

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


Vector Nonlinear
Fourier Crystal Optics

Solving

$$[(\nabla \times)^2 - k_0^2 \bar{\epsilon} \cdot] \mathbf{E}(\mathbf{r}) = k_0^2 \bar{\chi} : \mathcal{F}_\omega^{-1} [\tilde{\mathbf{E}}_p \tilde{\mathbf{E}}_p](\mathbf{r})$$
 analytically

2023.05 –

- First & fastest white box solver ever for this inhomogeneous $\mathbb{C}^3(\mathbb{R}^3)$ 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


decks [1](#) [2](#) [3](#) ... Complex Vector Linear
Fourier Crystal Optics

Analytic

$$\mathbf{E}(\mathbf{r}) \in \mathbb{C}^3(\mathbb{R}^3) \text{ to } [(\nabla \times)^2 - k_0^2 \bar{\epsilon} \cdot] \mathbf{E}(\mathbf{r}) = \mathbf{0} \text{ where } \epsilon_{ij} \in \mathbb{C}$$

2023.02 –

- Drawing insights from [PRS.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.](#)


decks [1](#) [2](#) [3](#) ... Real Scalar Nonlinear
Fourier Crystal Optics

Closed-form

$$\mathbf{E}_3(\mathbf{r}) \in \mathbb{C}(\mathbb{R}^3) \text{ in } [\nabla^2 + k_3^2] \mathbf{E}_3(\mathbf{r}) = -k_{03}^2 \chi(\mathbf{r}) E_1(\mathbf{r}) E_2(\mathbf{r})$$

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.](#)

decks [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 [slides] 2024.05.30
- [-1] **2023 CSOE-NJU¹ Book Club Meeting & Sharing Session** Nanjing, Jiangsu
"A guided tour to Ray & Wave Optics Simulation" | Talk [slides] 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

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|---|--|
| 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 $(\nabla^2 + k_3^2)E_3(r) \propto P_3^{(2)}(r)$ 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

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| 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

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|---------------------------|---|--|
| 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)<ul style="list-style-type: none">Favoring GPU is driven by "<i>fields in physics = arrays/matrices in math/programs</i>"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">Adaptive vertical iters & horizontal sums: ensuring the optimal speed-accuracyHaven'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> ...<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 photon_polarization_state-related BB84 protocolVisualized the distribution of anomalies along the fiber optic cable from user data | LabView |

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| 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 | EPL  |
| 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 | Keil.C C++   |
| 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 $R = -kv$ for the game DDTank <ul style="list-style-type: none"> → by solving $v' \propto R + F$, where driving force $F = \text{gravity } G + \text{wind force } W$ → which lead to the core transcendental equation $1 - e^{kt} + kt = k^2 M(F; \Delta r, \hat{v}_0)$ → that can be numerically solved by Newton's method for t with given $k, F; \Delta r, \hat{v}_0$ → Finally, for each $\Delta r, \hat{v}_0$, one can obtain corresponding initial velocity $v_0(k, F; t, M)$ <ul style="list-style-type: none"> • after k, 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 Δr 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 $6 = (1 + 2) \cdot 2$ 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.findmulticolorEX()</code> in <code>dm.dll</code> for pixel-level monitoring | VBA Excel E4A EPL   |
| 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 v between two coordinate systems → Special relativity: Had it been animated (by Manim?), it would have looked stunning | C++  |

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| 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

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|--------------------|-----------------------------|----------------|-------------------|
| Doctoral | Activities Academia | 24 – 27 clock4 | 2022.09 – 2025.06 |
| Postgraduate | Activities Courses Academia | 22 – 24 clock3 | 2020.09 – 2022.06 |
| Undergraduate | Activities Courses | 18 – 22 clock2 | 2016.09 – 2020.06 |
| Senior-high-school | Activities | 15 – 18 clock1 | 2013.09 – 2016.06 |