

Education

Nanjing University


College of Engineering and Applied Sciences

Nanjing, Jiangsu

Doctor of Philosophy

Optical Engineering

Q.E. – Top 15%



Nonlinear Fourier Optics 

– 2025.06

Dissertation: “Analytic 3D vector linear non-uniform & nonlinear Fourier crystal optics in arbitrary $\bar{\epsilon}$, $\bar{\chi}$ dielectrics” 

Master's Studies

Quantum Electronics

Courses Score – 93.5 THz OAM Source 

– 2022.06



Northeastern University

School of Physics, College of Science

Shenyang, Liaoning

Bachelor of Science

Applied Physics

GPA Rank – 1/400 DDTank Aimbots 


– 2020.06

Thesis: “Research & design of nonlinear holography based on lithium niobate 3D nonlinear photonic crystal”  

Freshman in College

Science

Sichuan Prov. – Top 2%


3 e-books with C++ 

2016.09 –


Research Projects

3D Vector Nonlinear
Fourier Crystal OpticsSolving
$$\left[(\nabla \times)^2 - k_0^2 \bar{\epsilon} \right] \mathbf{E}(\mathbf{r}) = k_0^2 \bar{\chi} : \mathcal{F}_\omega^{-1} \left[\tilde{\mathbf{E}}_p \tilde{\mathbf{E}}_p \right] (\mathbf{r})$$
 analytically 2023.05 –


- First & fastest white box solver ever for this inhomogeneous wave equation
 - or other similar equations, with unprecedented efficiency-accuracy product
- No competitors for the time being: other methods or software including
 - k-space RK4, pseudo-spectral, SSF, Green's Function methods, FDTD, COMSOL...
- Reproduced well-known papers, all of which provide either zero or wrong theory:
 - [Nat.Photo.](#) #proven theoretically wrong by this project #femtosecond pump
 - [O.E.](#) #Bloembergen's legacy2 #experiment | [O.M.E.](#) #z-component
 - [O.E.](#) | [Q.E.](#) #high N.A. # $\bar{\chi}$ anisotropy

PPTs [1](#) [2](#) [3](#) ... Complex Vector Linear
Fourier Crystal OpticsAnalytic solution $\mathbf{E}(\mathbf{r})$ to
$$\left[(\nabla \times)^2 - k_0^2 \bar{\epsilon} \right] \mathbf{E}(\mathbf{r}) = \mathbf{0}$$
 where $\varepsilon_{ij} \in \mathbb{C}$ 2023.02 –

- Drawing insights from [PR.S.A.](#) #M.V.Berry's legacy | [A.O.P.](#) | [A.P.B.](#) | [J.QSRT.](#)
- Next generation will come really close to the exact solution with highly !hermitian $\bar{\epsilon}$
- Reproduced well-known papers, some are purely experimental (too hard to model):
 - [J.O.S.A.](#) #Bloembergen's legacy1 | [J.O.](#) | [O.M.](#) | [O.M.](#) | [J.O.](#) | [L.P.R.](#)
 - [JOSA.A.](#) | [O.E.](#) #tightly focus # $\bar{\epsilon}$ anisotropy | [Light.Sci.App.](#) | [O.E.](#)

PPTs [1](#) [2](#) [3](#) ... Real Scalar Nonlinear
Fourier Crystal OpticsClosed-form $E_3(\mathbf{r})$ in
$$\left[\nabla^2 + k_3^2 \right] E_3(\mathbf{r}) = -k_{03}^2 \chi(\mathbf{r}) E_1(\mathbf{r}) E_2(\mathbf{r})$$
 2022.02 –

- Solving this multivariable/field nonlinear convolution equation on my own
- Strong alternative to Green's Function, pseudo-spectral, split-step Fourier methods
- Reproduced well-known papers & models with maximum accuracy & efficiency:
 - [P.R.L.](#) #Green | [P.R.L.](#) #experiment #quantum | [P.R.L.](#) #experiment #scatter | [P.R.L.](#)
 - [L.P.R.](#) #SSF #quantum | Matlab #RCWA | [A.P.L.](#) #femtosecond pump
 - [O.L.](#) | [P.R.A.](#)

PPTs [1](#) [2](#) [3](#) [4](#) ... 




















Scientific Activities

- [0] **The 4th Nanjing University Doctoral Interdisciplinary Innovation Forum** **Nanjing, Jiangsu**
 “Analytic vector linear & nonlinear Fourier crystal optics in arbitrary $\bar{\epsilon}$, $\bar{\chi}$ dielectrics” | Talk [PPT] 2024.05.30
- [1] **2023 CSOE-NJU¹ Book Club Meeting & Sharing Session** **Nanjing, Jiangsu**
 “A guided tour to Ray & Wave Optics Simulation” | Talk [PPT] 2023.12.09
- [2] **Academic Café Salon of the Research Group** **Nanjing, Jiangsu**
 “Bi-directional notes on Nonlinear Optics in a roam-like app: RoamEdit” | Talk [PDF] 2021.05.21

Publications

- [0] P. Chen, X. Xu, T. Wang, C. Zhou, D. Wei, J. Ma, J. Guo, X. Cui, X. Cheng, **C. Xie**, S. Zhang, S. Zhu, M. Xiao, and Y. Zhang, *Laser nanoprinting of 3D nonlinear holograms beyond 25000 pixels-per-inch for inter-wavelength-band information processing*, Nature Communications **14**, 5523 (2023)
- [1] J. Guo, Y. Zhang, H. Ye, L. Wang, P. Chen, D. Mao, **C. Xie**, Z. Chen, X. Wu, M. Xiao, and Y. Zhang, *Spatially Structured-Mode Multiplexing Holography for High-Capacity Security Encryption*, ACS Photonics **10**, 757–763 (2023)

Academic Focus

Next generation high N.A. 3D vector non-uniform analytic linear & nonlinear Fourier crystal optics 	2024.06 –
!Paraxial k_0^ω High N.A. 3D vector non-uniform analytic linear & nonlinear Fourier crystal optics 	2024.03 –
Emphasizing G_{xyz}^ω 3D vector non-uniform analytic linear & nonlinear Fourier crystal optics 	2023.12 –
Involving $\bar{\chi}_\omega^{(2)}$ anisotropy Vector non-uniform analytic linear & nonlinear Fourier crystal optics 	2023.06 –
!Unitary $G_\omega^\pm \Leftarrow$!Hermitian $\bar{\epsilon}_r^\omega \Rightarrow$ Non-uniform analytic linear & nonlinear Fourier crystal optics 	2023.03 –
Solution E_ω^\pm to $(\nabla^2 + k_{\omega\pm}^2)E_\omega^\pm \propto P_{\omega\pm}^{(2)}$ Analytic linear & nonlinear Fourier crystal optics 	2022.09 –
Solution $\mathcal{F}[E_3] = \mathcal{F}[f(\mathcal{F}^{-1}[\cdot])]$ to the Eq. below Nonlinear angular spectrum theory for SFG 	2022.06 –
Solution $\mathcal{F}[E_3] = \iiint \cdot$ to $(\nabla^2 + k_3^2)E_3(\mathbf{r}) \propto P_3^{(2)}(\mathbf{r})$ Nonlinear convolution solution to SFG 	2022.03 –
 Nonlinear THz LiNbO ₃ -based metasurface Quit THz project formally COMSOL	– 2022.01
 BWOPO + THz optical parametric amplification Mathematica BookxNote Pro	– 2021.12
 THz backward optical parametric oscillator (BWOPO) Mathematica VBA Excel	– 2021.11
 Multi-cycle THz orbital angular momentum (OAM) source RoamEdit Blender	– 2021.11
 Narrow-band THz OAM source via Optical Rectification (OR) Python Blender	– 2021.10
 Electricity $\xrightarrow{\text{produce}}$ Acoustics $\xrightarrow{\text{modulate}}$ Optics RoamEdit VBA Excel	– 2021.07
 Visible Photons $\xrightarrow{\text{SPDC}}$ THz Spectroscopy BookxNote Pro GeoGebra VBA Excel	– 2021.06
 Cavity Phase Matching = Sheet OPO Paint 3D RoamEdit GeoGebra VBA Excel	– 2021.05
 THz Holography via Optical Rectification Matlab GeoGebra VBA Excel	– 2021.01
 Femtosecond laser $\xrightarrow{\text{Optical Rectification}}$ Terahertz (THz) GeoGebra VBA Excel	– 2020.12
 Multicycle THz pulse generation by OR in LiNbO ₃ ... crystals VBA PowerPoint	– 2020.10

¹The Nanjing University student branch of the Chinese Society for Optical Engineering







Honors & Awards

Academia	Doctoral Interdisciplinary Forum (Oral)	2nd place		¥500	Nanjing	U.	2024.05
	Doctor's Qualification Exam (Oral)	Excellent		Top 15%	Nanjing	U.	2024.01
	Bachelor Thesis & Defense	Excellent		1/90	Northeastern	U.	2020.06
Competition	Three Provinces Achievement Expo	Exhibition		Leader	Three	Prov.	2019.10
	"Challenge Cup" Tech Competition	Grand prize		Leader	Liaoning	Prov.	2019.06
Scholarships & Fellowships	Academic Fellowship	1st class		¥40,000	Nanjing	U.	2020-24
	"Jinchuan" Scholarship	1st place		¥5,000	Northeastern	U.	2019.04
	Academic Scholarship	1st place		¥2,000	Northeastern	U.	2018.06
	Entrance Scholarship	3rd place		¥5,000	Leshan No.1	H.S.	2013.09
Honors & Titles	Graduation with Honor	Outstanding			Northeastern	U.	2020.07
	League Member	Excellent			Northeastern	U.	2019.11
	Undergraduate Student	Excellent			Northeastern	U.	2018.12
Memberships	Chinese Society for Optical Engineering	Member			Nanjing	U.	2021-25
	"Qian Sanqiang" Talent Class	Head			I.H.E.P.		2017-20

Personal Projects

Behind NLAST ²	0 → 1 : Techniques crafted from scratch in my acedemic project : NLAST	2022.02 –
	<ul style="list-style-type: none">Managed to realize <i>tree</i>-print feature in CMD lines without knowing <i>any tree</i>-packages<ul style="list-style-type: none">in order to visualize run-time <i>Call Stack</i> with <i>buried checkpoints</i> & display <i>crucial info</i>to understand the <i>hierarchical structure</i> of my code from a more <i>abstract</i> perspectiveEnabled <i>multi-threads</i> to accelerate <i>for loops</i> in python while preserving the <i>loops' order</i><ul style="list-style-type: none">Implemented through utilizing the <i>producer-consumer model</i> (producer = thread pool)Allow users to select which parts of the codes in the <i>for loops</i> to <i>parallelize</i> in CPUTransform <i>multi-layer for loops</i> into <i>nested multi-threads</i>: each thread = a new thread poolFuture model will move away from <i>python</i> as the primary language & shift to GPU<ul style="list-style-type: none">Favoring GPU is driven by "<i>fields</i> in physics = <i>arrays/matrices</i> in math/programs"Haven't decided which to employ: CUDA, Jax, webGL2, webGPU, Mojo or Bend?Decided to try some existing packages developed by flatiron instituteDeveloped a log file system to track & record the operating status for debugging<ul style="list-style-type: none">to output script parameters (<i>**kwargs</i>) for rapid reproducibility of data in the futureto store data files & folders, and their metadata for swift data import and reutilizationAchieved automatic skipping of functions that return repeated values stored in memory<ul style="list-style-type: none">via <i>@decorators</i>: let precomputation assess whether to execute the decorated functionWrap <i>matplotlib</i> into <i>plot_1d</i>(, <i>_2d</i>, <i>_3d</i>, <i>.gif</i> ...) for data visualization<ul style="list-style-type: none">also sped up by customized multi-threading ...	Matlab Mathematica JavaScript Python
LabView Projects	BB84 QKD protocol simulation & distributed optical fiber sensing	– 2021.06
	<ul style="list-style-type: none">Verified the information security of <i>photon_polarization_state</i>-related BB84 protocolVisualized the distribution of anomalies along the fiber optic cable from user data	 LabView

²Non-linear Angular Spectrum Theory (= Nonlinear Fourier Optics in ??)

Hanging Assist	<p>AFK/Bot script for game 「Duel City」 — a knock-off 「Yu-Gi-Oh」 — 2020.04</p> <ul style="list-style-type: none"> Automatic matching: Players (PVP), NPCs (PVE) Automatic switching: Multiple accounts supported + Anti-disconnection Display program stages: Real time understanding of current software state Stackable record: Incrementally output history for every hang-up to the log file.ini <ul style="list-style-type: none"> which is also loaded as the configuration file for the next boot <ul style="list-style-type: none"> to restore the program state from the last exit <p>EPL </p>	
Extended 1A2B	<p>A Code-breaking Game 「Bulls and cows」 : Guessing 4 digits → 1-9 digits — 2019.09</p> <ul style="list-style-type: none"> Hardware - MicroController (C8051F350.h) version of Original 1A2B: Guessing 4 numbers Software - VC++ 6.0 version of Upgraded 1A2B: Guessing 1-9 numbers <p>Keil.C C++  </p>	
DDTank Aimbots	<p>An inverse solving toolkit for a projectile game similar to 「Angry Birds」 — 2018.04</p> <ul style="list-style-type: none"> Established an aerodynamic model with air resistance $\mathbf{R} = -k\mathbf{v}$ for the game DDTank <ul style="list-style-type: none"> by solving $\mathbf{v}' \propto \mathbf{R} + \mathbf{F}$, where driving force $\mathbf{F} = \text{gravity } \mathbf{G} + \text{wind force } \mathbf{W}$ which lead to the core transcendental equation $1 - e^{kt} + kt = k^2 M(\mathbf{F}; \Delta \mathbf{r}, \hat{\mathbf{v}}_0)$ that can be numerically solved by Newton's method for t with given $k, \mathbf{F}; \Delta \mathbf{r}, \hat{\mathbf{v}}_0$ Finally, for each $\Delta \mathbf{r}, \hat{\mathbf{v}}_0$, one can obtain corresponding initial velocity $v_0(k, \mathbf{F}; t, M)$ <ul style="list-style-type: none"> after k, \mathbf{F} are determined (by the game engine itself) v_0 ends up the very info required to accurately hit an enemy at a distance of $\Delta \mathbf{r}$ from you Software Features: multi-OS/end, multi-hit_mode, multi-trajectory, multi-thread supported <ul style="list-style-type: none"> Multi-OS: classic Web game on Windows, Mobile game on Android & Android Emulator Multi-hit_mode: charge-mode for value v_0, drag_mode (like angry birds) for extended curve Multi-trajectory: predicts up to $6 = (1+2)*2$ trajectories for the player: split 3 + backward 3 Multi-threading: succeeded in coordinating multiple timers to implement multi-threading Capturing game data semi-automatically with computer vision purely <ul style="list-style-type: none"> call <code>dm.findmulticolorEXO</code> in <code>dm.dll</code> for pixel-level monitoring <p>VBA Excel E4A EPL  </p>	
Three e-books	<p>Freely explored math, physics, and programming with raw intellect — 2017.09</p> <ul style="list-style-type: none"> Book 1: mainly on mathematics, some intriguing chapters are: <ul style="list-style-type: none"> Multinomial theorem: $(\sum_{i=1}^n a_i)^m = \sum \frac{m!}{\prod_{i=1}^n b_i!} \prod_{i=1}^n a_i^{b_i}$ over $\{b_i \geq 0\}$, where $\sum_{i=1}^n b_i = m$ Strive to get the general formula for the n-th derivatives $f(g(x))^{(n)}$ of a composite function Connection between the sums of certain series and the indefinite integrals of their terms Explaining Euler's formula $a + b - c = n$ through topology Retracing the birth of the determinant calculation rules Book 2: up to 12 programs designed to solve mathematical / physical problems <ul style="list-style-type: none"> Multinomial theorem \implies Microstate count $\Omega_l = \frac{(g_l + a_l - 1)!}{(g_l - 1)! a_l!}$ of Bose-Einstein systems All solutions $\{b_i\}$ that meet the condition $\sum_{i=1}^m i \cdot b_i = m$ of the Faà di Bruno Formula Deep recursion algorithms for partition number $P(n)$ & the two aforementioned contexts General solution $\{x_i\}$ of multivariable linear Diophantine equation $\sum_{i=1}^n a_i \cdot x_i = b$ Complete solution v_{\max}, v_{\min} to the Double Comb/Ruler problem Minimum integer solution x, y of linear Diophantine equation $a \cdot x + b \cdot y = c$ Book 3: geometry-related mathematics & physics <ul style="list-style-type: none"> Spherical trigonometry: from which I designed a non-Euler_angle rotation operator for NLAST <ul style="list-style-type: none"> which converts direction θ, ϕ of a 3D real vector \mathbf{v} between two coordinate systems Special relativity: Had it been animated (by Manim?), it would have looked stunning <p>C++ </p>	

Rulesmd.ini	<div>Modified rules.ini of 「Red Alert II」's 17 mods</div> <div><ul style="list-style-type: none">Conflict-free key-value pairs, game-easing buildings, cooldown-free teleporting minecartsMental Omega v3.3.6: the modified rulesmo.ini for mo-3.3.6 has now been added</div>	<div>– 2016.09</div> <div>.ini</div>
Static Web Pages	<div>Personal website containing decryption elements</div> <div><ul style="list-style-type: none">All of these constitutes the exploration, shouting, and wandering of that personal period<ul style="list-style-type: none">clues for cracking password, modifying game files (e.g. Stranded II, Star Wolves 3)bi-directional links between pages, space exploration, hand-picked background musicExplore freely until you decrypt the password and unlock the hidden webpages<ul style="list-style-type: none">Solve the riddle! Or you'll be stuck here: in the middle of nowhere forever!</div>	<div>– 2014.05</div> <div>HTML</div>

Historical Details

Senior-high-school	Activities			
Undergraduate	Activities	Courses		
Postgraduate	Activities	Courses	Academia	
Doctoral	Activities		Academia	