Optical Properties of Icosahedral Quasicrystals

A. Sinelnik[1 a)], I. Shishkin[1,2], X. Yu[1,3], K. Samusev[1,4], P. Belov[1], M. Limonov[1,4], P. Ginzburg[1,3], and M. Rybin[1,4]

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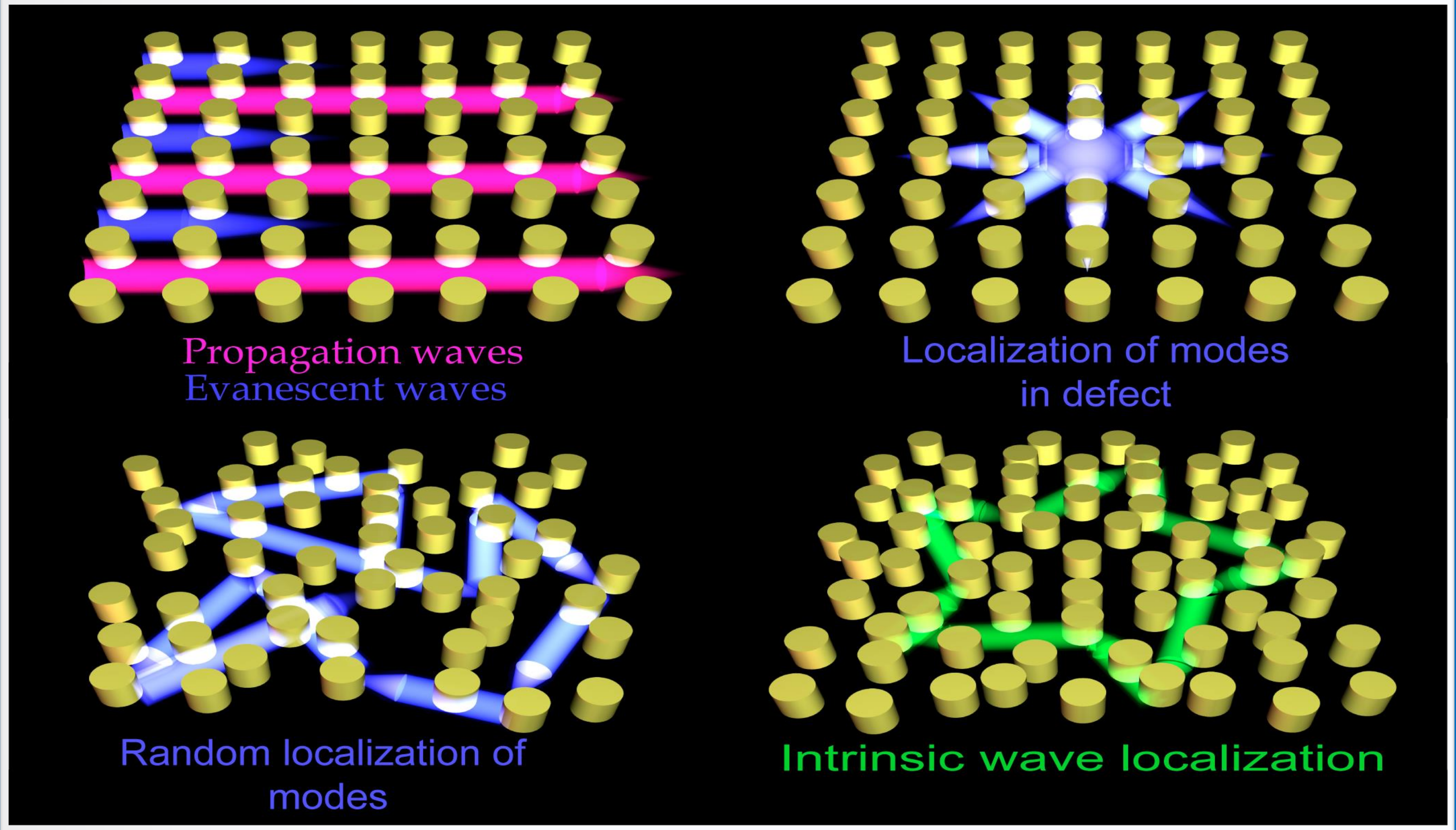
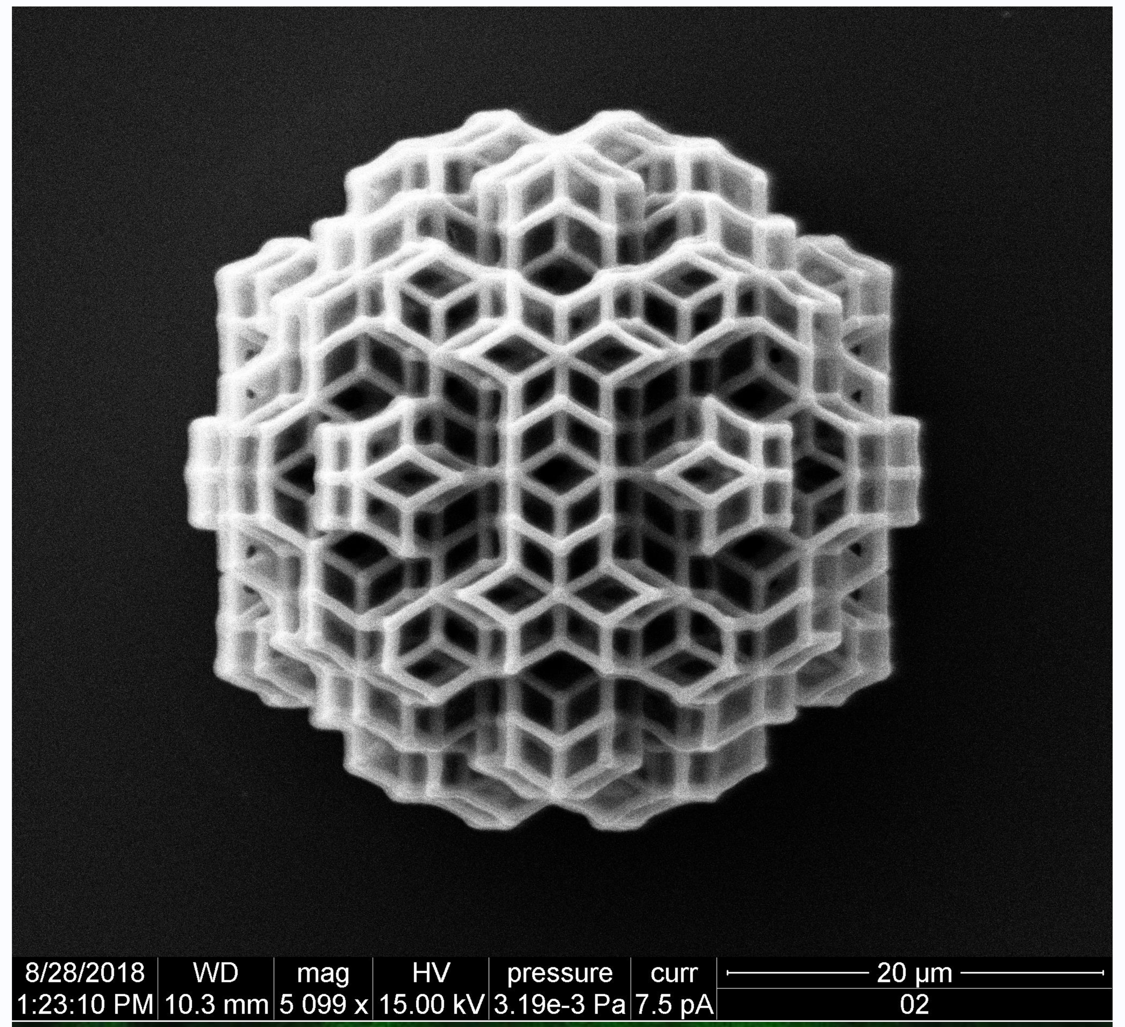
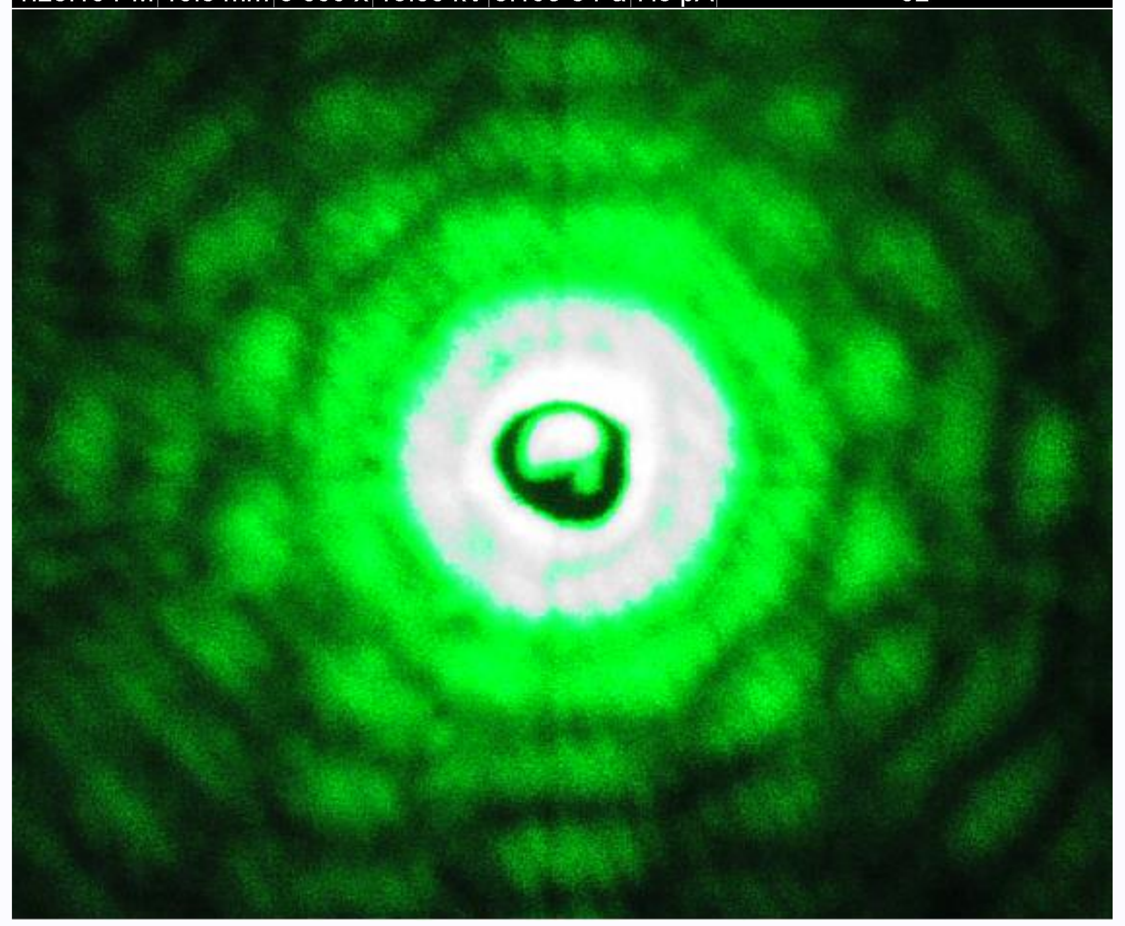
Abstract. In this work, we consider the optical properties of icosahedral quasicrystal. We experimentally investigated the intrinsic localization of light in three-dimensional quasicrystals.

Introduction

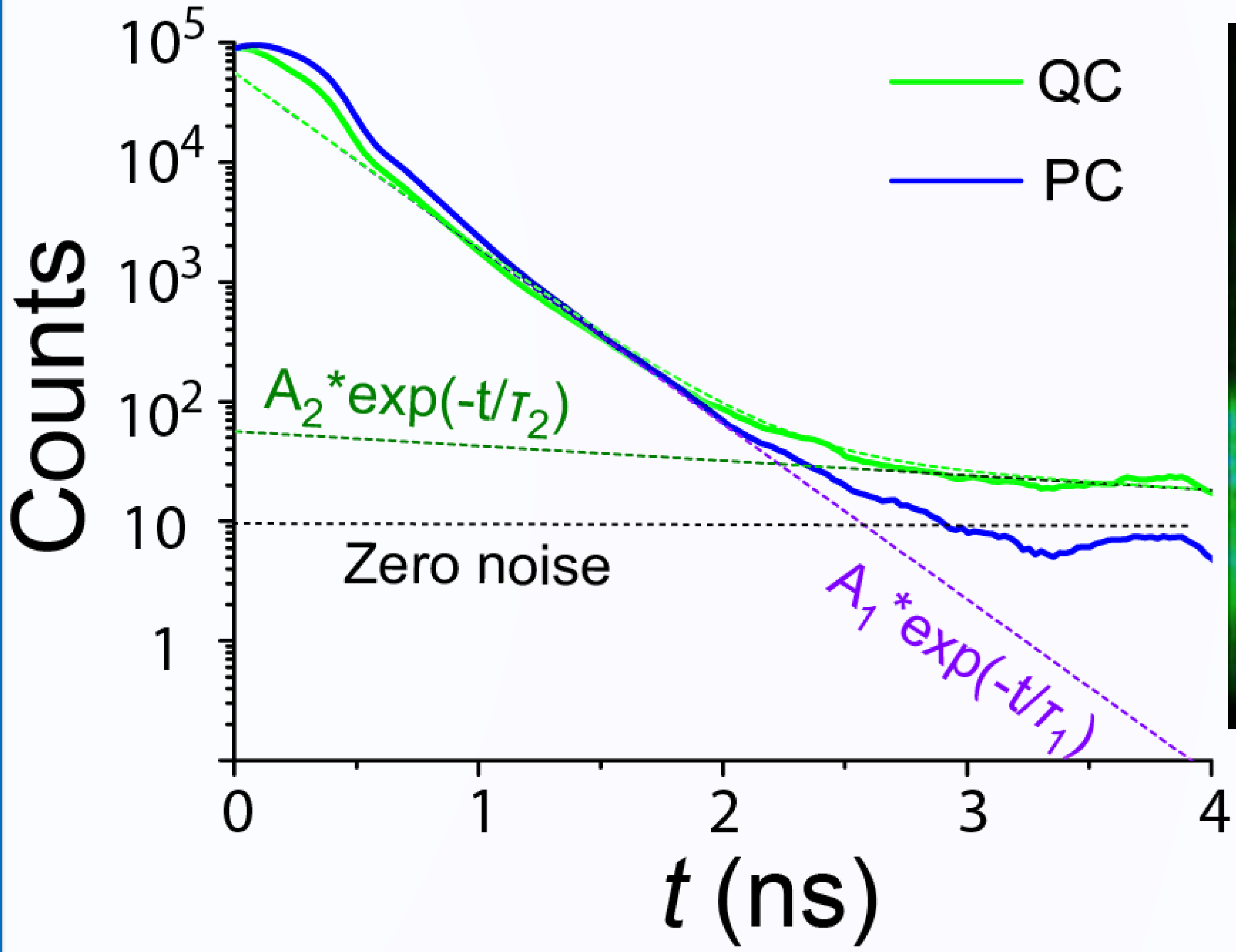


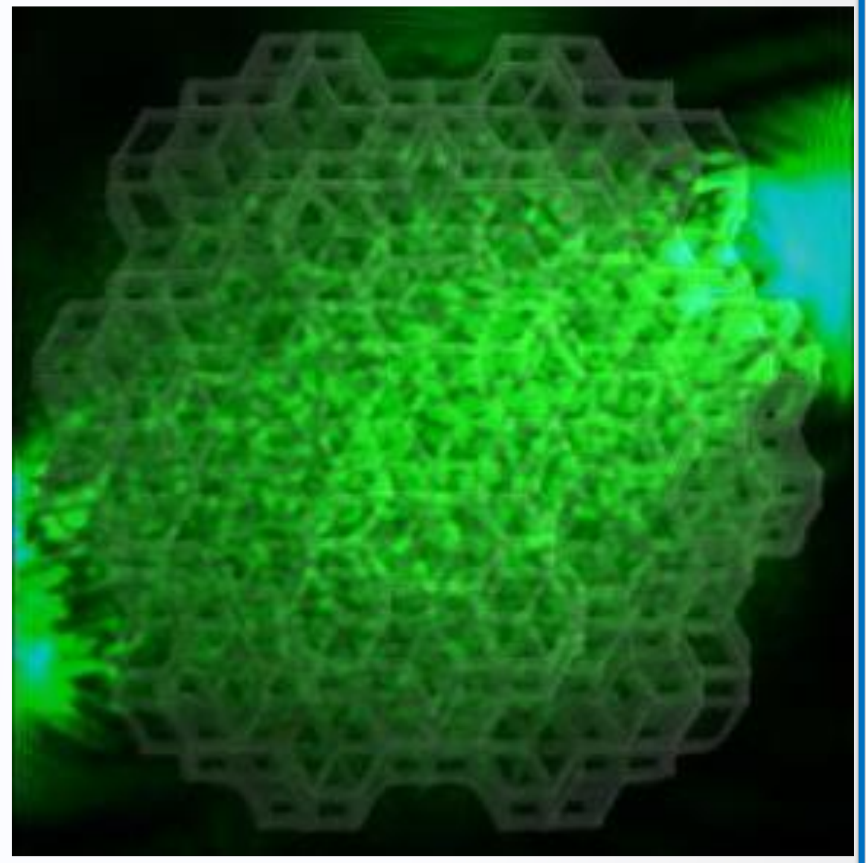
Creating structures





Experiment





Reference

1. D. Levine et al. Phys. Rev. Lett. 53, 2477-2480 (1984)
2. Jeon S. Y et al. Nature Physics. 13. 4 363-368 (2017)
3. A. Sinelnik et al. Adv. Opt. Mat. 2001170 (2020)

Conclusion. We have fabricated three-dimensional quasicrystals using DLW technology. The quality of the structures was monitored with SEM and optical diffraction techniqua. Intrinsic localization of light in quasicrystals was experimentally shown by us for the first time.


Propagation waves
Evanescent waves
Localization of modes
in defect
Random localization of
modes
Intrinsic wave localization

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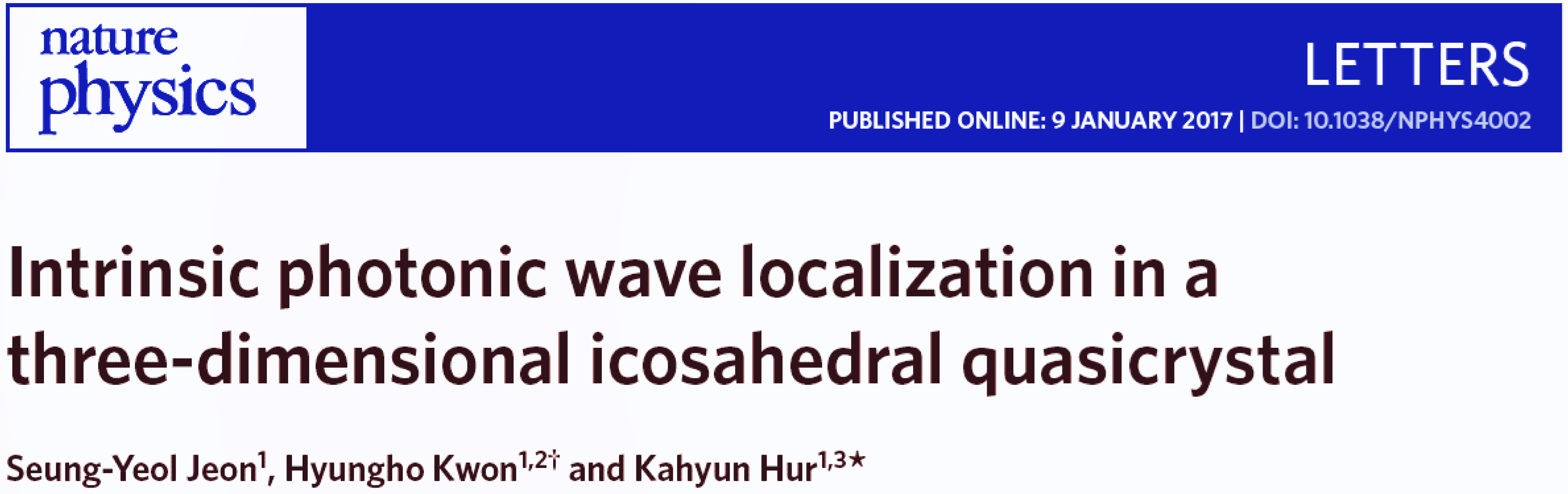
Introduction

The theoretical paper in NPHYS predicts an intrinsic wave localization in 3D quasi-crystals, which is not detected in periodic woodpile structures as a reference. Our aim is to this unusual localization experimentally


nature physics

LETTERS

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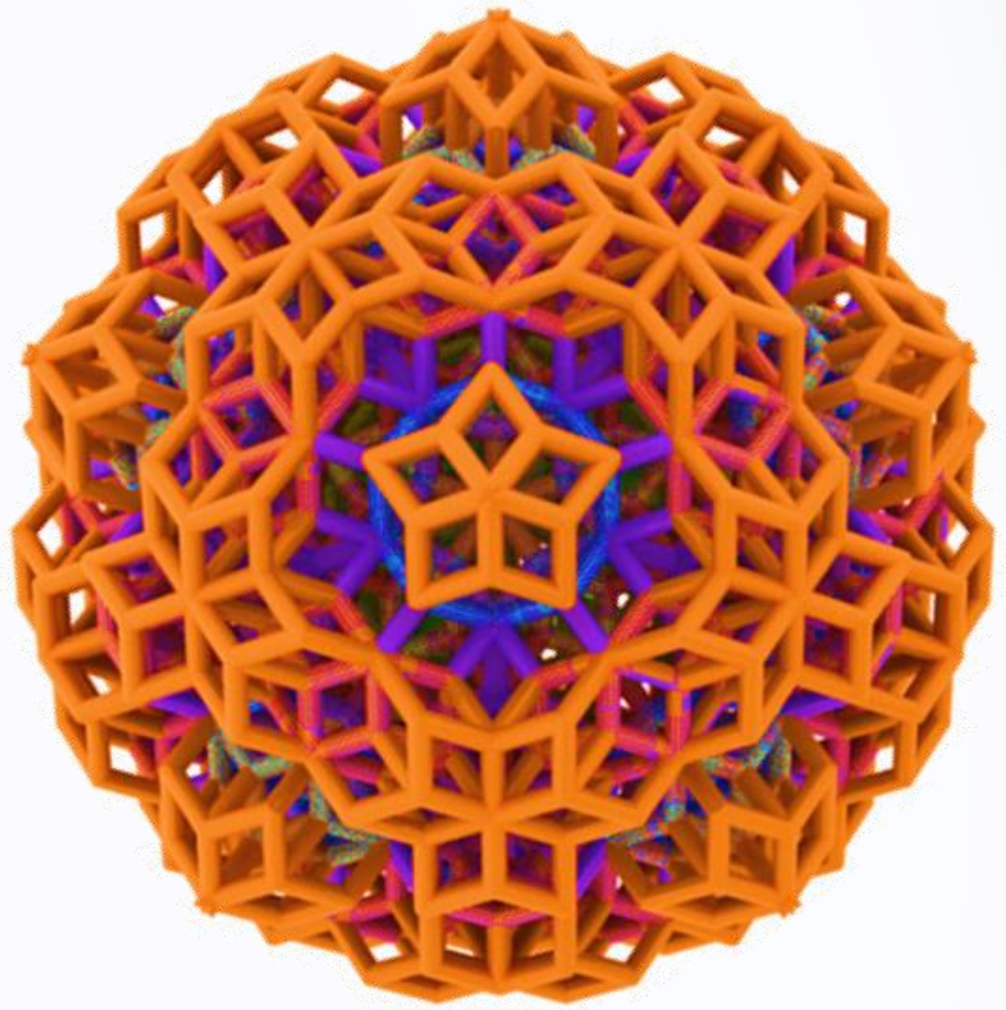
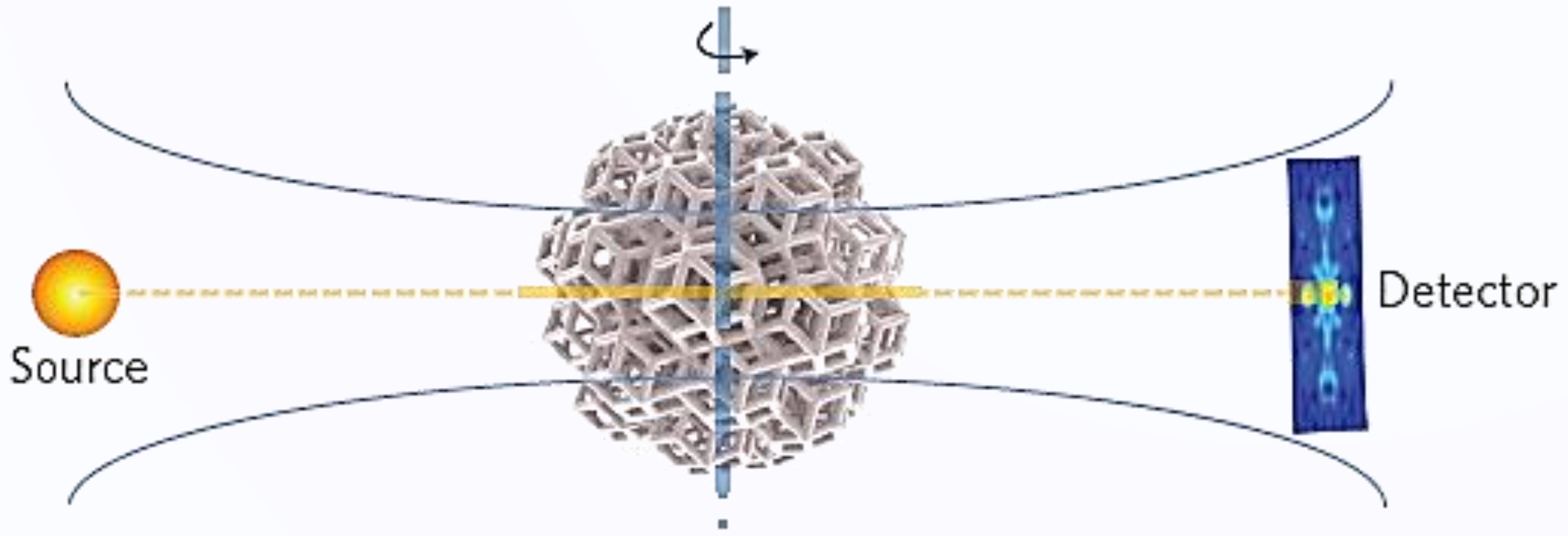
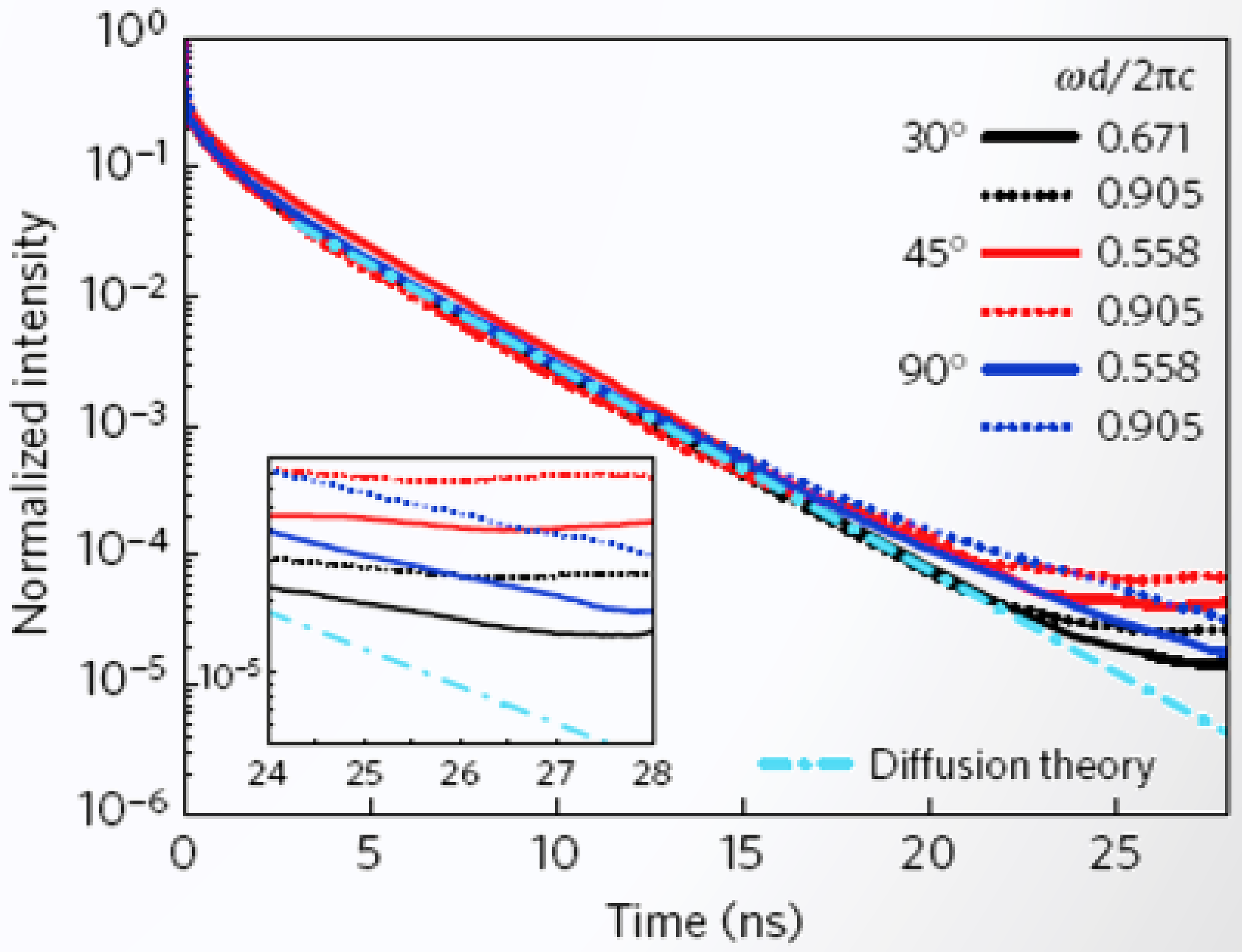
Intrinsic photonic wave localization in a three-dimensional icosahedral quasicrystal

Seung-Yeol Jeon[1], Hyungho Kwon[1,2†] and Kahyun Hur[1,3*]







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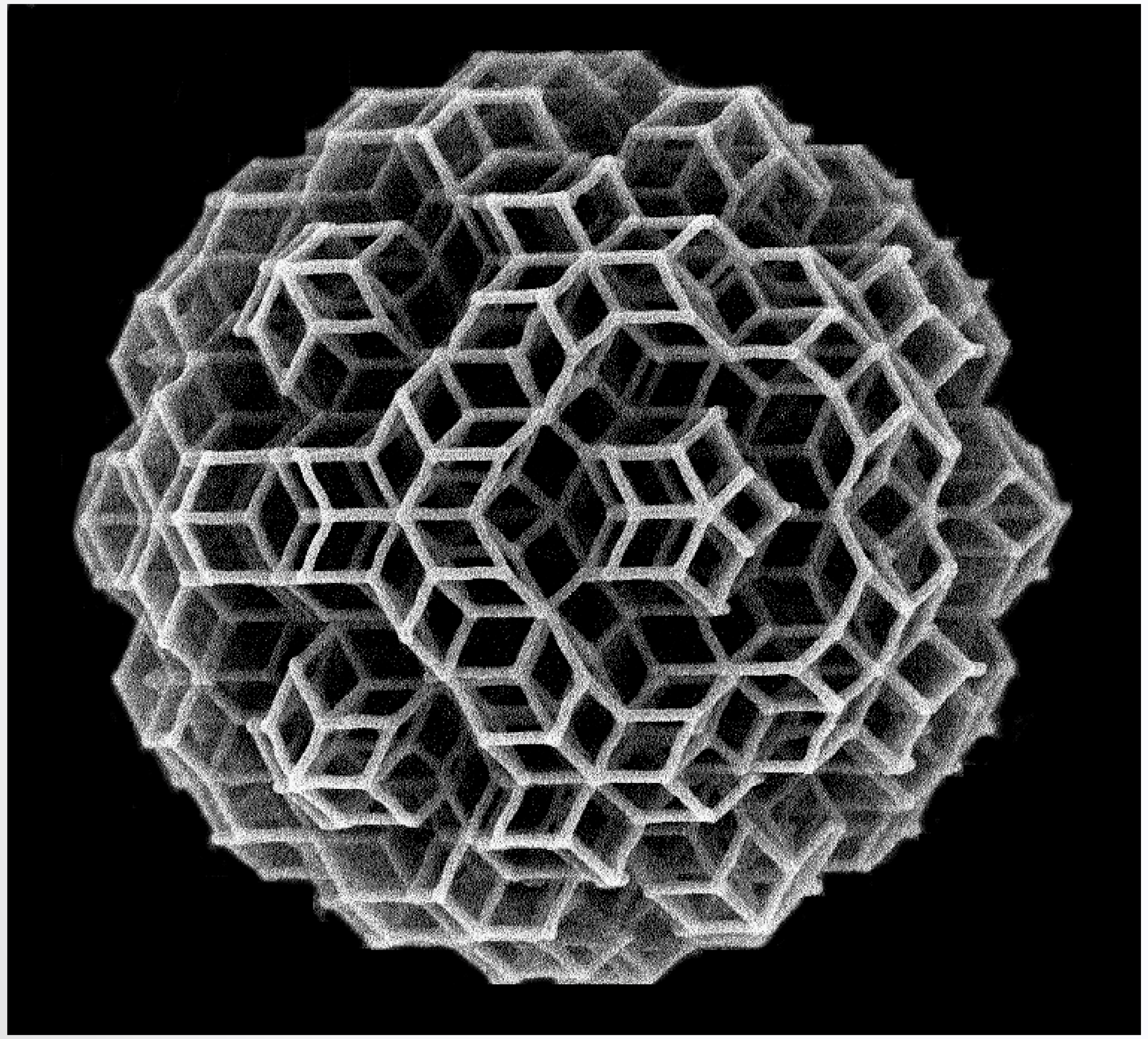
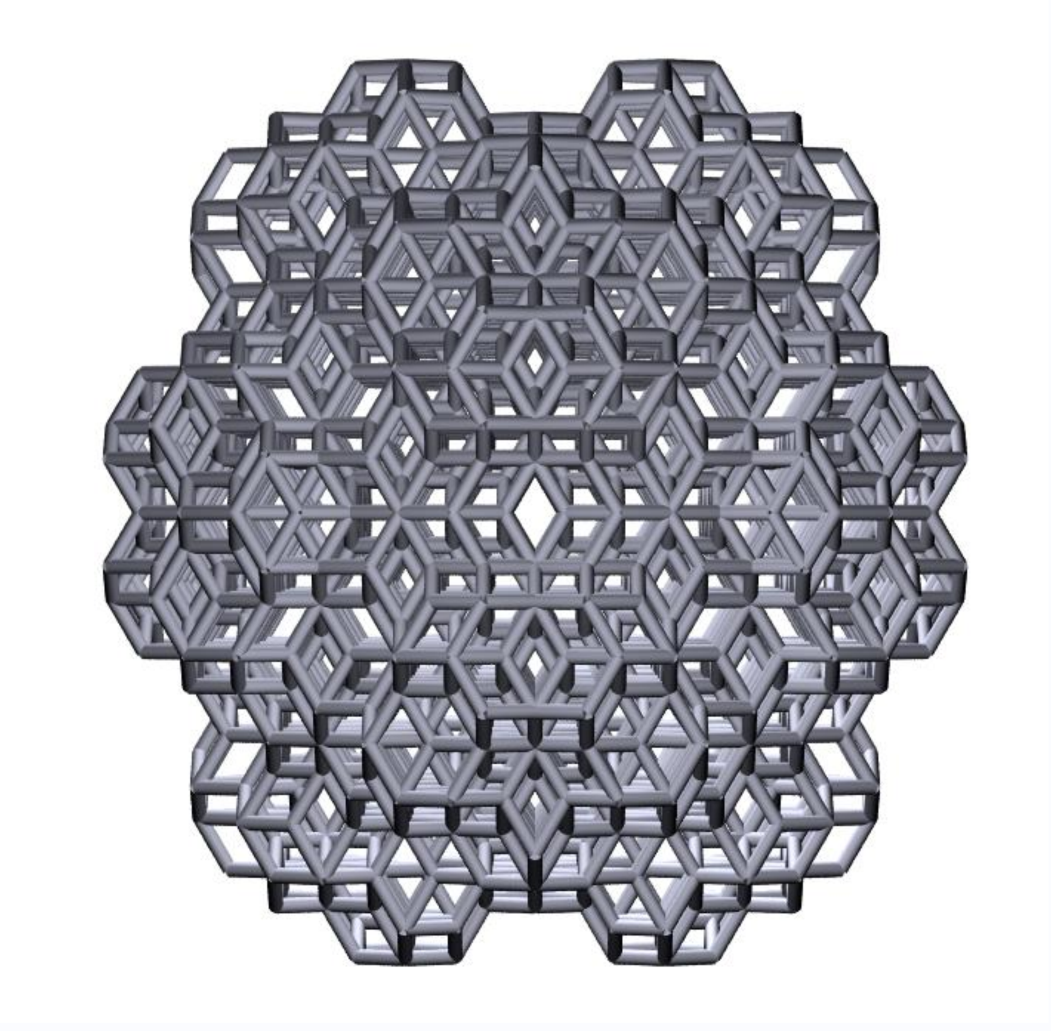
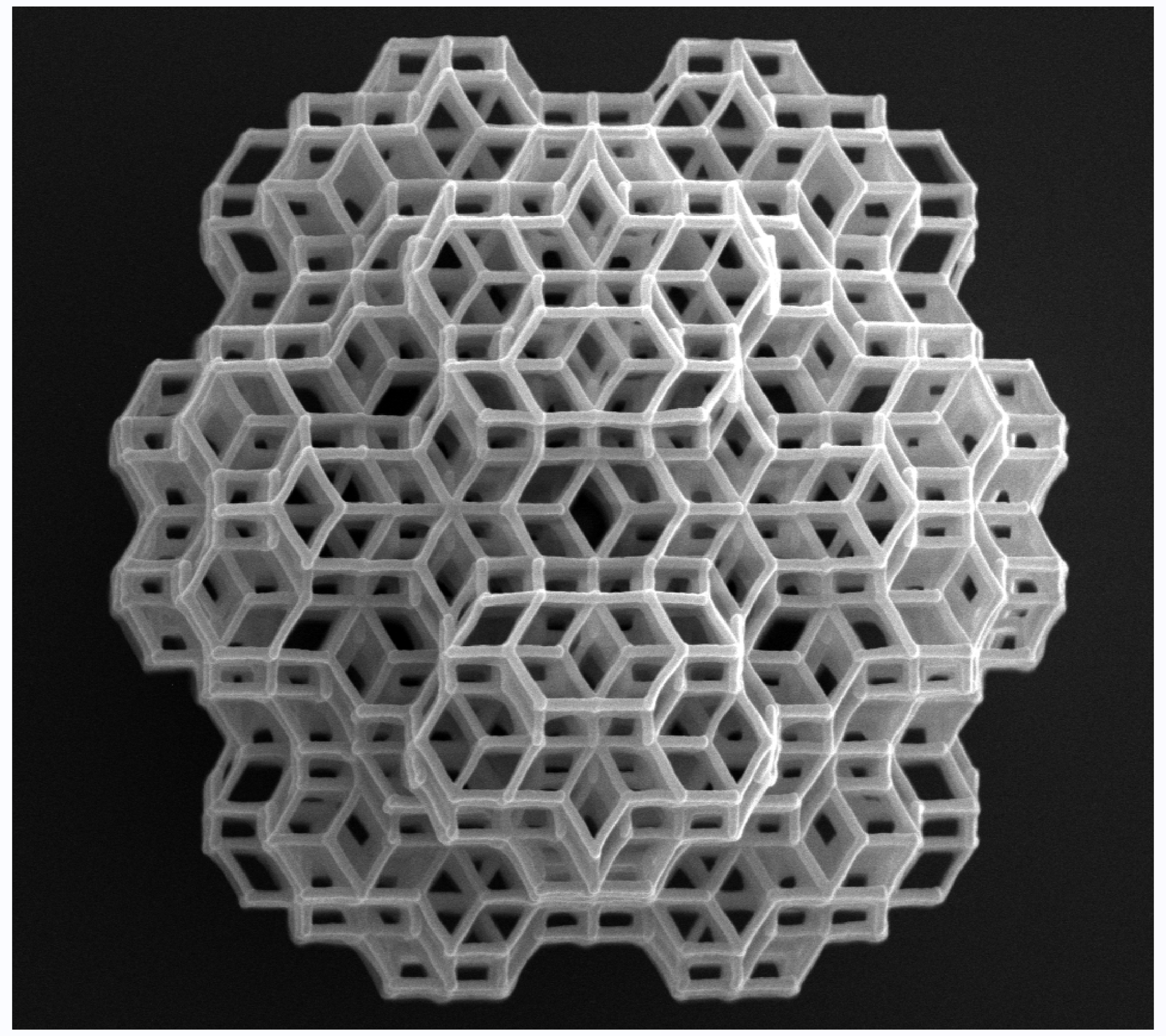
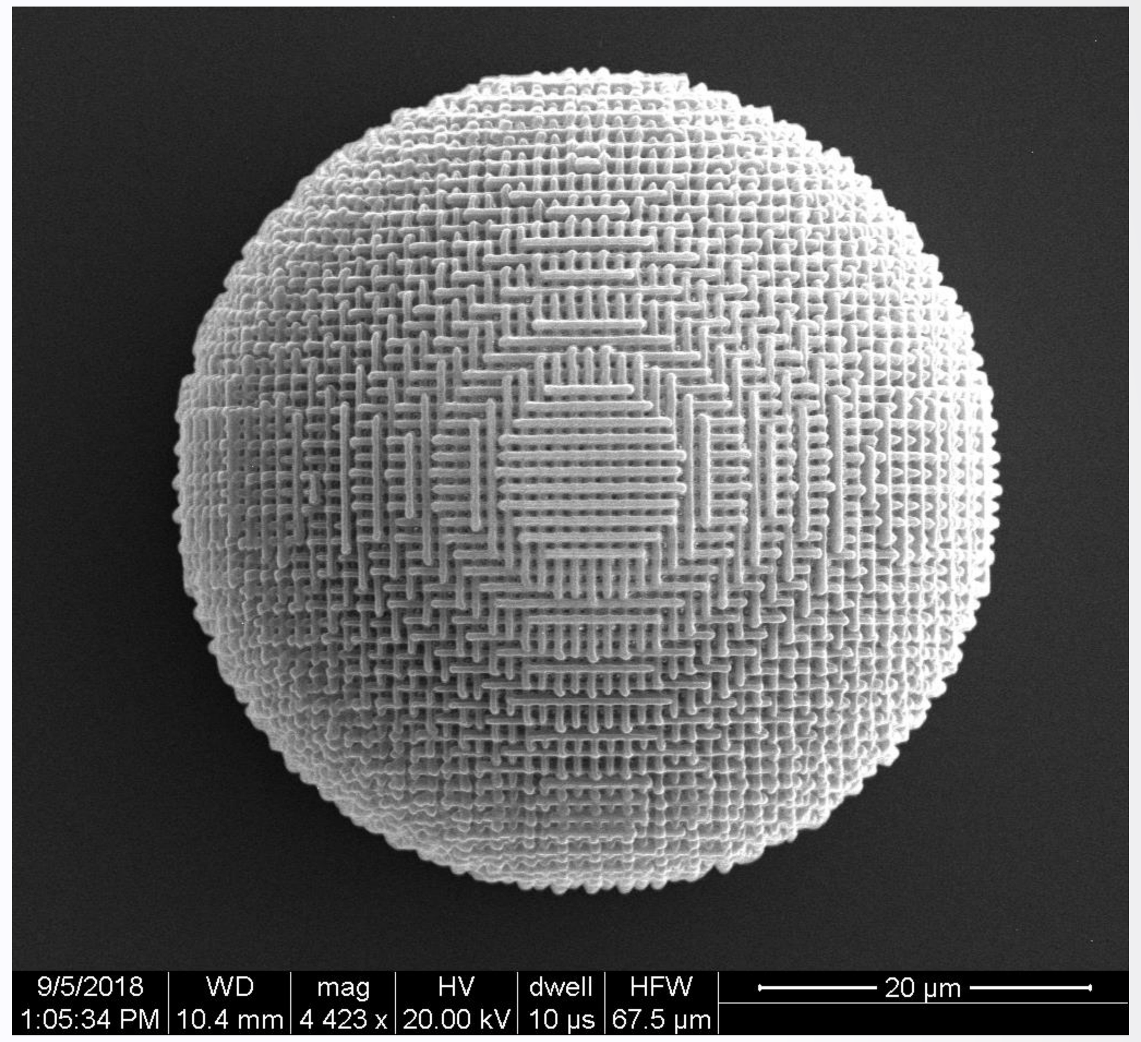
To fabricate experimental samples, we first generated a computer model of an icosahedral quasicrystal structure in accordance with the substitution rules. These quasicrystals had icosahedral symmetry with fifteen C2v, ten C3v and six C5v axes, which led to the absence of periodicity, despite the fact that the structures had perfect ordering and regularity.

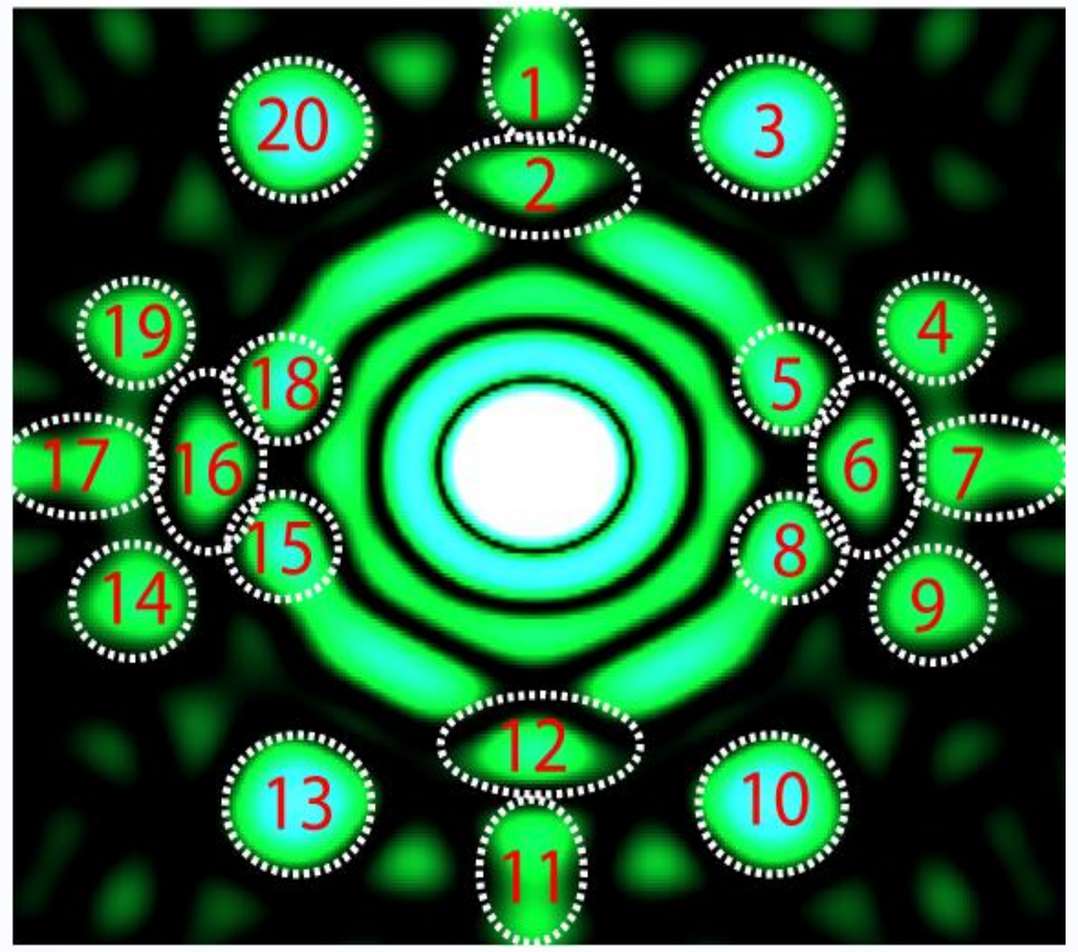


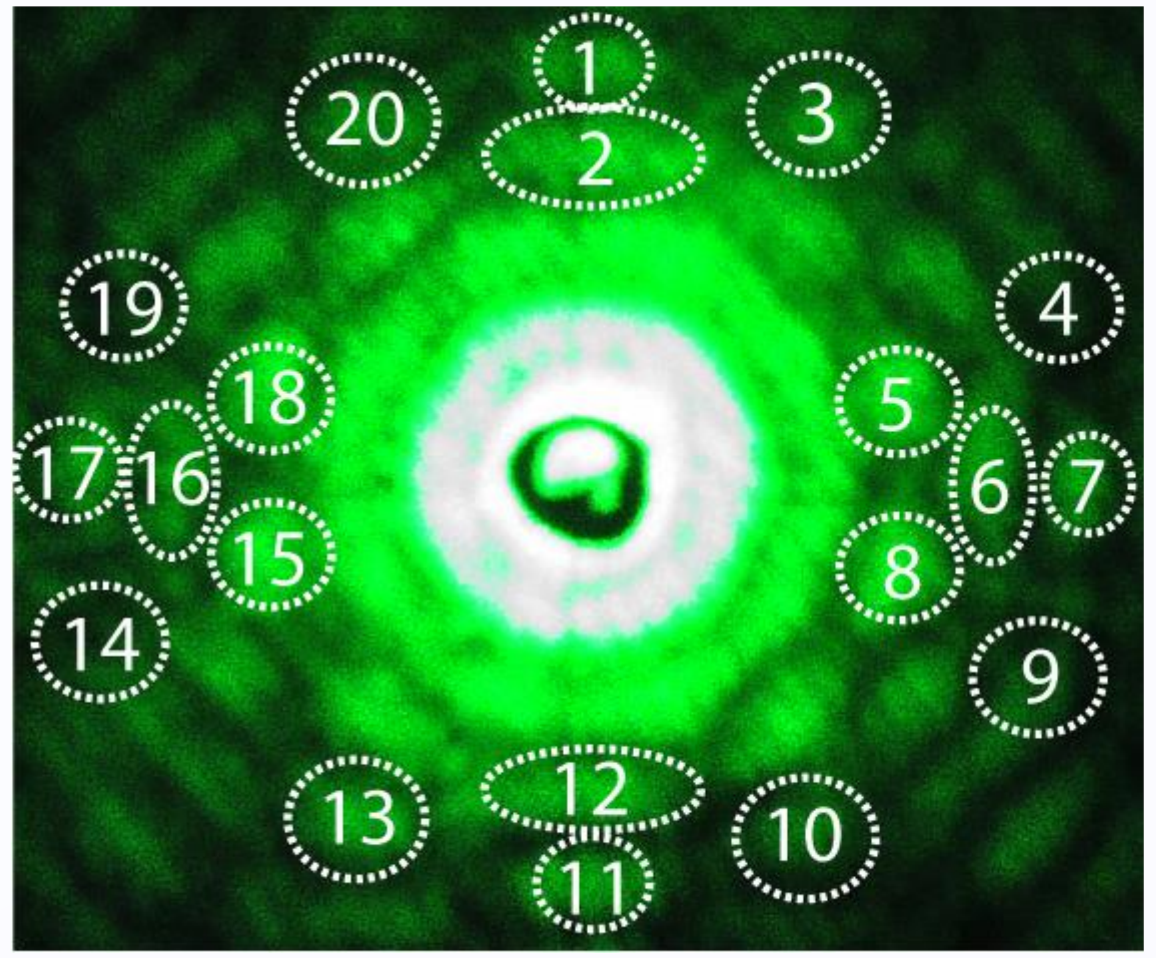
Creating structures

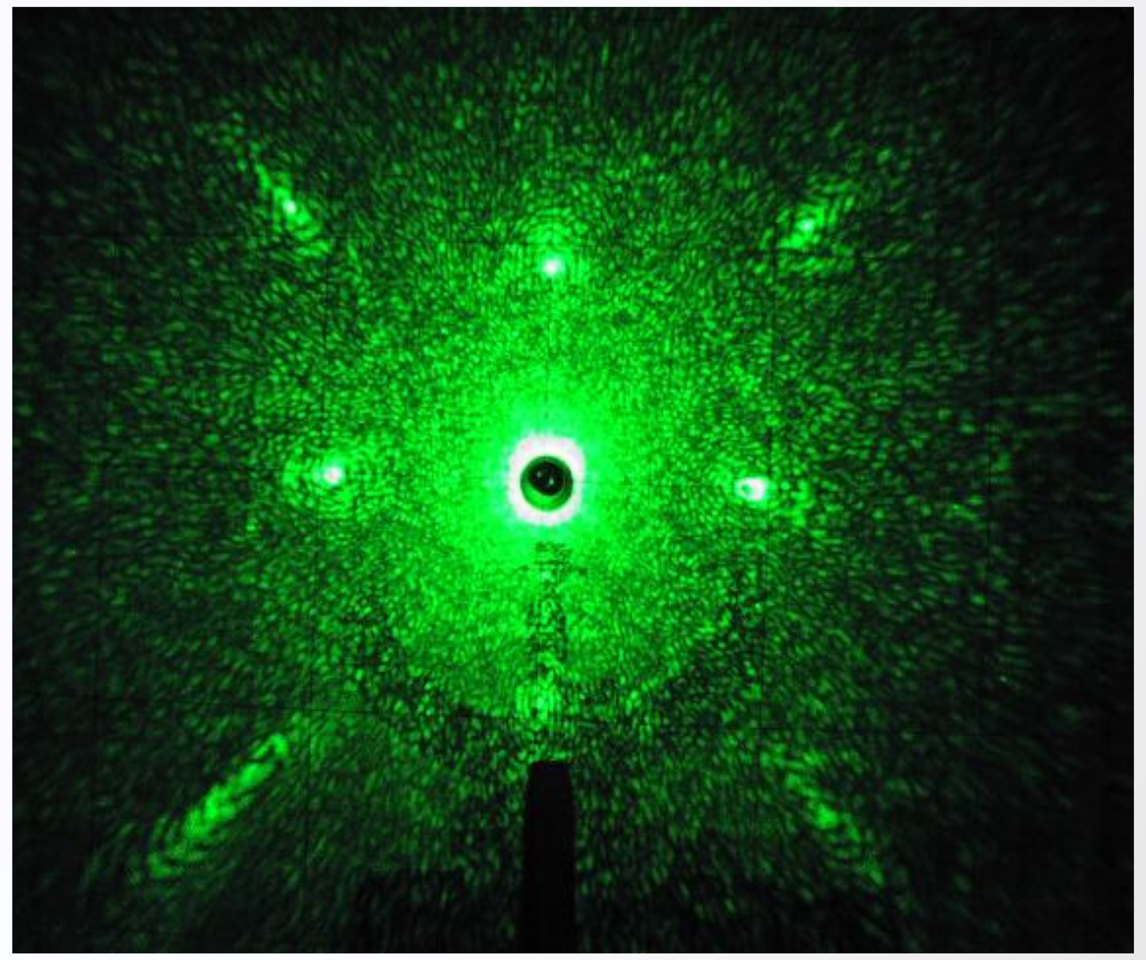












The samples were prepared by direct laser writing technique. using a hybrid organic-inorganic material based on zirconium propoxide with a refractive index of about n = 1.52 with an Irgacure 369 photo-initiator.

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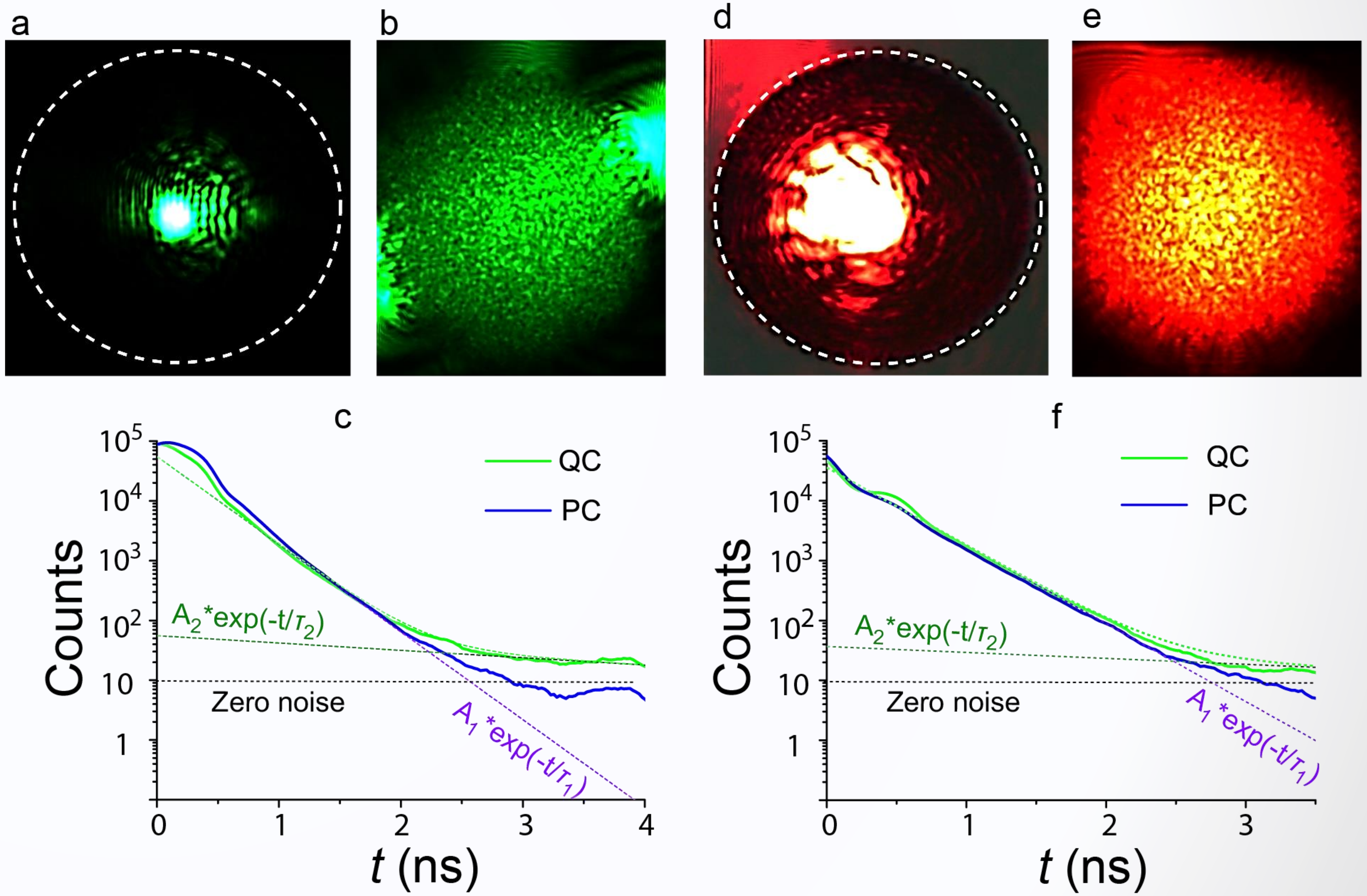
Experiment

Figures (c,f) present the transmitted intensity as a function of time at wavelengths of 530 nm and 630 nm through quasicrystal and woodpile samples. In the case of the woodpile crystal, the decay curve best fitted with a one-exponential decay model with a decay time of τ = 0.29 ns for both 530 nm and 630 nm wavelengths. The intensity decay curves of the transmission through the quasicrystal along a 2-fold symmetry axis were best fitted with a dual-exponential decay model determining the values of τ1 = 0.29 ns for the wavelength 530 nm and τ1 = 0.30 ns for 630 nm (with a fractional amplitude of A1=99% for 530 nm and 630 nm both). These decay times corresponded to the intrinsic instrument response. The second exponent was related to the process with the decay time of τ2 = 3.3 ns (530 nm) and τ2 = 4.3 ns (630 nm) with the fractional amplitude A2=1%). The values of τ2 were longer by an order of magnitude than τ1.



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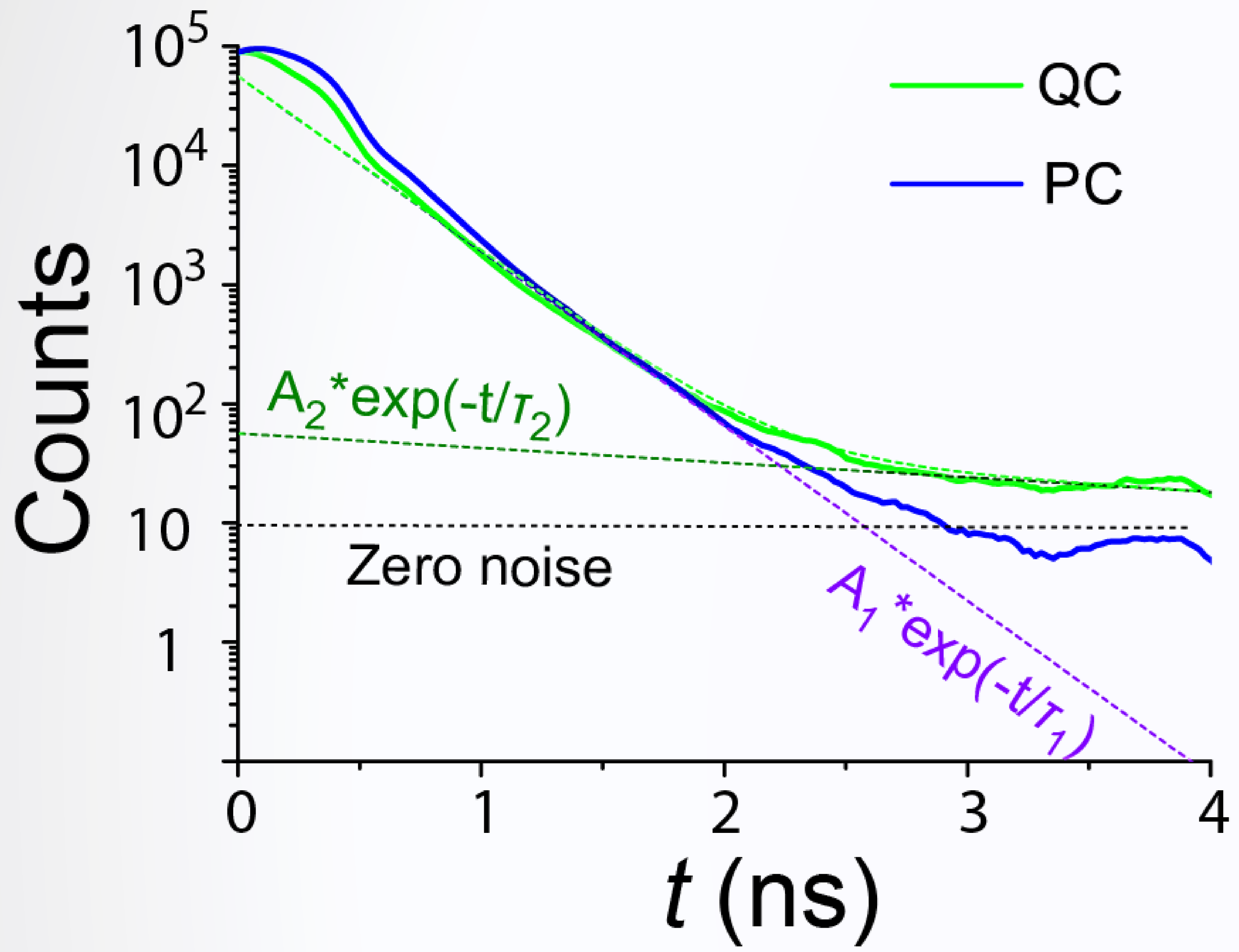
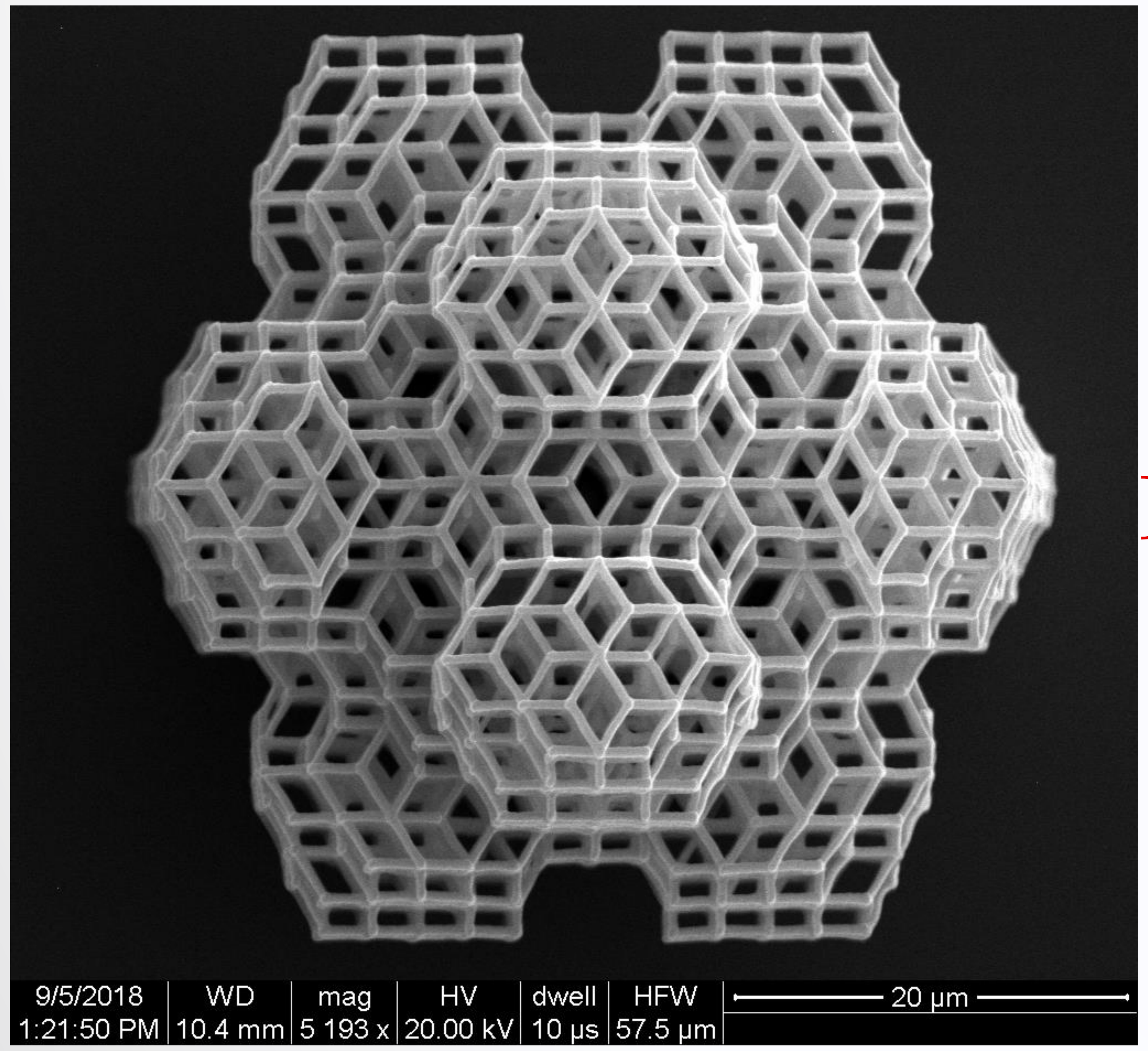
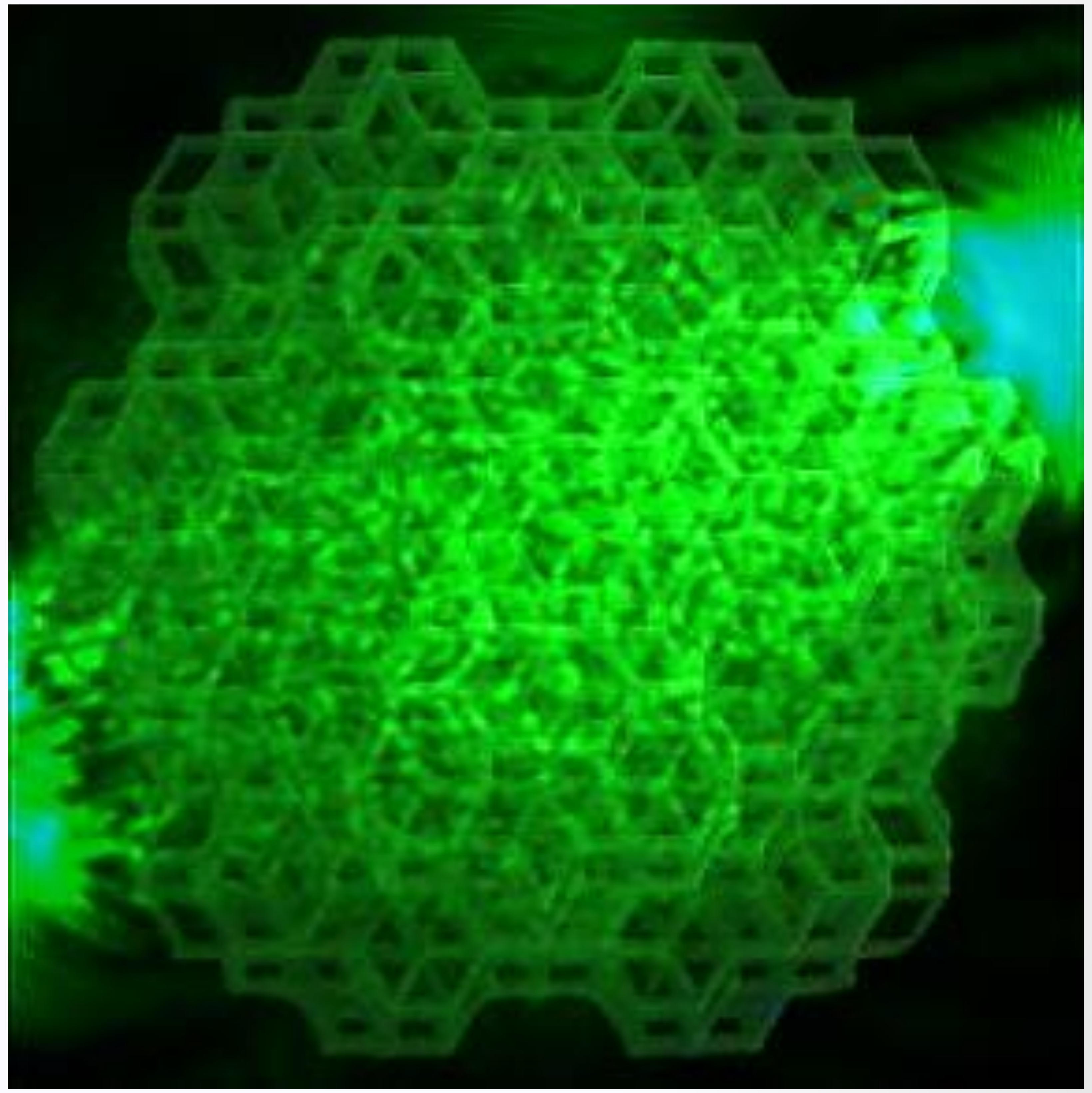
Conclusion





We have fabricated three-dimensional quasicrystals by using DLW technology. The quality of the structures was monitored with SEM and optical diffraction technique. Intrinsic localization of light in quasicrystals was experimentally shown by us for the first time.

The results of this work were published in Advanced Optical Materials



Thank you for attention

artem.sinelnik@metalab.ifmo.ru

My PhD thesis defence is going to be in December 2020.
I am looking for a position.

A. Sinelnik et al. Experimental observation of intrinsic light localization in photonic icosahedral quasicrystals. Adv. Opt. Mat. 2001170 (2020)