan, Dong; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engr, Haikou 571158, Peoples R China.
[Wu, Jinhui] Northeast Normal Univ, Ctr Quantum Sci, Changchun 130024, Peoples R China.
[Wu, Jinhui] Northeast Normal Univ, Sch Phys, Changchun 130024, Peoples R China.
通讯作者地址: Yan, D; Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engr, Haikou 571158, Peoples R China.
电子邮件地址: yand@hainnu.edu.cn; 060064@hainnu.edu.cn
IDS 号: OW5G8
eISSN: 2304-6732
2023 年 SCI 影响因子为 2.1
2023 年中科院分区升级版:
大类 物理与天体物理 4 区
小类 OPTICS 光学 4 区

检索员(签字):  技术职务: 副研究员
检索单位(签章): 中国热带农业科学院科技信息研究所
2024 年 10 月 11 日

编号: JS2024223

文献收录检索证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 《科学引文索引》(SCI-E)、《期刊引证报告》(JCR)、中国科学院文献情报中心期刊分区表在线平台(升级版 2019-2023 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红(*为通讯作者), 第一署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Perfect non-reciprocal reflection amplification in closed loop coherent gain atomic system

作者: Li, GR (Li Guan-Rong); Zheng, YT (Zheng Yi-Ting); Xu, QY (Xu Qiong-Yi); Pei, XS (Pei Xiao -Shan); Geng, Y (Geng Yue); Yan, D (Yan Dong); **Yang, H (Yang Hong)***

来源出版物: ACTA PHYSICA SINICA 卷: 73 期: 12 文献号: 126401 DOI: 10.7498/aps.73.20240347

Published Date: 2024 JUN 20

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001251024200025

文献类型: Article

地址: [Li Guan-Rong; Zheng Yi-Ting; Xu Qiong-Yi; Pei Xiao -Shan; Geng Yue; Yan Dong; **Yang Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Hainan, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Hainan, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: UW2B8

ISSN: 1000-3290

2023 年 SCI 影响因子为 0.8

2023 年中科院分区升级版:

大类 物理与天体物理 4 区

小类 PHYSICS, MULTIDISCIPLINARY 物理: 综合 4 区

检索员(签字): 李一萍 技术职务: 副研究员

检索单位(签章): 中国热带农业科学院科技信息研究所

2024 年 10 月 11 日

编号: JS2024223

文献收录检索证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 《科学引文索引》(SCI-E)、《期刊引证报告》(JCR)、中国科学院文献情报中心期刊分区表在线平台(升级版 2019-2023 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红(*为通讯作者), 第一署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Phase and detuning control of the unidirectional reflection amplification based on the broken spatial symmetry

作者: Li, GR (Li, Guanrong); Geng, Y (Geng, Yue); Pei, XS (Pei, Xiaoshan); Wu, JH (Wu, Jinhui); Lin, XY (Lin, Xinyu); Yan, D (Yan, Dong); Zhang, HX (Zhang, Hanxiao); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 32 期: 7 文献号: 520454 DOI: 10.1364/OE.520454 Published Date: 2024 MAR 25

Web of Science 核心合集中的 "被引频次": 0

被引频次合计: 0

入藏号: WOS:001206868200001

文献类型: Article

地址: [Li, Guanrong; Geng, Yue; Pei, Xiaoshan; Lin, Xinyu; Yan, Dong; Zhang, Hanxiao; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

[Wu, Jinhui] Northeast Normal Univ, Ctr Quantum Sci, Changchun 130024, Peoples R China.

[Wu, Jinhui] Northeast Normal Univ, Sch Phys, Changchun 130024, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: OJ3Q8

ISSN: 1094-4087

2023 年 SCI 影响因子为 3.2

2023 年中科院分区升级版:

大类 物理与天体物理 2 区 TOP 期刊

小类 OPTICS 光学 2 区

检索员(签字): 李一萍 技术职务: 副研究员

检索单位(签章): 中国热带农业科学院科技信息研究所



编号: JS2024223

文献收录检索证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 《科学引文索引》(SCI-E)、《期刊引证报告》(JCR)、中国科学院文献情报中心期刊分区表在线平台(升级版 2019-2023 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红(*为通讯作者), 第一署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Spatial susceptibility modulation and controlled unidirectional reflection amplification via four-wave mixing

作者: Geng, Y (Geng, Yue); Pei, XS (Pei, Xiaoshan); Li, GR (Li, Guanrong); Lin, XY (Lin, Xinyu); Zhang, HX (Zhang, Hanxiao); Yan, D (Yan, Dong); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 31 期: 23 页: 38228-38239 文献号: 499738 DOI: 10.1364/OE.499738

Published Date: 2023 NOV 6

Web of Science 核心合集中的 "被引频次": 2

被引频次合计: 3

入藏号: WOS:001105995100002

文献类型: Article

地址: [Geng, Yue; Pei, Xiaoshan; Li, Guanrong; Lin, Xinyu; Zhang, Hanxiao; Yan, Dong; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: Y5XV6

ISSN: 1094-4087

2023 年 SCI 影响因子为 3.2

2023 年中科院分区升级版:

大类 物理与天体物理 2 区 TOP 期刊

小类 OPTICS 光学 2 区

检索员(签字): 李一萍 技术职务: 副研究员

检索单位(签章): 中国热带农业科学院科技信息研究所



文献收录检索证明

委托人: 杨红 (Yang, Hong)

委托单位: 海南师范大学

检索数据库: 《科学引文索引》(SCI-E)、《期刊引证报告》(JCR)、中国科学院文献情报中心期刊分区表在线平台(升级版 2019-2023 年)

检索结果:

根据委托人的检索要求, 查询了相关数据库。经检索, 通讯作者为杨红(*为通讯作者), 第一署名单位为海南师范大学的以下论文被 SCI-E 收录, 详细信息如下:

标题: Two-color unidirectional reflections by modulating the spatial susceptibility in a homogeneous atomic medium
作者: Pei, XS (Pei, Xiao-Shan); Zhang, HX (Zhang, Han-Xiao); Pan, MM (Pan, Meng-Mei); Geng, Y (Geng, Yue); Li, TM (Li, Tian-Ming); **Yang, H (Yang, Hong)***

来源出版物: OPTICS EXPRESS 卷: 31 期: 9 页: 14694-14704 DOI: 10.1364/OE.488247 Published Date: 2023 APR 24

Web of Science 核心合集中的 "被引频次": 3

被引频次合计: 3

入藏号: WOS:000985383600005

文献类型: Article

地址: [Pei, Xiao-Shan; Zhang, Han-Xiao; Pan, Meng-Mei; Geng, Yue; **Yang, Hong**] Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

[Li, Tian-Ming] South China Normal Univ, Sch Phys & Telecommun Engn, Guangzhou 510006, Peoples R China.

通讯作者地址: Yang, H (通讯作者), Hainan Normal Univ, Sch Phys & Elect Engn, Haikou 571158, Peoples R China.

电子邮件地址: yang_hongbj@126.com

IDS 号: F9HK8

ISSN: 1094-4087

2023 年 SCI 影响因子为 3.2

2023 年中科院分区升级版:

大类 物理与天体物理 2 区 TOP 期刊

小类 OPTICS 光学 2 区

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荣誉证书

论文层次：2024年海南省优秀硕士论文

论文题目：基于各向同性原子介质中光学非互易性的动力学调控

论文作者：裴笑山

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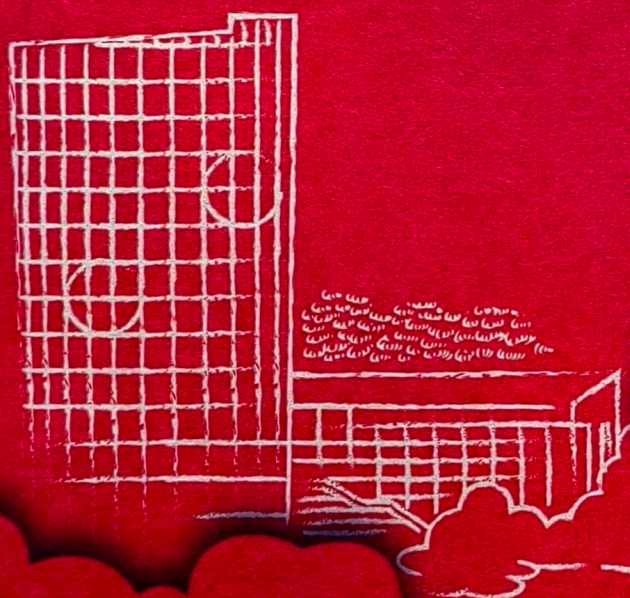
证书编号：HNS2024-79





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民族和社会的发展

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SEEK TRUTH, FOSTER ORIGINALITY,
AND LIVE UP TO THE NAME OF A TEACHER.



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郑鑫福 同学：

祝贺你被录取为我校物理与电子科学学院原子与分子物理专业 2026 级全日制非定向就业博士研究生。请凭本通知书到校报到，具体报到时间及要求详见我校研究生招生信息网新生报到须知。

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