

Semi-analytical model for the modeling of disordered photonic crystals

This Mathematica code has been used to generate the results that can be found in the paper “Long-wavelength reflecting filters found in the larval retinas of one mantis shrimp family (Nannosquillidae)” by Feller et al. (code authored by G. Jacucci)

Model calculations (more details can be found in the Supporting Information of the paper)

```

ClearAll["Global`*"]

ψ = 1.08; (*histological expansion factor during imaging*)
ff[a_, rr_] :=  $\left( \frac{\frac{16}{3} * 3.14 * (rr * \psi)^3}{(a * \psi)^3} \right)$ ; (*filling fraction*)

nves = 1.48; (*vesicles refractive index*)
nmatrix = 1.33; (*matrix refractive index*)
λ[a_, rr_] :=  $2 * \frac{(a * \psi)}{2} * \sqrt{(ff[a, rr] * n_{ves}^2 + (1 - ff[a, rr]) * n_{matrix}^2)}$ 

(*The model takes as an input the experimentally
measure distributions of vesicles' size and crystal
periodicity and the peak shape calculated via FDTD*)
H = 17.6 * PDF[NormalDistribution[392, 7], A]; (*periodicity distribution
extracted from the Structure Factor (Figure 4, Main Text)*)
H2 = 12.53 * PDF[NormalDistribution[82, 5], R];
(*radii distribution extracted from TEM images*)
Dist[μ_] := 4.9 * PDF[NormalDistribution[μ, 6], x]; (*peak shape from FDTD*)
samplingNum = 100;
A = RandomVariate[NormalDistribution[392, 7], samplingNum];
R = RandomVariate[NormalDistribution[82, 5], samplingNum];
L = λ [A, R];
(*Model computation*)
Model = (Dist /@ L) * H2 * H;

```

Results plot

```
M = λ[392, 82];
```

```
(*Calculated wavelength for the average values of the parameters*)
```

```
Show[
```

```
  Plot[Model // Evaluate, {x, 400, 700},
    PlotStyle → RGBColor[0.4, 0.4, 0.4], Filling → Axis,
      FillingStyle → Directive[Opacity[0.01], RGBColor[0.4, 0.4, 0.4]],
    ImageSize → Large,
      FrameLabel -> {"Wavelength (nm)", "Reflectance"},
      Frame → True, Axes → None,
      PlotRange → {{M - 50, M + 50}, {0, .4}}
    ],
```

```
  Plot[Table[4.9 * PDF[NormalDistribution[M, σ], x], {σ, {6}}] // Evaluate,
    {x, 400, 700}, PlotStyle → Red, Filling → Axis,
      FillingStyle → Directive[Opacity[0.1], Red],
      PlotRange → {{M - 50, M + 50}, {0, .4}}
    ],
```

```
  Plot[Table[4.9 * PDF[NormalDistribution[M, σ], x], {σ, {14}}] // Evaluate,
    {x, 400, 700}, PlotStyle → Blue, Filling → Axis,
      FillingStyle → Directive[Opacity[0.2], Blue],
      PlotRange → {{M - 50, M + 50}, {0, .4}}
    ]
]
```

