Chen-Zhu Xie 谢尘竹

Portfolio:
Scholar:
Preference:
Contact:
Personality: aries INTP ab

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 $\bar{\bar{\varepsilon}}, \bar{\bar{\bar{\chi}}}$ 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 –

Personal Projects

Three e-books — **3 primitive e-books on mathematics, physics, and programming** – 2017.08

- Book 1: mainly on mathematics, some intriguing chapters are:
  - Multinomial theorem: $(\Sigma_{i=1}^{n} a_i)^m = \Sigma \frac{m!}{\Pi_{i=1}^{n} b_i!} \Pi_{i=1}^{n} {a_i}^{b_i}$ over $\{b_i \geq 0\}$, where $\Sigma_{i=1}^{n} b_i = m$
  - 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
  - Multinomial theorem $\Longrightarrow$ 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 prerequisite $\Sigma_{i=1}^{m} i \cdot b_i = m$ of the Faà di Bruno Formula
  - Deep recursion algorithms for partition number $P(n)$ & all the aforementioned contexts
  - General solution $\{x_i\}$ of multivariable linear Diophantine equation $\Sigma_{i=1}^{n} a_i \cdot x_i = b$
  - 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
  - Spherical trigonometry: from which I designed a non-Euler_angle rotation operator for NLAST
    - which converts direction θ, ϕ of a 3D real vector $\boldsymbol{v}$ between two coordinate systems
  - Special relativity: Had it been animated (by Manim?), it would have looked stunning C++

Behind NLAST[1]

0 → 1 : Techniques crafted from scratch in my acedemic project : NLAST 2022.02 –

- Managed to realize *tree*-print feature in CMD lines without knowing *any tree*-packages
  - in order to visualize run-time *Call Stack* with *buried checkpoints* & display *crucial info*
  - to understand the *hierarchical structure* of my code from a more *abstract* perspective
- Enabled *multi-threads* to accelerate *for loops* in python while preserving the *loops' order*
  - Implemented through utilizing the *producer-consumer model* (producer = thread pool)
  - Allow users to select which parts of the codes in the *for loops* to *parallelize* in CPU
  - Transform *multi-layer for loops* into *nested multi-threads*: each thread = a new thread pool
  - Future model will move away from *python* as the primary language & shift to GPU
    - Favoring GPU is driven by "*fields* in physics = *arrays*/*matrices* in math/programs"
    - Haven't decided which to employ: CUDA, Jax, webGL2, webGPU, Mojo or Bend?
- Developed a log file system to track & record the operating status for debugging
  - to output script parameters (***kwargs*) for rapid reproducibility of data in the future
  - to store data files & folders, and their metadata for swift data import and reutilization
- Achieved automatic skipping of functions that return repeated values stored in memory
  - via *@decorators*: let precomputation assess whether to execute the decorated function
- Wrap *matplotlib* into plot_1d(, _2d, _3d, .gif ...) for data visualization
  - also sped up by customized multi-threading ... Matlab | Mathematica | JavaScript | Python

LabView Projects

BB84 QKD protocol simulation & distributed optical fiber sensing – 2021.06

- Verified the information security of photon_polarization_state-related BB84 protocol
- Visualized the distribution of anomalies along the fiber optic cable from user data LabView

Extended 1A2B

A Code-breaking Game - Bulls and cows: Guessing 4 digits → 1-9 digits – 2019.09

- 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

An inverse solving toolkit for a projectile game similar to Angry Birds – 2017.04

- Established an aerodynamic model with air resistance $\boldsymbol{R} = -k\boldsymbol{v}$ for the game DDTank
  - by solving $\boldsymbol{v}' \propto \boldsymbol{R} + \boldsymbol{F}$, where driving force $\boldsymbol{F}$ = gravity $\boldsymbol{G}$ + wind force $\boldsymbol{W}$
  - which lead to the core transcendental equation $1 - e^{kt} + kt = k^2 M(\boldsymbol{F}; \Delta\boldsymbol{r}, \hat{\boldsymbol{v}}_0)$
  - that can be numerically solved by Newton's method for t with given $k, \boldsymbol{F}; \Delta\boldsymbol{r}, \hat{\boldsymbol{v}}_0$
  - Finally, for each $\Delta\boldsymbol{r}, \hat{\boldsymbol{v}}_0$, one can obtain corresponding initial velocity $v_0\ (k, \boldsymbol{F}; t, M)$
    - after $k, \boldsymbol{F}$ are determined (by the game engine itself)
  - v_0 ends up the very info required to accurately hit an enemy at a distance of $\Delta\boldsymbol{r}$ from you
- Software Features: multi-OS/end, multi-hit_mode, multi-trajectory, multi-thread supported
  - 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
  - call dm.findmulticolorEX() in dm.dll VBA Excel | E4A | EPL

[1] Non-linear Angular Spectrum Theory

DDTank Aimbots **Analytic solution** 2023.02 –

- Drawing insights from PRS.A. #M.V.Berry's legacy | A.O.P. | A.P.B. | J.QSRT.
- The next generation of this project will come really close to the exact solution
- logging system
  - J.O.S.A. #Bloembergen's legacy1 | J.O. | O.M. | O.M. | J.O. | L.P.R.
  - JOSA.A. | O.E. #tightly focus #$\bar{\bar{\varepsilon}}$ anisotropy | Light.Sci.App. | O.E. PPT 1 2 3 ...

Three Books **Closed-form** $E_3(\boldsymbol{r})$ in $\left[\nabla^2 + k_3^2\right] E_3(\boldsymbol{r}) = -k_{03}^2\,\chi(\boldsymbol{r}) E_1(\boldsymbol{r}) E_2(\boldsymbol{r})$ 2022.02 –

- Solving this multivariable/field nonlinear convolution equation on my own
- Strong alternative to Green's Function, pseudo-spectral, split-step Fourier methods
- Developed a log file system to record and output script runtime parameters**kwargs,
  - 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. PPT 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 $\bar{\bar{\varepsilon}}$, $\bar{\bar{\chi}}$ dielectrics" | Oral [PPT] 2024.05.29

[-1] **2023 CSOE-NJU[2] Book Club Meeting & Sharing Session** **Nanjing, Jiangsu**
"A guided tour to Ray & Wave Optics Simulation" | Oral [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" | Oral [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 $\bar{\bar{\chi}}_{\omega}^{(2)}$ anisotropy **Vector** non-uniform analytic linear & nonlinear Fourier crystal optics 2023.06 –
!Unitary $G_{\omega}^{\pm} \Leftarrow$!Hermitian $\bar{\bar{\varepsilon}}_{r}^{\omega} \Rightarrow$ **Non-uniform** analytic linear & nonlinear Fourier crystal optics 2023.03 –

[2] The Nanjing University student branch of the Chinese Society for Optical Engineering

Solution $\boldsymbol{E}_{\omega}^{\pm}$ to $(\nabla^2 + k_{\omega\pm}^2)\boldsymbol{E}_{\omega}^{\pm} \propto \boldsymbol{P}_{\omega\pm}^{(2)}$	**Analytic** linear & nonlinear Fourier crystal optics	2022.09 –
Solution $\mathcal{F}[E_3] = \mathcal{F}\left[f\left(\mathcal{F}^{-1}[\cdot]\right)\right]$ to the Eq. below	**Nonlinear** angular spectrum theory for SFG	2022.06 –
Solution $\mathcal{F}[E_3] = \iiint \cdot$ to $(\nabla^2 + k_3^2)E_3(\boldsymbol{r}) \propto P_3^{(2)}(\boldsymbol{r})$	**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

Honors & Awards

Academia	Doctor's Qualification Exam (Oral)	Excellent	*Top 15%*	Nanjing U.	2024.01
	Bachelar 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

Research Projects

3D Vector Nonlinear
Fourier Crystal Optics

Solving $\left[(\boldsymbol{\nabla}\times)^2 - k_0^2\,\bar{\bar{\varepsilon}}\cdot\right]\boldsymbol{E}(\boldsymbol{r}) = k_0^2\,\bar{\bar{\boldsymbol{\chi}}}:\mathcal{F}_\omega^{-1}\left[\widetilde{\boldsymbol{E}}_\mathrm{p}\widetilde{\boldsymbol{E}}_\mathrm{p}\right](\boldsymbol{r})$ **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 theoratically wrong by this project #femtosecond pump
  - O.E. #Bloembergen's legacy2 #experiment | O.M.E. #z-component
  - O.E. | Q.E. #high N.A. #$\bar{\bar{\chi}}$ anisotropy PPT 1 2 3 ...

Complex Vector Linear
Fourier Crystal Optics

Analytic solution $\boldsymbol{E}(\boldsymbol{r})$ **to** $\left[(\boldsymbol{\nabla}\times)^2 - k_0^2\,\bar{\bar{\varepsilon}}\cdot\right]\boldsymbol{E}(\boldsymbol{r}) = \boldsymbol{0}$ **where** $\varepsilon_{ij}\in\mathbb{C}$ 2023.02 –

- Drawing insights from PRS.A. #M.V.Berry's legacy | A.O.P. | A.P.B. | J.QSRT.
- Next generation of this project will come really close to the exact solution
- 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 #$\bar{\bar{\varepsilon}}$ anisotropy | Light.Sci.App. | O.E. PPT 1 2 3 ...

Real Scalar Nonlinear
Fourier Crystal Optics

Closed-form $E_3(\boldsymbol{r})$ **in** $\left[\boldsymbol{\nabla}^2 + k_3^2\right]E_3(\boldsymbol{r}) = -k_{03}^2\,\chi(\boldsymbol{r})E_1(\boldsymbol{r})E_2(\boldsymbol{r})$ 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. PPT 1 2 3 4 ...

Extracurricular Activities

- Member at Some Club 2017–Current
  Detailed explanation of what you do at this club
- Member at Some Club 2016–2017
  Detailed explanation of what you do at this club
- Volunteer at Some Event Fall 2019
  Detailed explanation of what you do in this event
- Volunteer at Some Event Winter 2015
  Detailed explanation of what you do in this event

Skills

- **Skill Group:** List of technologies
- **Skill Group:** List of technologies
- **Skill Group:** List of technologies
- **Skill Group:** List of technologies

Languages

- **Language:** language proficiency level
  - **EXAM:** details
- **Language:** language proficiency level
- **Language:** language proficiency level