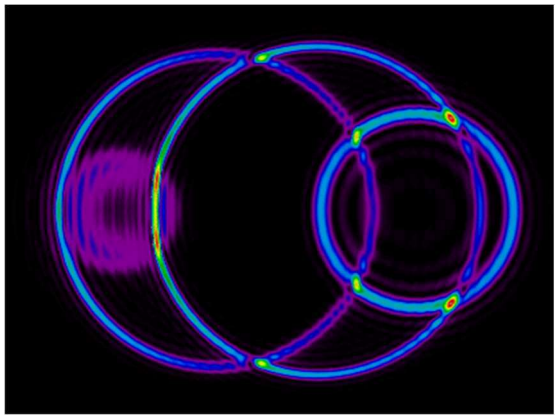

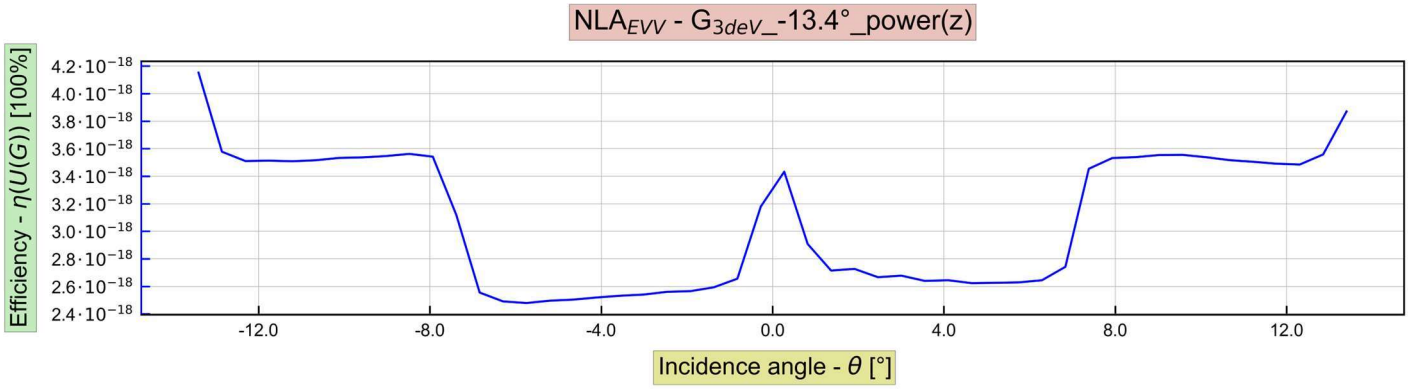

ω_s and specific wave vector k_s. Since the Kronecker product in Equation (6) squares the amount of memory needed (the computation for two $M \times M$ matrices yields a $M \times M \times M \times M$ matrix), for computing only the far-field pattern, we can directly compute the diagonal elements to reduce the memory necessary from $O(M^4)$ to $O(M^2)$. The far-field image converges quickly and is clearly evident after very few iterations. This configuration is very complex, and required high pixel resolution, as well as a long crystal (M = 500 and 5000 longitudinal steps), so each split-step Fourier iteration lasted ≈13 min on a standard PC (12 GB RAM). Figure 1d shows the simulated spatial distributions for the different incidence angles, for eight noise realizations. Clearly, excellent agreement can be found between the simulation and experiments, as presented in Figure 1c,d. Although the general trend of the emission pattern can be predicted geometrically using wavevector considerations, our method provides much more information, as it reproduces the relative intensities and higher-order effects (detailed in the next sections), all in a single calculation. For more complex structures, such as aperiodic nonlinear photonic crystals,[5] these advantages become crucial for the correct calculation of the SPDC emission pattern.

由于方程（6）中的 Kronecker 乘积是所需内存量的平方（两个 M×M 矩阵的 com 假定产生一个 M×M×M×M 矩阵），对于仅计算远场模式，我们可以直接计算对角元素，以将所需内存从 O（M 4）减少到 O（M 2）。

远场图像收敛速度很快，经过很少的迭代后就清晰可见。

这种配置非常复杂，需要高像素分辨率，以及长晶体（M= 500 和 5000 个纵向步长），因此在标准 PC（12 GB RAM）上，每次分步傅立叶迭代持续≈ 13 分钟。

图 1 d 显示了八种噪声实现的不同入射角的模拟空间分布。

显然，在模拟和实验之间可以找到极好的一致性，如图 1 c，d 所示。

尽管发射模式的总体趋势可以使用波矢量考虑进行几何预测，但我们的方法提供了更多的信息，因为它在一次计算中再现了相对强度和高阶效应（详见下一节）。

对于更复杂的结构，如非周期非线性光子晶体，[5] 这些优势对于 SPDC 发射模式的正确计算至关重要。

```
"U_pixels_x": 500, "U_pixels_y": 500,
"theta_x": 0.2, "theta_y": 0,  # 0.2 --> -4.4 --> -8.6 --> -13.4
```

```
├── 晶体_纵向切片_EVV
│    ├── z0_section_1 = 0.0 mm
│    ├── z0_section_2 = 0.24 mm
│    ├── z0_section_1 = 0.0 mm
│    └── z0_section_2 = 0.24 mm
├── cos:1.0, sinc:0.0, dismatch:0.0
├── cos:0.99, sinc:0.01, dismatch:0.0
├── cos:0.99, sinc:0.01, dismatch:0.0
├── cos:0.98, sinc:0.02, dismatch:0.0
├── begin_my_thread --> consume time: 2.1358184814453125 s
├── NLA_EVV - U3deV_0.24mm.power = 8.69e-21
└── NLA_EVV - U3deV_0.24mm.conversion_efficiency = 3.458980099263625e-18
```

```
# %%
"Tx": 2.4, "Ty": 24, "Tz": 3.06,
"mx": 1, "my": 0, "mz": 1,
```

13 mm / 0.24 mm * 2.13 s ≈ 115 s ≈ 2 min

```
# %%
"U_size": 0.4, "w0": 0.04,
"L0_Crystal": 0.24, "z1_AST": 0.6, "sheets_stored_num": 3,
# %%
"lam1": 0.808, "is_pump_dielectric": 0, "is_dielectric": 1, "T": 25,
"lam_structure": 0.404, "is_structure_pump_dielectric": 0, "T_structure": 25,
```

```
# %%
"theta_z": 90, "phi_z": 90, "phi_c": 23.7,
"polar": "V", "match_type": "ee",
"polar3": "e", "ray": "3",  # 这里的 ray 表
"lam3": 0.404,
```