

## delauney\_grid

November 27, 2025

```
[3]: import numpy as np
import matplotlib.pyplot as plt
from scipy.spatial import Delaunay

# -----
# 1.
# -----
def sample_points_in_disk(n_points=400, radius=1.0, seed=0):
    rng = np.random.default_rng(seed)
    #  $r \sim \{1/2\}$ 
    r = radius * np.sqrt(rng.random(n_points))
    theta = 2 * np.pi * rng.random(n_points)
    x = r * np.cos(theta)
    y = r * np.sin(theta)
    return np.vstack([x, y]).T

points = sample_points_in_disk(n_points=450, radius=1.0, seed=42)

# -----
# 2. Delaunay
# -----
tri = Delaunay(points)
triangles = tri.simplices # (n_tri, 3)

#
centroids = points[triangles].mean(axis=1)
mask = np.linalg.norm(centroids, axis=1) <= 1.0
triangles = triangles[mask]

# -----
# 3.
# -----
fig, ax = plt.subplots(figsize=(7, 7))
ax.set_aspect("equal")
ax.set_facecolor("#111111") # /
fig.patch.set_facecolor("#111111")
```

```

#
#
rng = np.random.default_rng(123)
colors = rng.random((len(triangles), 3)) * 0.7 + 0.3 #

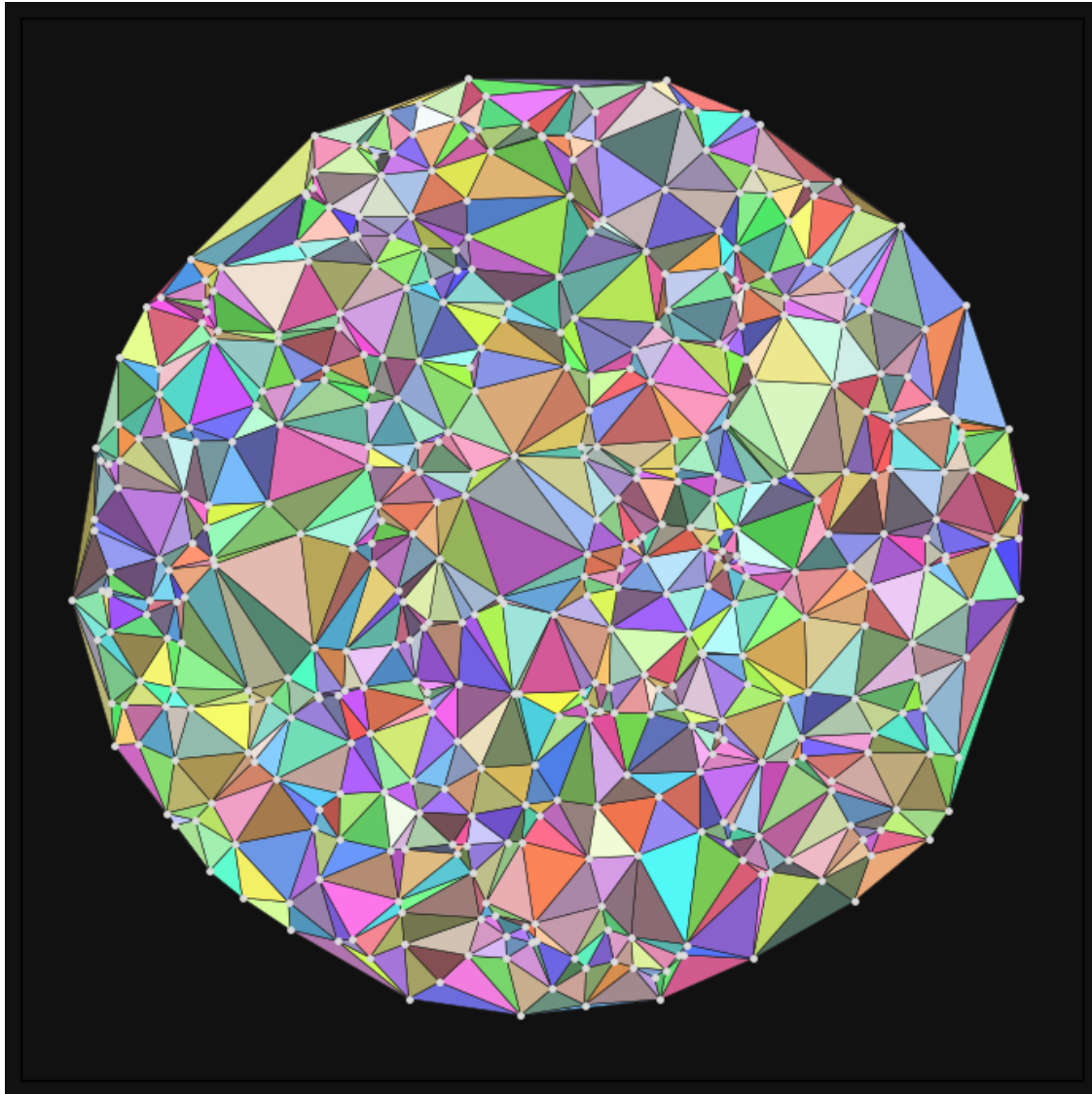
for tri_idx, col in zip(triangles, colors):
    tri_coords = points[tri_idx]
    poly = plt.Polygon(tri_coords, closed=True,
                        facecolor=col,
                        edgecolor="#222222",
                        linewidth=0.4)
    ax.add_patch(poly)

#
ax.scatter(points[:, 0], points[:, 1],
           s=6, c="#dddddd", zorder=3)

#
ax.set_xticks([])
ax.set_yticks([])
ax.set_xlim(-1.1, 1.1)
ax.set_ylim(-1.1, 1.1)

plt.tight_layout()
plt.show()

```



```
[4]: import numpy as np
import matplotlib.pyplot as plt
from scipy.spatial import Delaunay

# -----
# 1. Generate points in a circle (fibonacci spiral for even distribution)
# -----
n_points = 320 # adjust for density

# Fibonacci (golden angle) spiral - gives beautiful uniform circular
# ↪ distribution
golden_angle = np.pi * (3 - np.sqrt(5))
theta = golden_angle * np.arange(n_points)
```

```

# Radius increases toward the edge
radius = np.sqrt(np.arange(n_points) / float(n_points))

x = radius * np.cos(theta)
y = radius * np.sin(theta)

points = np.column_stack((x, y))

# Add the center point explicitly (optional, improves aesthetics)
points = np.vstack(([0, 0], points))

# -----
# 2. Compute Delaunay triangulation
# -----
tri = Delaunay(points)

# -----
# 3. Plot it exactly like your image
# -----
plt.figure(figsize=(10, 10), facecolor='black')
ax = plt.gca()
ax.set_facecolor('black')
ax.axis('off')
ax.set_aspect('equal')

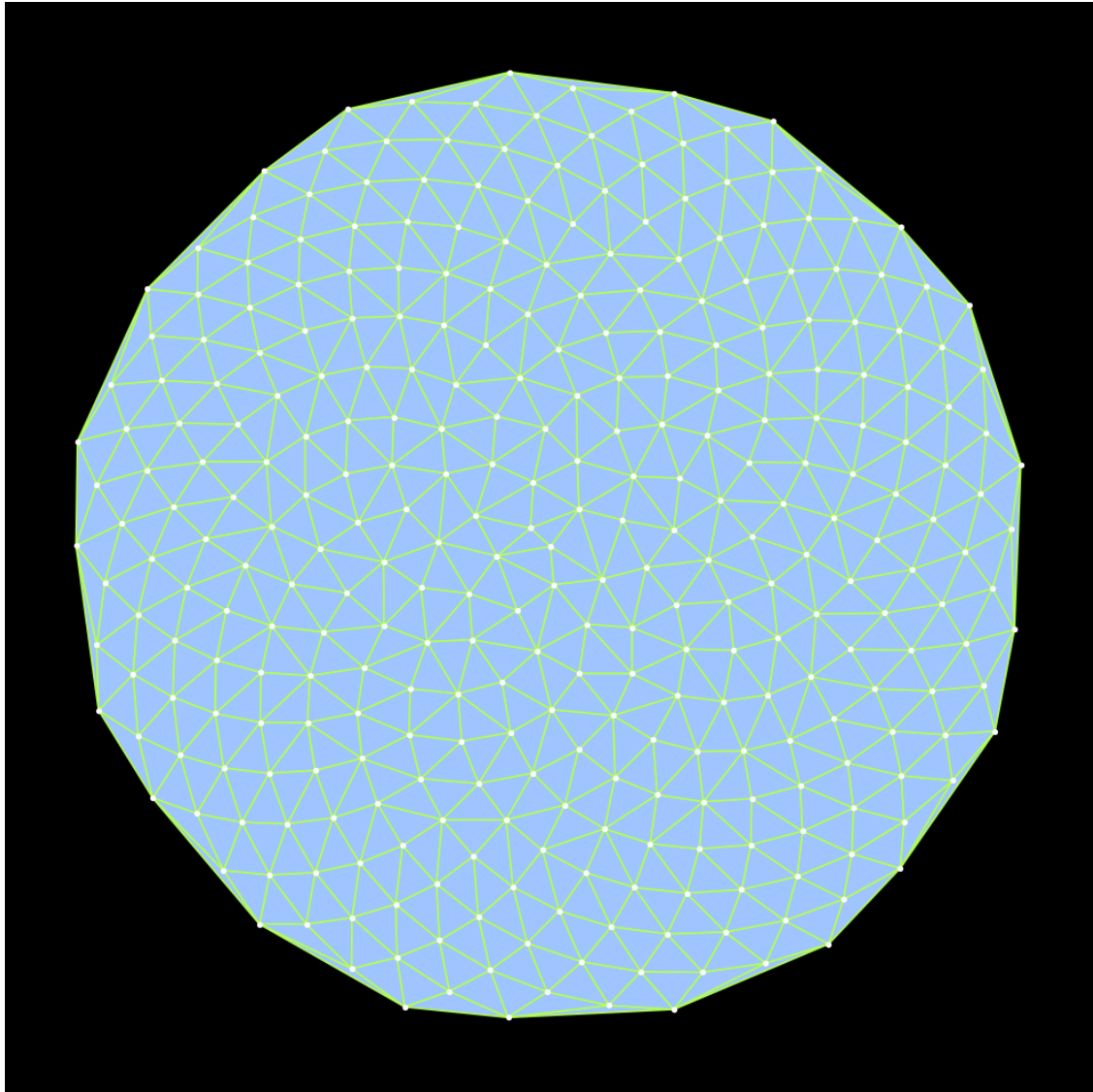
# Triangle face color (light blue)
face_color = "#a0c4ff" # soft blue
# Edge color (lime green)
edge_color = "#b2ff59" # bright lime green

# Plot every triangle
for simplex in tri.simplices:
    triangle = points[simplex]
    # Fill triangle
    plt.fill(triangle[:, 0], triangle[:, 1],
             color=face_color, edgecolor=edge_color, linewidth=1.2)

# Optional: plot vertices as tiny white dots (like in your image)
plt.scatter(points[:, 0], points[:, 1], c='white', s=8, zorder=5)

plt.xlim(-1.1, 1.1)
plt.ylim(-1.1, 1.1)
plt.tight_layout()
plt.show()

```



```
[5]: import numpy as np
import matplotlib.pyplot as plt

# -----
#
# -----
R = 1.0          #
n_rays = 20      # 360 / 18 = 20
ray_len = 1.2    #

# -----
# 1.
# -----
```

```

#      90°      72°
angles_pent = np.deg2rad(90 + np.arange(5) * 72)
pent_x = R * np.cos(angles_pent)
pent_y = R * np.sin(angles_pent)

# -----
# 2. 18°
# -----
angles_rays_deg = np.arange(0, 360, 18)      # 0, 18, 36, ..., 342
angles_rays = np.deg2rad(angles_rays_deg)

#
ray_x = ray_len * np.cos(angles_rays)
ray_y = ray_len * np.sin(angles_rays)

# -----
# 3.
# -----
fig, ax = plt.subplots(figsize=(6, 6))
ax.set_aspect("equal")
ax.set_facecolor("#111111")
fig.patch.set_facecolor("#111111")

# (a)      +
ax.fill(pent_x, pent_y, color="#4c78ff", alpha=0.25, linewidth=0)
ax.plot(np.append(pent_x, pent_x[0]),
        np.append(pent_y, pent_y[0]),
        color="#9fb6ff", linewidth=2.2)

# (b)      18° / 36°
for ang_deg, x, y in zip(angles_rays_deg, ray_x, ray_y):
    #      36°      0, 36, 72, ...
    if ang_deg % 36 == 0:
        color = "#66ff99"      #
    else:
        color = "#ffcc66"      #

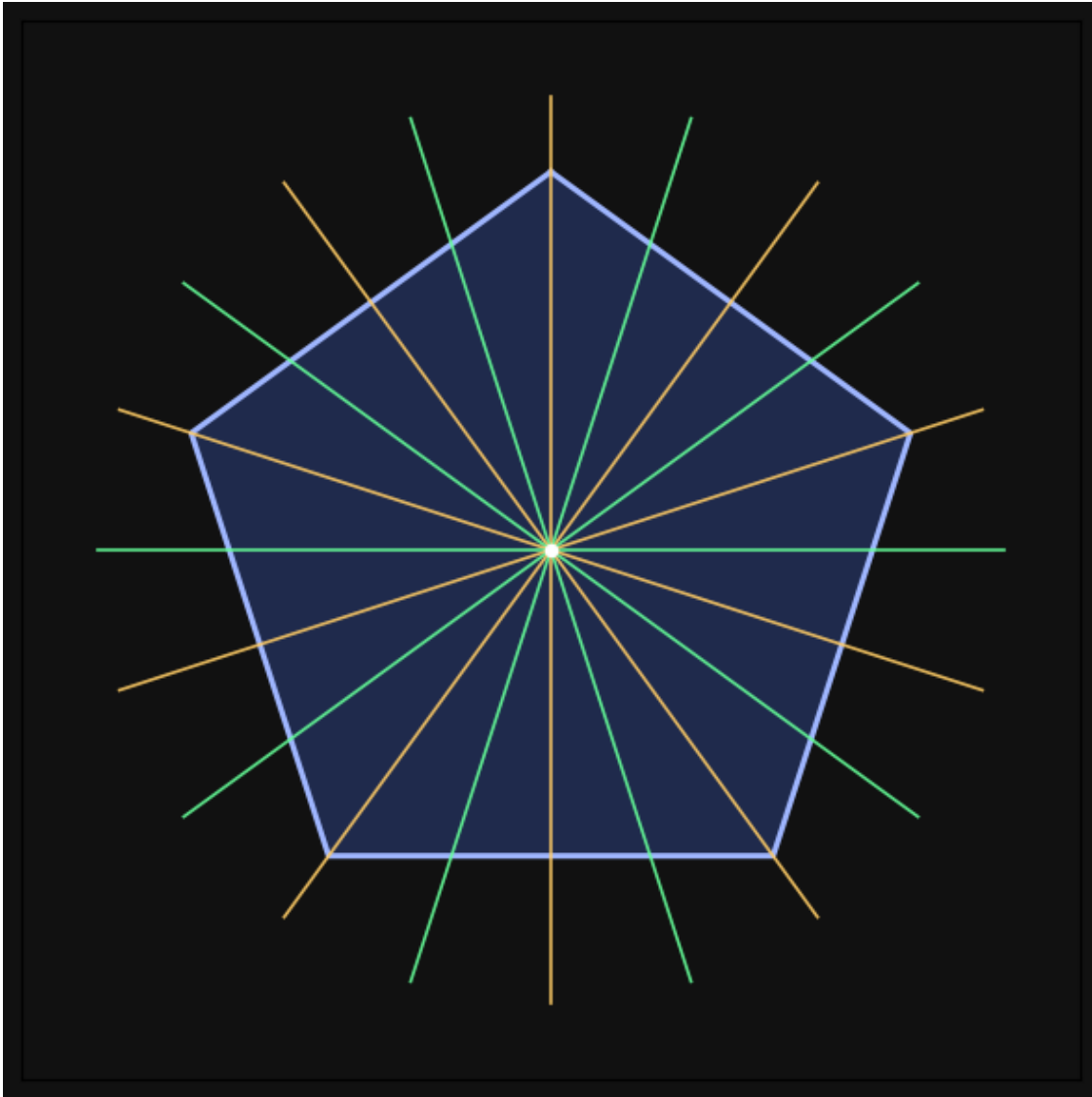
    ax.plot([0, x], [0, y], color=color, linewidth=1.2, alpha=0.9)

# (c)
ax.scatter([0], [0], s=20, color="ffffff", zorder=5)

#
ax.set_xticks([])
ax.set_yticks([])
ax.set_xlim(-1.4, 1.4)
ax.set_ylim(-1.4, 1.4)

```

```
plt.tight_layout()
plt.show()
```



```
[6]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

tau = np.pi * 2
D = 5          # number of directions
L = 31         # lines per direction
G = 0.25      # spacing
```

```

es = np.ones(D) / D    # same as JS default
off_x = 0.0
off_y = 0.0

def get_e_ang(e_i):
    return tau/4 + e_i * tau / D    # /2 + 2 k/D

def line_intersection(p1, d1, p2, d2):
    """Intersection of two lines p1 + t d1 and p2 + s d2."""
    A = np.array([d1, -d2]).T
    b = p2 - p1
    try:
        t, s = np.linalg.solve(A, b)
    except np.linalg.LinAlgError:
        return None
    return p1 + t * d1

def compute_goal(pos, d1, d2, c):
    """CPU version of the shader's 'goal' computation."""
    e_scale = 2.0 / D
    goal = np.zeros(2)
    for i in range(D):
        ang = get_e_ang(i)
        unit = np.array([np.cos(ang), np.sin(ang)])
        units = np.dot(unit, pos) / G - es[i]

        if i == d1:
            units = np.round(units)
            if c in (0, 1):
                units -= 1.0
        elif i == d2:
            units = np.round(units)
            if c in (1, 2):
                units -= 1.0
        else:
            units = np.floor(units)

        goal += unit * (units * G * e_scale)

    # offset (kept zero here, but you can add scroll logic)
    goal[0] += off_x
    goal[1] += off_y
    return goal

polys = []
colors = []

```



```

for d1 in range(D):
    for d2 in range(d1 + 1, D):
        ang1 = get_e_ang(d1)
        ang2 = get_e_ang(d2)
        unit1 = np.array([np.cos(ang1), np.sin(ang1)])
        unit2 = np.array([np.cos(ang2), np.sin(ang2)])
        side1 = np.array([np.cos(ang1 + tau/4), np.sin(ang1 + tau/4)])
        side2 = np.array([np.cos(ang2 + tau/4), np.sin(ang2 + tau/4)])

    for i in range(L):
        for j in range(L):
            len1 = (es[d1] + (i - L//2)) * G
            len2 = (es[d2] + (j - L//2)) * G
            p1 = unit1 * len1
            p2 = unit2 * len2
            pos = line_intersection(p1, side1, p2, side2)
            if pos is None:
                continue

            # four vertices (c = 0,1,2,3)
            verts = [compute_goal(pos, d1, d2, c) for c in (0, 1, 2, 3)]
            v0, v1, v2, v3 = verts

            # two triangles per rhombus
            polys.append([v0, v1, v3])
            polys.append([v1, v2, v3])

            # color by angle difference
            diff = (d1 - d2) % D
            diff = min(diff, D - diff) - 1    # 0 or 1 for D=5
            if diff == 0:
                col = (0.40, 0.65, 1.00, 1.0) # blue-ish
            else:
                col = (0.30, 0.80, 0.40, 1.0) # green-ish
            colors.append(col)
            colors.append(col)

# ---- Plot ----
fig, ax = plt.subplots(figsize=(8, 8))
ax.set_aspect('equal')
fig.patch.set_facecolor("#111111")
ax.set_facecolor("#111111")

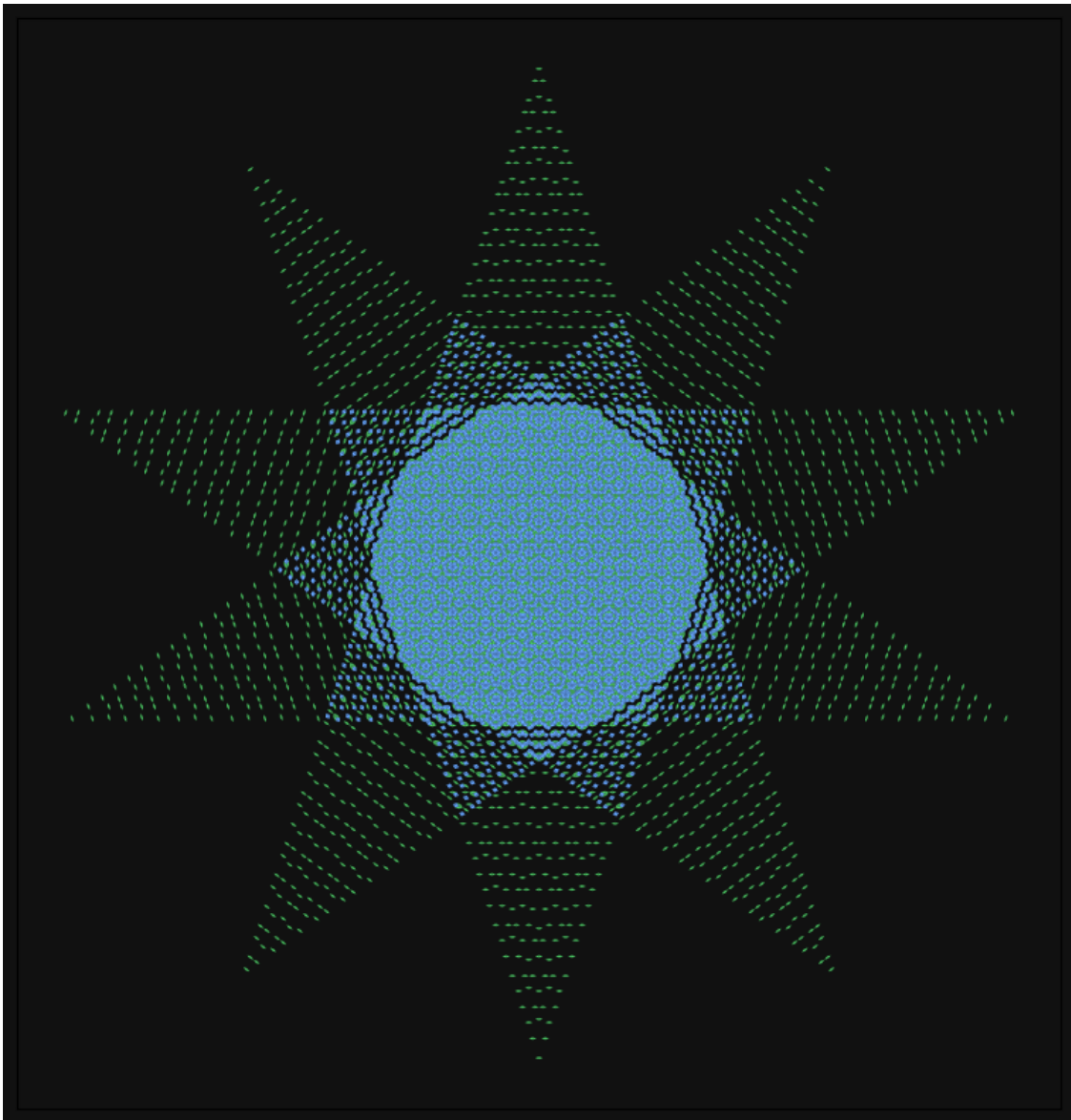
pc = PolyCollection(polys, facecolors=colors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])

```

```
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
mx, my = 0.05 * (xmax - xmin), 0.05 * (ymax - ymin)
ax.set_xlim(xmin - mx, xmax + mx)
ax.set_ylim(ymin - my, ymax + my)
ax.set_xticks([])
ax.set_yticks([])

plt.tight_layout()
plt.show()
```



```

[7]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

tau = np.pi * 2
D = 5          # number of directions
L = 31         # lines per direction (total index span)
G = 0.25       # spacing

es = np.ones(D) / D  # same as JS default
off_x = 0.0
off_y = 0.0

# ===== K =====
K = 6  # 1, 2, ...

def get_e_ang(e_i):
    return tau/4 + e_i * tau / D  #  $\pi/4 + 2k/D$ 

def line_intersection(p1, d1, p2, d2):
    """Intersection of two lines  $p1 + t d1$  and  $p2 + s d2$ ."""
    A = np.array([d1, -d2]).T
    b = p2 - p1
    try:
        t, s = np.linalg.solve(A, b)
    except np.linalg.LinAlgError:
        return None
    return p1 + t * d1

def compute_goal(pos, d1, d2, c):
    """CPU version of the shader's 'goal' computation."""
    e_scale = 2.0 / D
    goal = np.zeros(2)
    for i in range(D):
        ang = get_e_ang(i)
        unit = np.array([np.cos(ang), np.sin(ang)])
        units = np.dot(unit, pos) / G - es[i]

        if i == d1:
            units = np.round(units)
            if c in (0, 1):
                units -= 1.0
        elif i == d2:
            units = np.round(units)
            if c in (1, 2):
                units -= 1.0
        else:

```

```

        units = np.floor(units)

        goal += unit * (units * G * e_scale)

    goal[0] += off_x
    goal[1] += off_y
    return goal

polys = []
colors = []

#       $i-L//2$ 
center = L // 2

for d1 in range(D):
    for d2 in range(d1 + 1, D):
        ang1 = get_e_ang(d1)
        ang2 = get_e_ang(d2)
        unit1 = np.array([np.cos(ang1), np.sin(ang1)])
        unit2 = np.array([np.cos(ang2), np.sin(ang2)])
        side1 = np.array([np.cos(ang1 + tau/4), np.sin(ang1 + tau/4)])
        side2 = np.array([np.cos(ang2 + tau/4), np.sin(ang2 + tau/4)])

        for i in range(L):
            #       $|i - center| \leq K$  "  $K$  "
            if abs(i - center) > K:
                continue
            for j in range(L):
                if abs(j - center) > K:
                    continue

                len1 = (es[d1] + (i - center)) * G
                len2 = (es[d2] + (j - center)) * G
                p1 = unit1 * len1
                p2 = unit2 * len2
                pos = line_intersection(p1, side1, p2, side2)
                if pos is None:
                    continue

                # four vertices ( $c = 0,1,2,3$ )
                verts = [compute_goal(pos, d1, d2, c) for c in (0, 1, 2, 3)]
                v0, v1, v2, v3 = verts

                # two triangles per rhombus
                polys.append([v0, v1, v3])
                polys.append([v1, v2, v3])

```

```

        # color by angle difference
        diff = (d1 - d2) % D
        diff = min(diff, D - diff) - 1    # 0 or 1 for D=5
        if diff == 0:
            col = (0.40, 0.65, 1.00, 1.0) # blue-ish
        else:
            col = (0.30, 0.80, 0.40, 1.0) # green-ish
        colors.append(col)
        colors.append(col)

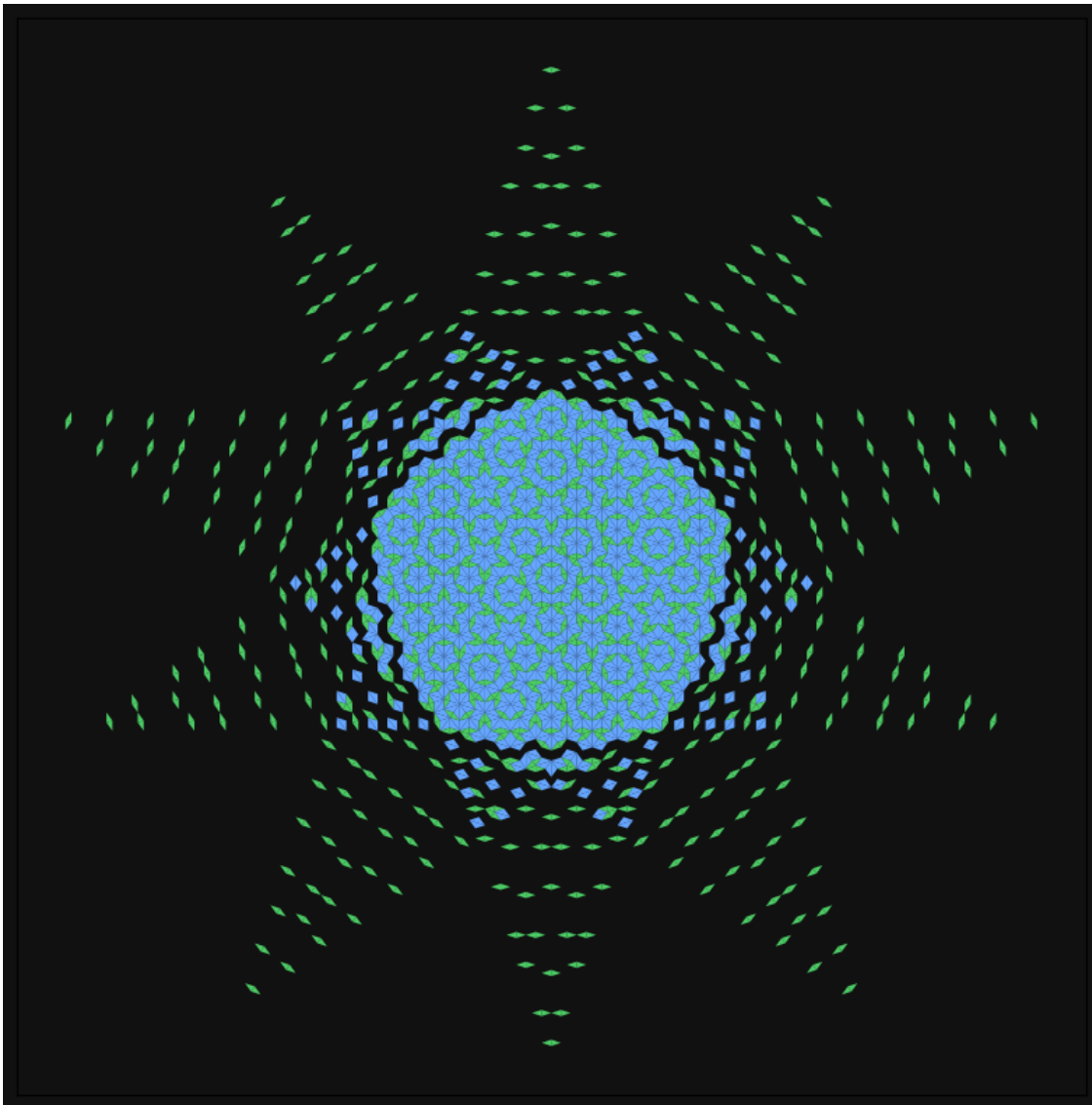
# ---- Plot ----
fig, ax = plt.subplots(figsize=(8, 8))
ax.set_aspect('equal')
fig.patch.set_facecolor("#111111")
ax.set_facecolor("#111111")

pc = PolyCollection(polys, facecolors=colors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
mx, my = 0.05 * (xmax - xmin), 0.05 * (ymax - ymin)
ax.set_xlim(xmin - mx, xmax + mx)
ax.set_ylim(ymin - my, ymax + my)
ax.set_xticks([])
ax.set_yticks([])

plt.tight_layout()
plt.show()

```



```
[8]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

tau = np.pi * 2
D = 5
L = 31
G = 0.25
es = np.ones(D) / D
off_x = 0.0
off_y = 0.0
K = 6 # " "
```

```

def get_e_ang(e_i):
    return tau/4 + e_i * tau / D

def line_intersection(p1, d1, p2, d2):
    A = np.array([d1, -d2]).T
    b = p2 - p1
    try:
        t, s = np.linalg.solve(A, b)
    except np.linalg.LinAlgError:
        return None
    return p1 + t * d1

def compute_goal(pos, d1, d2, c):
    e_scale = 2.0 / D
    goal = np.zeros(2)
    for i in range(D):
        ang = get_e_ang(i)
        unit = np.array([np.cos(ang), np.sin(ang)])
        units = np.dot(unit, pos) / G - es[i]
        if i == d1:
            units = np.round(units)
            if c in (0, 1):
                units -= 1.0
        elif i == d2:
            units = np.round(units)
            if c in (1, 2):
                units -= 1.0
        else:
            units = np.floor(units)
        goal += unit * (units * G * e_scale)
    goal[0] += off_x
    goal[1] += off_y
    return goal

# -----
rhombi_vertices = [] # (v0, v1, v2, v3)
rhombi_centers = []
rhombi_colors = []

center_idx = L // 2

for d1 in range(D):
    for d2 in range(d1 + 1, D):
        ang1 = get_e_ang(d1)
        ang2 = get_e_ang(d2)
        unit1 = np.array([np.cos(ang1), np.sin(ang1)])

```

```

unit2 = np.array([np.cos(ang2), np.sin(ang2)])
side1 = np.array([np.cos(ang1 + tau/4), np.sin(ang1 + tau/4)])
side2 = np.array([np.cos(ang2 + tau/4), np.sin(ang2 + tau/4)])

for i in range(L):
    if abs(i - center_idx) > K:
        continue
    for j in range(L):
        if abs(j - center_idx) > K:
            continue

        len1 = (es[d1] + (i - center_idx)) * G
        len2 = (es[d2] + (j - center_idx)) * G
        p1 = unit1 * len1
        p2 = unit2 * len2
        pos = line_intersection(p1, side1, p2, side2)
        if pos is None:
            continue

        v0, v1, v2, v3 = [compute_goal(pos, d1, d2, c) for c in (0, 1, 2, 3)]

        rhombi_vertices.append((v0, v1, v2, v3))
        center = (v0 + v1 + v2 + v3) / 4.0
        rhombi_centers.append(center)

        diff = (d1 - d2) % D
        diff = min(diff, D - diff) - 1
        if diff == 0:
            col = (0.40, 0.65, 1.00, 1.0) #
        else:
            col = (0.30, 0.80, 0.40, 1.0) #
        rhombi_colors.append(col)

rhombi_centers = np.vstack(rhombi_centers)
N = len(rhombi_centers)

# ----- " " -----
# 1.
dist_matrix = np.linalg.norm(
    rhombi_centers[:, None, :] - rhombi_centers[None, :, :],
    axis=2
)
np.fill_diagonal(dist_matrix, np.inf)
nearest = dist_matrix.min(axis=1)
base = np.median(nearest)
thresh = base * 1.3 # thresh

```



```

# 2.
adj = [[] for _ in range(N)]
for i in range(N):
    nbrs = np.where(dist_matrix[i] < thresh)[0]
    for j in nbrs:
        adj[i].append(j)

# 3. " " BFS
radii = np.linalg.norm(rhombi_centers, axis=1)
start = np.argmin(radii)

visited = np.zeros(N, dtype=bool)
stack = [start]
visited[start] = True
while stack:
    i = stack.pop()
    for j in adj[i]:
        if not visited[j]:
            visited[j] = True
            stack.append(j)

keep_indices = np.where(visited)[0]

# -----
polys = []
colors = []
for idx in keep_indices:
    v0, v1, v2, v3 = rhombi_vertices[idx]
    col = rhombi_colors[idx]
    polys.append([v0, v1, v3])
    polys.append([v1, v2, v3])
    colors.append(col)
    colors.append(col)

fig, ax = plt.subplots(figsize=(8, 8))
ax.set_aspect('equal')
fig.patch.set_facecolor("#111111")
ax.set_facecolor("#111111")

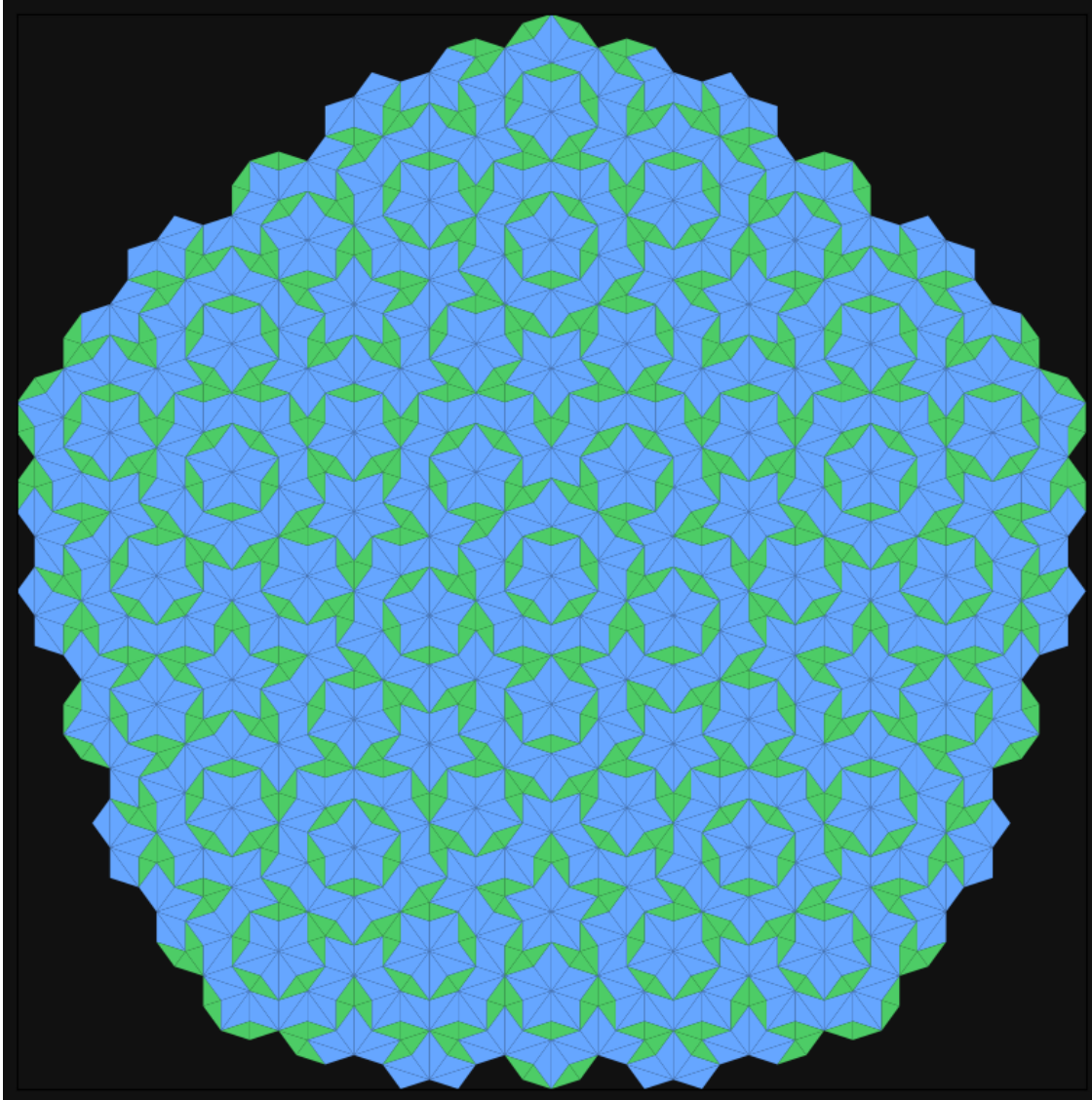
pc = PolyCollection(polys, facecolors=colors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
ax.set_xlim(xmin, xmax)
ax.set_ylim(ymin, ymax)

```

```
ax.set_xticks([])
ax.set_yticks([])

plt.tight_layout()
plt.show()
```



```
[9]: import numpy as np
import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

tau = np.pi * 2
D = 5
```

```

L = 31
G = 0.25
es = np.ones(D) / D
off_x = 0.0
off_y = 0.0
K = 6    # " "

def get_e_ang(e_i):
    return tau/4 + e_i * tau / D

def line_intersection(p1, d1, p2, d2):
    A = np.array([d1, -d2]).T
    b = p2 - p1
    try:
        t, s = np.linalg.solve(A, b)
    except np.linalg.LinAlgError:
        return None
    return p1 + t * d1

def compute_goal(pos, d1, d2, c):
    e_scale = 2.0 / D
    goal = np.zeros(2)
    for i in range(D):
        ang = get_e_ang(i)
        unit = np.array([np.cos(ang), np.sin(ang)])
        units = np.dot(unit, pos) / G - es[i]
        if i == d1:
            units = np.round(units)
            if c in (0, 1):
                units -= 1.0
        elif i == d2:
            units = np.round(units)
            if c in (1, 2):
                units -= 1.0
        else:
            units = np.floor(units)
        goal += unit * (units * G * e_scale)
    goal[0] += off_x
    goal[1] += off_y
    return goal

# -----
rhombi_vertices = []
rhombi_centers = []
rhombi_colors = []

center_idx = L // 2

```

```

for d1 in range(D):
    for d2 in range(d1 + 1, D):
        ang1 = get_e_ang(d1)
        ang2 = get_e_ang(d2)
        unit1 = np.array([np.cos(ang1), np.sin(ang1)])
        unit2 = np.array([np.cos(ang2), np.sin(ang2)])
        side1 = np.array([np.cos(ang1 + tau/4), np.sin(ang1 + tau/4)])
        side2 = np.array([np.cos(ang2 + tau/4), np.sin(ang2 + tau/4)])

        for i in range(L):
            if abs(i - center_idx) > K:
                continue
            for j in range(L):
                if abs(j - center_idx) > K:
                    continue

                len1 = (es[d1] + (i - center_idx)) * G
                len2 = (es[d2] + (j - center_idx)) * G
                p1 = unit1 * len1
                p2 = unit2 * len2
                pos = line_intersection(p1, side1, p2, side2)
                if pos is None:
                    continue

                v0, v1, v2, v3 = [compute_goal(pos, d1, d2, c) for c in
↪(0,1,2,3)]

                rhombi_vertices.append((v0, v1, v2, v3))
                center = (v0 + v1 + v2 + v3) / 4.0
                rhombi_centers.append(center)

                diff = (d1 - d2) % D
                diff = min(diff, D - diff) - 1
                if diff == 0:
                    col = (0.40, 0.65, 1.00, 1.0)
                else:
                    col = (0.30, 0.80, 0.40, 1.0)
                rhombi_colors.append(col)

rhombi_centers = np.vstack(rhombi_centers)
N = len(rhombi_centers)

# -----
dist_matrix = np.linalg.norm(
    rhombi_centers[:, None, :] - rhombi_centers[None, :, :],
    axis=2
)

```

```

np.fill_diagonal(dist_matrix, np.inf)
nearest = dist_matrix.min(axis=1)
base = np.median(nearest)
thresh = base * 1.3

adj = [[] for _ in range(N)]
for i in range(N):
    nbrs = np.where(dist_matrix[i] < thresh)[0]
    for j in nbrs:
        adj[i].append(j)

# -----
radii = np.linalg.norm(rhombi_centers, axis=1)
start = np.argmin(radii)

visited = np.zeros(N, dtype=bool)
stack = [start]
visited[start] = True
while stack:
    i = stack.pop()
    for j in adj[i]:
        if not visited[j]:
            visited[j] = True
            stack.append(j)

comp = np.where(visited)[0]

# ----- r_cut -----
deg = np.array([len(adj[i]) for i in range(N)])
deg_comp = deg[comp]
r_comp = radii[comp]

# 20%
inner_mask = r_comp < np.quantile(r_comp, 0.2)
inner_deg_median = np.median(deg_comp[inner_mask])

# 80%
deg_min = int(np.floor(inner_deg_median * 0.8))

# >= deg_min " "
good_mask = deg_comp >= deg_min
good_radii = r_comp[good_mask]
r_cut = good_radii.max() #

# <= r_cut
final_indices = comp[r_comp <= r_cut]

```

```

# -----      +      -----
polys = []
colors = []
for idx in final_indices:
    v0, v1, v2, v3 = rhombi_vertices[idx]
    col = rhombi_colors[idx]
    polys.append([v0, v1, v3])
    polys.append([v1, v2, v3])
    colors.append(col)
    colors.append(col)

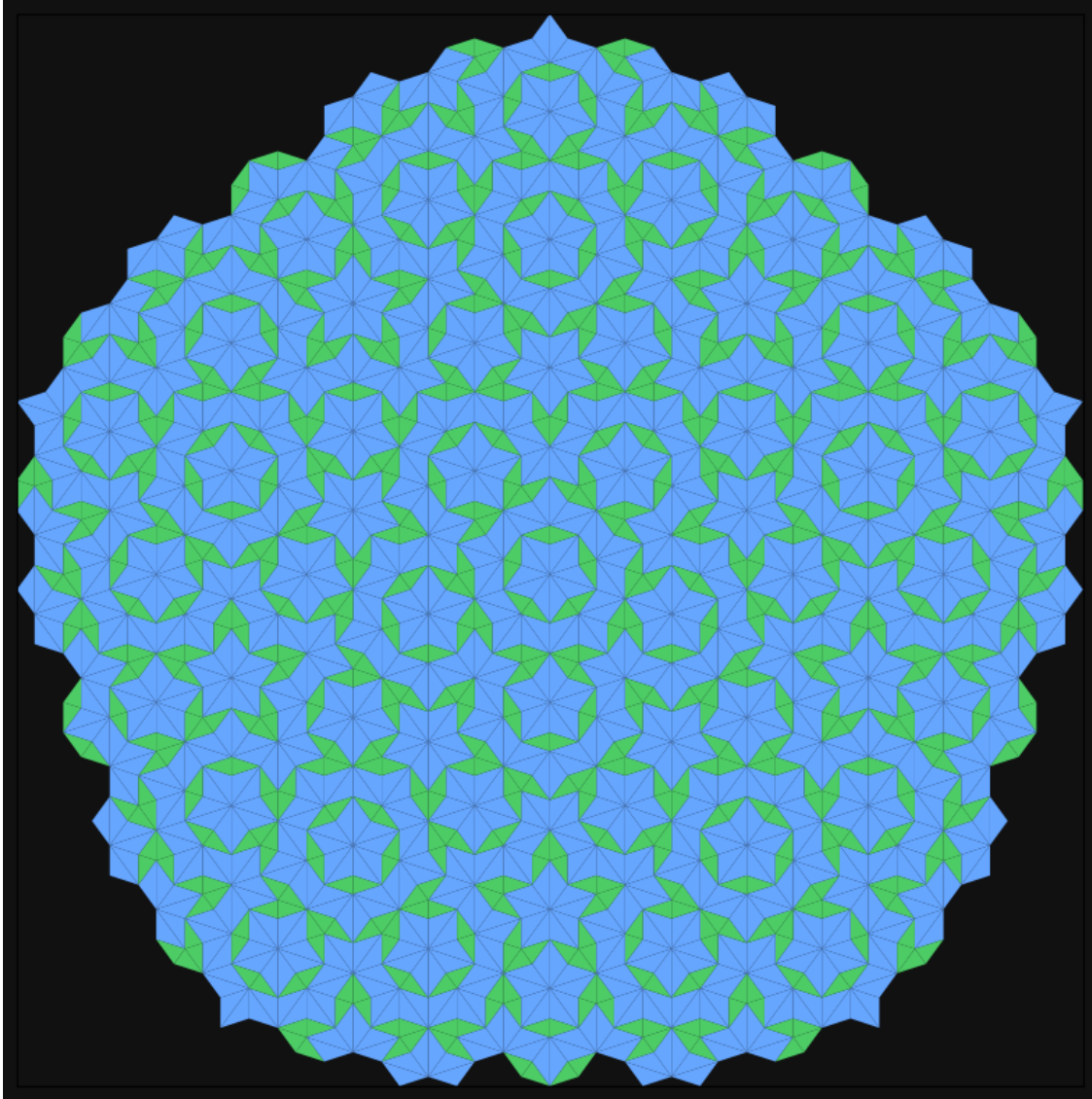
fig, ax = plt.subplots(figsize=(8, 8))
ax.set_aspect('equal')
fig.patch.set_facecolor("#111111")
ax.set_facecolor("#111111")

pc = PolyCollection(polys, facecolors=colors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
ax.set_xlim(xmin, xmax)
ax.set_ylim(ymin, ymax)
ax.set_xticks([])
ax.set_yticks([])

plt.tight_layout()
plt.show()

```



```
[10]: # ----- + BFS -----
radii = np.linalg.norm(rhombi_centers, axis=1)
start = np.argmin(radii)

visited = np.zeros(N, dtype=bool)
dist_layer = np.full(N, -1, dtype=int) # BFS
queue = [start]
visited[start] = True
dist_layer[start] = 0
head = 0
while head < len(queue):
    i = queue[head]
```

```

    head += 1
    for j in adj[i]:
        if not visited[j]:
            visited[j] = True
            dist_layer[j] = dist_layer[i] + 1
            queue.append(j)

comp = np.where(visited)[0]

# ..... / r_cut .....

# ----- BFS " " -----
max_r_by_layer = {}
for idx in comp:
    layer = dist_layer[idx]
    rr = radii[idx]
    if layer not in max_r_by_layer or rr > max_r_by_layer[layer]:
        max_r_by_layer[layer] = rr

layer_for_rcut = None
for layer in sorted(max_r_by_layer.keys()):
    if r_cut <= max_r_by_layer[layer] + 1e-9:
        layer_for_rcut = layer
        break

print("r_cut =", r_cut)
print("approx ring index (BFS layer) =", layer_for_rcut)

```

```

r_cut = 1.7753288904374112
approx ring index (BFS layer) = 23

```

```

[11]: import numpy as np

#
radii = np.linalg.norm(rhombi_centers, axis=1)
central_five = np.argsort(radii)[:5] # 5

N = len(rhombi_centers)

# " " BFS
dist_from_center5 = np.full(N, -1, dtype=int)
q = []

for idx in central_five:
    dist_from_center5[idx] = 0
    q.append(idx)

```



```

head = 0
while head < len(q):
    i = q[head]
    head += 1
    for j in adj[i]:
        if dist_from_center5[j] == -1:
            dist_from_center5[j] = dist_from_center5[i] + 1
            q.append(j)

#
dists_final = dist_from_center5[final_indices]
max_graph_dist = int(dists_final.max())

# " " = - 1
ring_count = max(0, max_graph_dist - 1)

print("max graph distance from central five =", max_graph_dist)
print("ring count =", ring_count)

import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

# [0, 1] colormap
norm_dists = dists_final.astype(float) / max_graph_dist
cmap = plt.get_cmap("viridis") # 'plasma', 'magma'

# →
color_lookup = {idx: cmap(norm_dists[k]) for k, idx in enumerate(final_indices)}

# 2
polys = []
colors = []
for idx in final_indices:
    v0, v1, v2, v3 = rhombi_vertices[idx]
    col = color_lookup[idx]
    polys.append([v0, v1, v3])
    polys.append([v1, v2, v3])
    colors.append(col)
    colors.append(col)

#
fig, ax = plt.subplots(figsize=(8, 8))
ax.set_aspect('equal')
fig.patch.set_facecolor("black")
ax.set_facecolor("black")

pc = PolyCollection(polys, facecolors=colors, edgecolors='none')

```

```

ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
ax.set_xlim(xmin, xmax)
ax.set_ylim(ymin, ymax)
ax.set_xticks([])
ax.set_yticks([])

# colorbar "      index "
sm = plt.cm.ScalarMappable(cmap=cmap,
                           norm=plt.Normalize(vmin=0, vmax=max_graph_dist))
sm.set_array([])
cbar = plt.colorbar(sm, ax=ax, fraction=0.046, pad=0.04)
cbar.set_label("Graph distance from central five (ring index)")

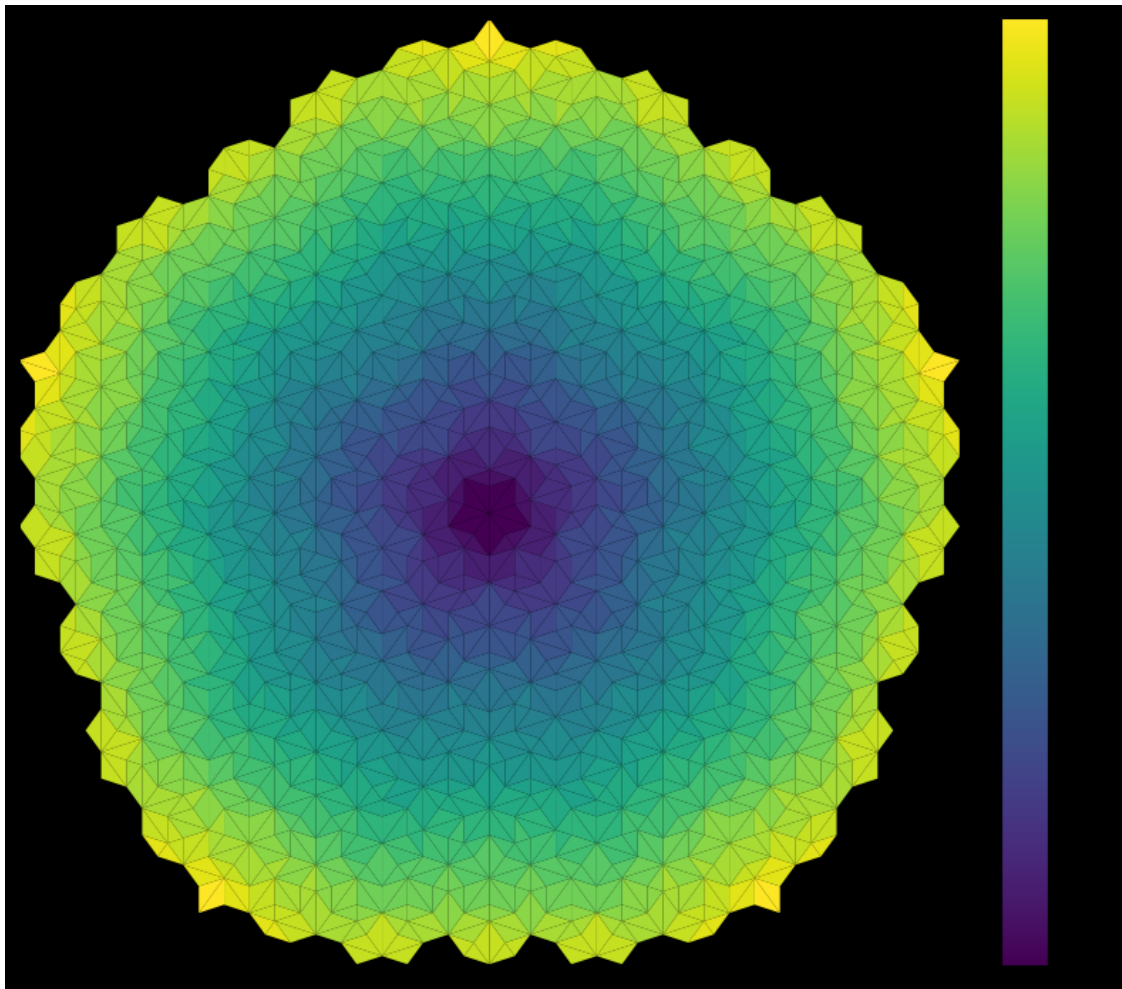
plt.tight_layout()
plt.show()

```

```

max graph distance from central five = 23
ring count = 22

```



```
[13]: import numpy as np

N = len(rhombi_centers)

# " "
radii = np.linalg.norm(rhombi_centers, axis=1)
central_five = np.argsort(radii)[:5]

# BFS " "
dist_from_center5 = np.full(N, -1, dtype=int)
q = []

for idx in central_five:
    dist_from_center5[idx] = 0
    q.append(idx)
```

```

head = 0
while head < len(q):
    i = q[head]
    head += 1
    for j in adj[i]:
        if dist_from_center5[j] == -1: #
            dist_from_center5[j] = dist_from_center5[i] + 1
            q.append(j)

# dist >= 0 " "
connected_mask = dist_from_center5 >= 0
valid_dists = dist_from_center5[connected_mask]

max_graph_dist = int(valid_dists.max())

# graph_dist - 1 -1
ring_index = np.full(N, -1, dtype=int)
ring_index[connected_mask] = np.maximum(valid_dists - 1, 0)

max_ring = ring_index.max()
print("max_ring =", max_ring)

def tiles_for_rings(rings: int):
    """
    ring_index >= 0
    """
    rings = int(rings)
    mask = (ring_index >= 0) & (ring_index <= rings)
    return np.where(mask)[0]

import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

def plot_for_rings(rings: int):
    idxs = tiles_for_rings(rings)
    if len(idxs) == 0:
        print("rings ")
        return

    cmap = plt.get_cmap("viridis")
    norm_vals = ring_index[idxs].astype(float) / max_ring
    colors = [cmap(v) for v in norm_vals]

    polys = []
    facecolors = []
    for idx, col in zip(idxs, colors):

```

```

    v0, v1, v2, v3 = rhombi_vertices[idx]
    polys.append([v0, v1, v3])
    polys.append([v1, v2, v3])
    facecolors.append(col)
    facecolors.append(col)

fig, ax = plt.subplots(figsize=(6, 6))
ax.set_aspect('equal')
fig.patch.set_facecolor("black")
ax.set_facecolor("black")

pc = PolyCollection(polys, facecolors=facecolors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
ax.set_xlim(xmin, xmax)
ax.set_ylim(ymin, ymax)
ax.set_xticks([])
ax.set_yticks([])
ax.set_title(f"{rings} rings (0 = center, only connected part)")

sm = plt.cm.ScalarMappable(cmap=cmap,
                           norm=plt.Normalize(vmin=0, vmax=max_ring))
sm.set_array([])
cbar = plt.colorbar(sm, ax=ax, fraction=0.046, pad=0.04)
cbar.set_label("Ring index")

plt.tight_layout()
plt.show()

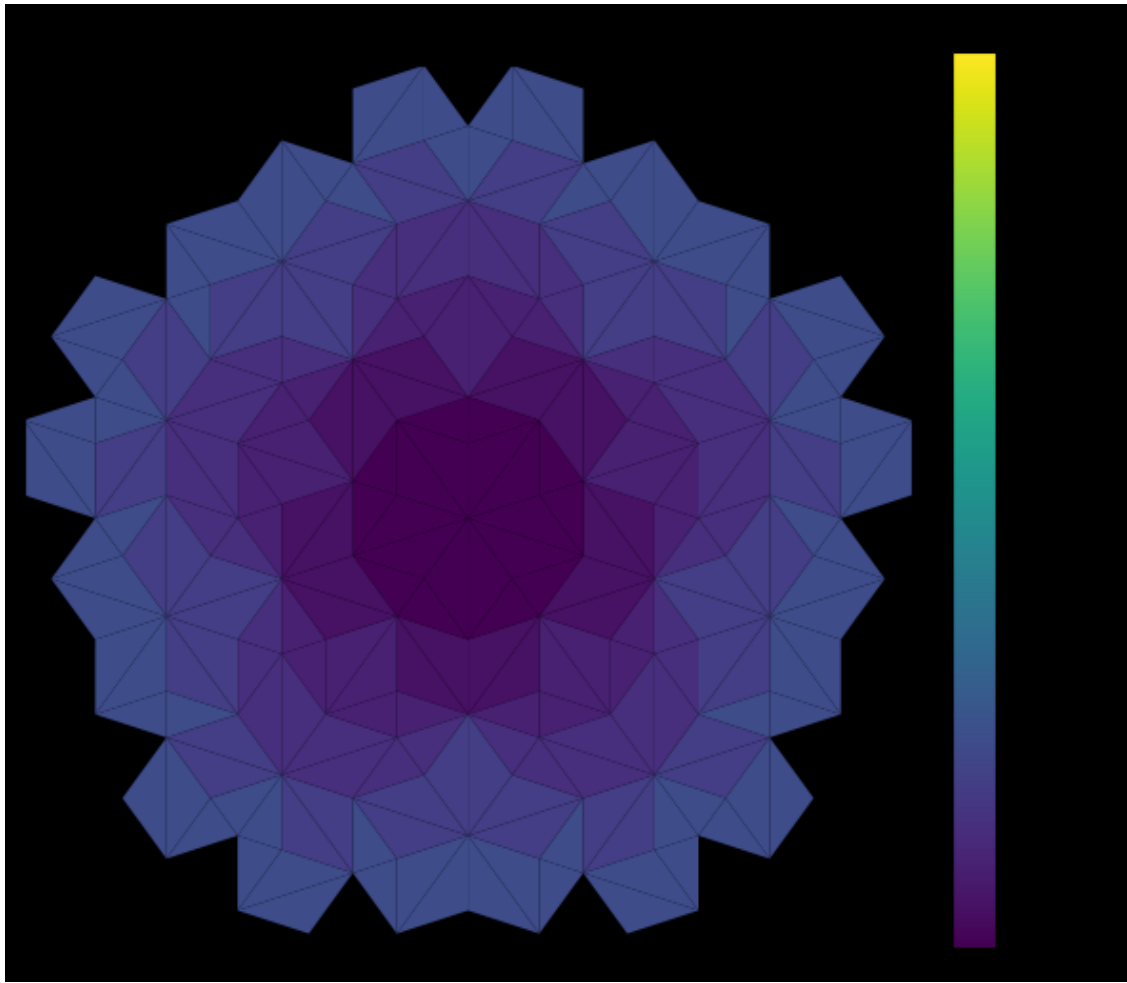
plot_for_rings(5)    #    0~5
plot_for_rings(10)   #    10

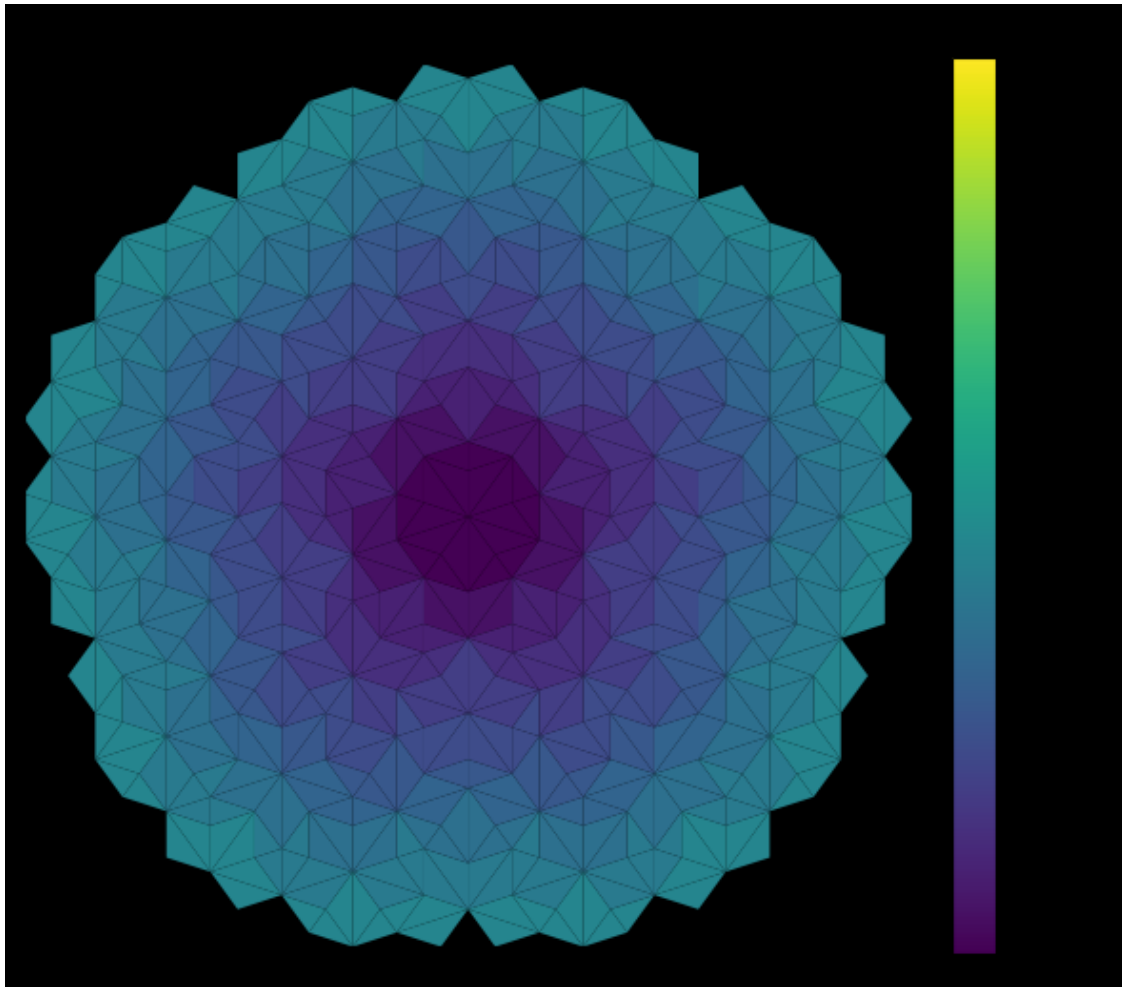
```

```

max_ring = 22

```





```
[17]: tau = np.pi * 2
      D = 5
      L = 31
      G = 0.25
      es = np.ones(D) / D
      off_x = 0.0
      off_y = 0.0
      K = 6      #      i,j      K

      def get_e_ang(e_i):
          return tau/4 + e_i * tau / D

      def line_intersection(p1, d1, p2, d2):
          A = np.array([d1, -d2]).T
          b = p2 - p1
          try:
```

```

        t, s = np.linalg.solve(A, b)
    except np.linalg.LinAlgError:
        return None
    return p1 + t * d1

def compute_goal(pos, d1, d2, c):
    e_scale = 2.0 / D
    goal = np.zeros(2)
    for i in range(D):
        ang = get_e_ang(i)
        unit = np.array([np.cos(ang), np.sin(ang)])
        units = np.dot(unit, pos) / G - es[i]
        if i == d1:
            units = np.round(units)
            if c in (0, 1):
                units -= 1.0
        elif i == d2:
            units = np.round(units)
            if c in (1, 2):
                units -= 1.0
        else:
            units = np.floor(units)
        goal += unit * (units * G * e_scale)
    goal[0] += off_x
    goal[1] += off_y
    return goal

# ----- pos & goal -----
rhombi_vertices_goal = [] # (N, 4, 2)
rhombi_pos = [] # (N, 2)
rhombi_centers = []

center_idx = L // 2

for d1 in range(D):
    for d2 in range(d1 + 1, D):
        ang1 = get_e_ang(d1)
        ang2 = get_e_ang(d2)
        unit1 = np.array([np.cos(ang1), np.sin(ang1)])
        unit2 = np.array([np.cos(ang2), np.sin(ang2)])
        side1 = np.array([np.cos(ang1 + tau/4), np.sin(ang1 + tau/4)])
        side2 = np.array([np.cos(ang2 + tau/4), np.sin(ang2 + tau/4)])

        for i in range(L):
            if abs(i - center_idx) > K:
                continue
            for j in range(L):

```



```

        if abs(j - center_idx) > K:
            continue

        len1 = (es[d1] + (i - center_idx)) * G
        len2 = (es[d2] + (j - center_idx)) * G
        p1 = unit1 * len1
        p2 = unit2 * len2
        pos = line_intersection(p1, side1, p2, side2)
        if pos is None:
            continue

        # goal
        goals = np.array([compute_goal(pos, d1, d2, c) for c in (0, 1, 2, 3)])

        rhombi_vertices_goal.append(goals)
        rhombi_pos.append(pos)
        rhombi_centers.append(goals.mean(axis=0)) # goal /

rhombi_vertices_goal = np.stack(rhombi_vertices_goal, axis=0) # (N,4,2)
rhombi_pos = np.vstack(rhombi_pos) # (N,2)
rhombi_centers = np.vstack(rhombi_centers) # (N,2)
N = len(rhombi_centers)

# --- ---
dist_matrix = np.linalg.norm(
    rhombi_centers[:, None, :] - rhombi_centers[None, :, :],
    axis=2
)
np.fill_diagonal(dist_matrix, np.inf)
nearest = dist_matrix.min(axis=1)
base = np.median(nearest)
thresh = base * 1.3

adj = [[] for _ in range(N)]
for i in range(N):
    nbrs = np.where(dist_matrix[i] < thresh)[0]
    for j in nbrs:
        adj[i].append(j)

# --- BFS " " + ---
radii = np.linalg.norm(rhombi_centers, axis=1)
central_five = np.argsort(radii)[:5]

dist_from_center5 = np.full(N, -1, dtype=int)
q = []
for idx in central_five:
    dist_from_center5[idx] = 0

```

```

        q.append(idx)

head = 0
while head < len(q):
    i = q[head]
    head += 1
    for j in adj[i]:
        if dist_from_center5[j] == -1:
            dist_from_center5[j] = dist_from_center5[i] + 1
            q.append(j)

# = BFS
connected_mask = dist_from_center5 >= 0
valid_dists = dist_from_center5[connected_mask]
max_graph_dist = int(valid_dists.max())

# graph_dist - 1 -1
ring_index = np.full(N, -1, dtype=int)
ring_index[connected_mask] = np.maximum(valid_dists - 1, 0)
max_ring = ring_index.max()

print("max_ring =", max_ring)

def tiles_for_rings(rings: int):
    """ """
    rings = int(rings)
    mask = (ring_index >= 0) & (ring_index <= rings)
    return np.where(mask)[0] # --- ---
dist_matrix = np.linalg.norm(
    rhombi_centers[:, None, :] - rhombi_centers[None, :, :],
    axis=2
)
np.fill_diagonal(dist_matrix, np.inf)
nearest = dist_matrix.min(axis=1)
base = np.median(nearest)
thresh = base * 1.3

adj = [[] for _ in range(N)]
for i in range(N):
    nbrs = np.where(dist_matrix[i] < thresh)[0]
    for j in nbrs:
        adj[i].append(j)

# --- BFS " " + ---
radii = np.linalg.norm(rhombi_centers, axis=1)
central_five = np.argsort(radii)[:5]

```

```

dist_from_center5 = np.full(N, -1, dtype=int)
q = []
for idx in central_five:
    dist_from_center5[idx] = 0
    q.append(idx)

head = 0
while head < len(q):
    i = q[head]
    head += 1
    for j in adj[i]:
        if dist_from_center5[j] == -1:
            dist_from_center5[j] = dist_from_center5[i] + 1
            q.append(j)

# = BFS
connected_mask = dist_from_center5 >= 0
valid_dists = dist_from_center5[connected_mask]
max_graph_dist = int(valid_dists.max())

# graph_dist - 1 -1
ring_index = np.full(N, -1, dtype=int)
ring_index[connected_mask] = np.maximum(valid_dists - 1, 0)
max_ring = ring_index.max()

def tiles_for_rings(rings: int):
    """
    rings = int(rings)
    mask = (ring_index >= 0) & (ring_index <= rings)
    return np.where(mask)[0]

import matplotlib.pyplot as plt
from matplotlib.collections import PolyCollection

def plot_for_rings(rings: int, slider: float = 1.0):
    """
    rings : 0 = , 1 = + , ...
    slider : 0.0 pos
            1.0 goal

    """
    rings = int(rings)
    slider = float(np.clip(slider, 0.0, 1.0))

    idxs = tiles_for_rings(rings)
    if len(idxs) == 0:

```

```

print("rings      ")
return

cmap = plt.get_cmap("viridis")
norm_vals = ring_index[idxs].astype(float) / max_ring
tile_colors = [cmap(v) for v in norm_vals]

polys = []
facecolors = []

for idx, col in zip(idx, tile_colors):
    pos = rhombi_pos[idx]          # (2,)
    goals = rhombi_vertices_goal[idx] # (4,2)

    # pos goal
    interp = (1.0 - slider) * pos + slider * goals # (4,2)
    v0, v1, v2, v3 = interp

    polys.append([v0, v1, v3])
    polys.append([v1, v2, v3])
    facecolors.append(col)
    facecolors.append(col)

fig, ax = plt.subplots(figsize=(6, 6))
ax.set_aspect('equal')
fig.patch.set_facecolor("black")
ax.set_facecolor("black")

pc = PolyCollection(polys, facecolors=facecolors, edgecolors='none')
ax.add_collection(pc)

all_pts = np.vstack([np.array(p) for poly in polys for p in poly])
xmin, ymin = all_pts.min(axis=0)
xmax, ymax = all_pts.max(axis=0)
ax.set_xlim(xmin, xmax)
ax.set_ylim(ymin, ymax)
ax.set_xticks([])
ax.set_yticks([])
ax.set_title(f"rings = {rings}, slider = {slider:.2f}")

sm = plt.cm.ScalarMappable(cmap=cmap,
                           norm=plt.Normalize(vmin=0, vmax=max_ring))
sm.set_array([])
cbar = plt.colorbar(sm, ax=ax, fraction=0.046, pad=0.04)
cbar.set_label("Ring index")

plt.tight_layout()

```

```

plt.show()

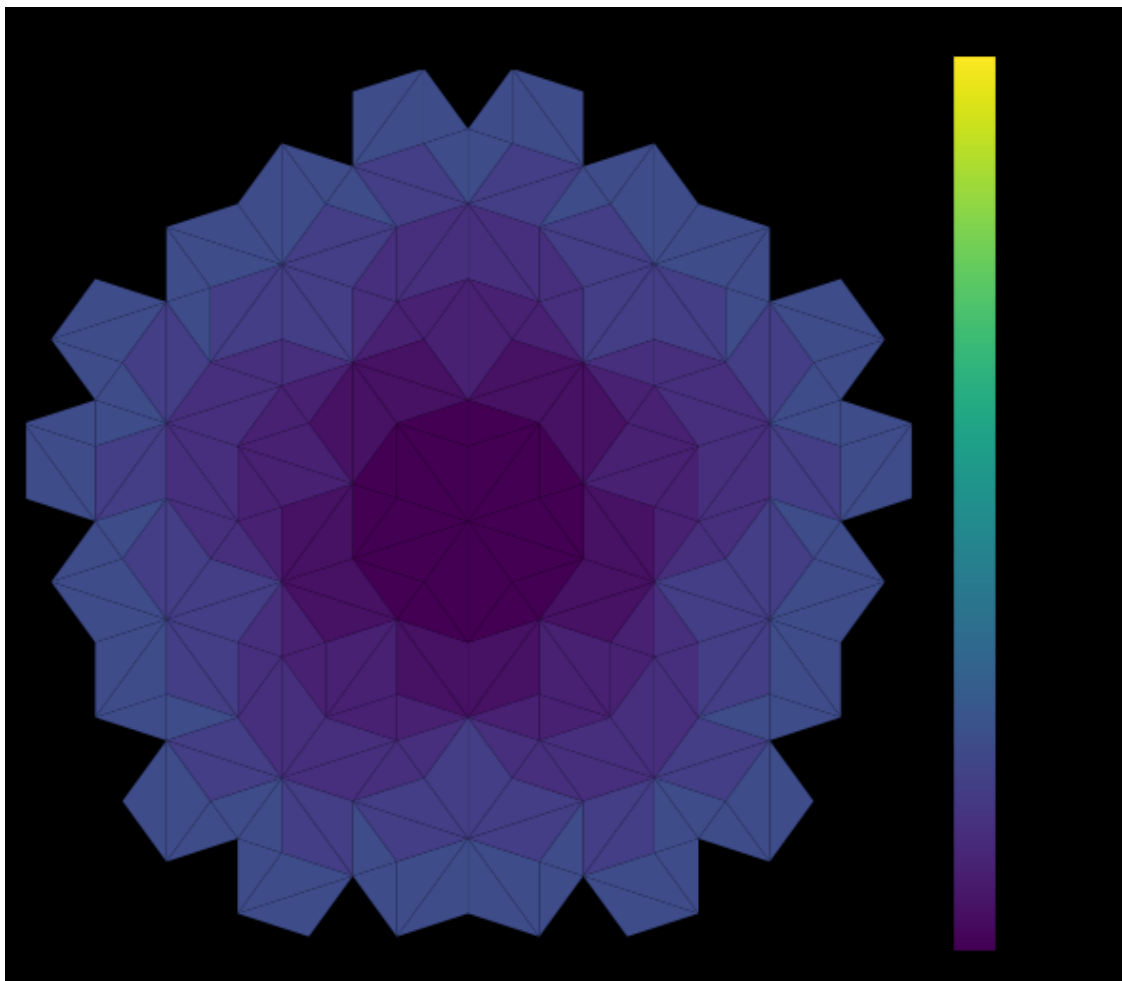
# 5 goal
plot_for_rings(5, slider=1.0)

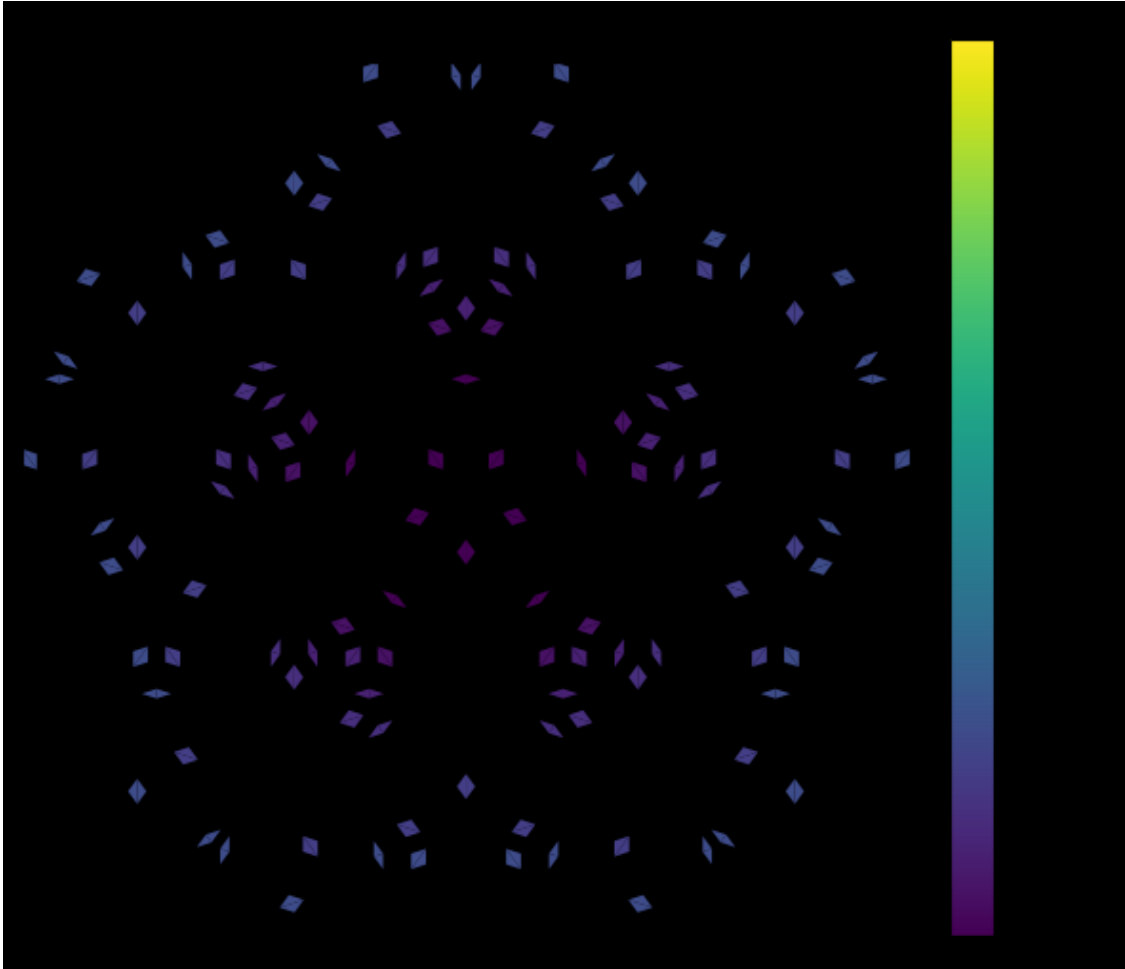
# 5
plot_for_rings(5, slider=0.2)

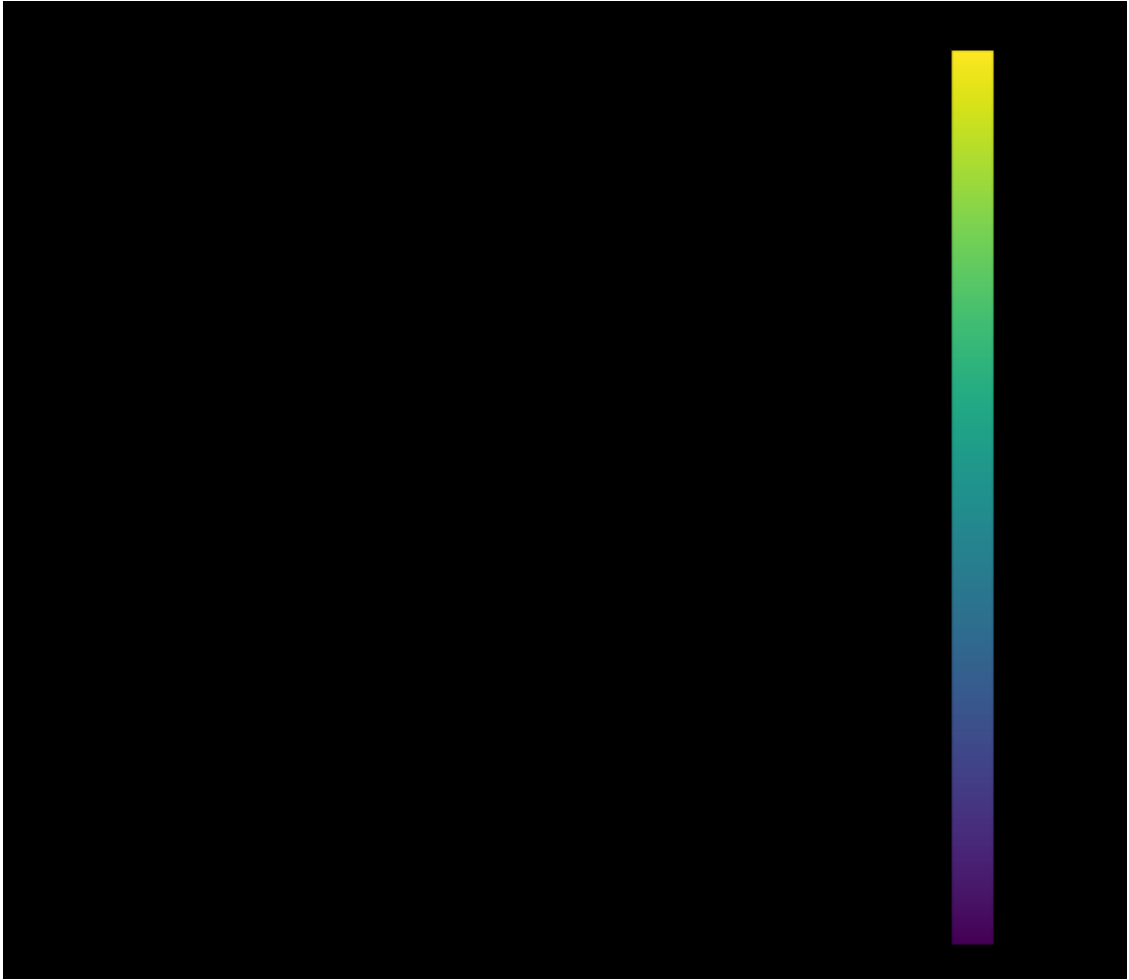
# " "
for s in np.linspace(0, 1, 6):
    plot_for_rings(max_ring, slider=s)

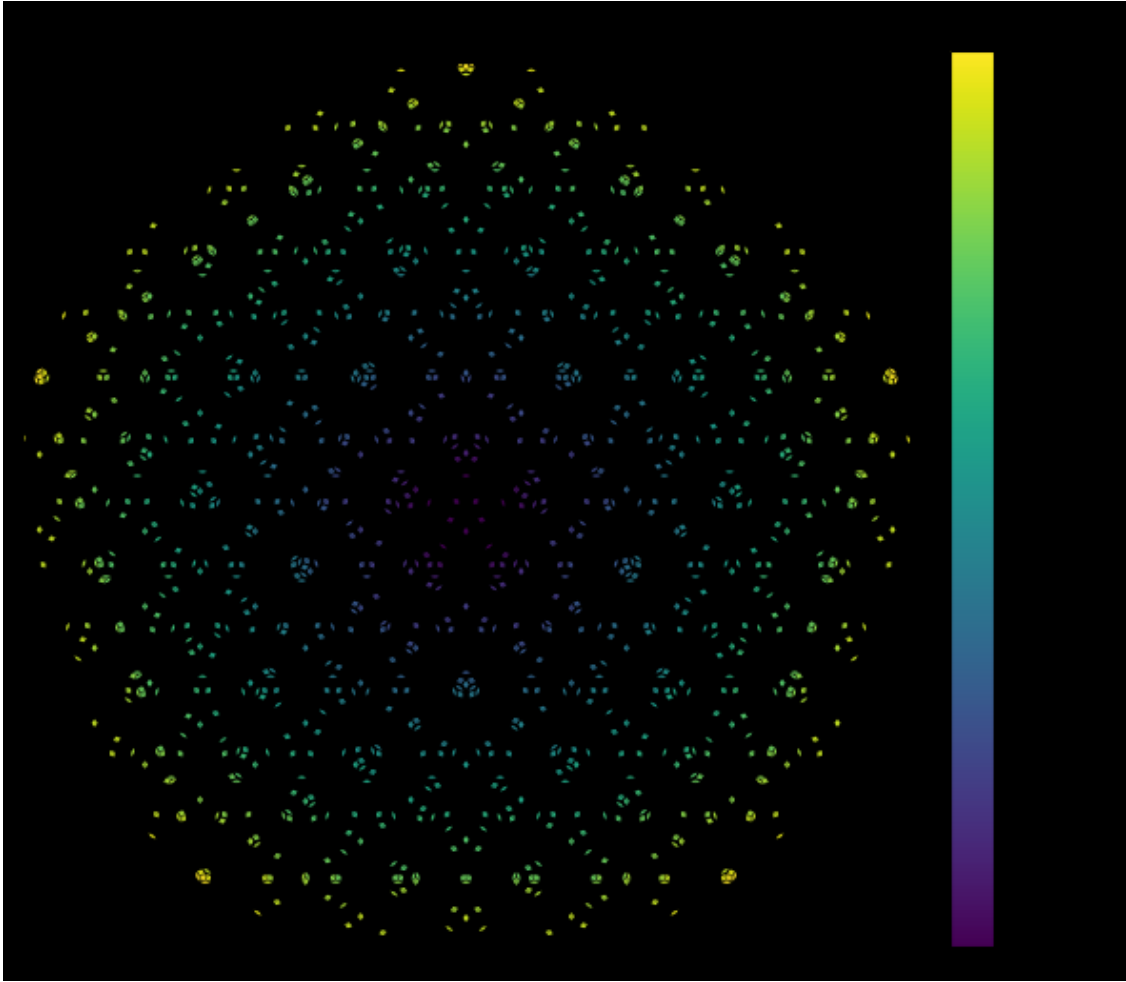
```

max\_ring = 22

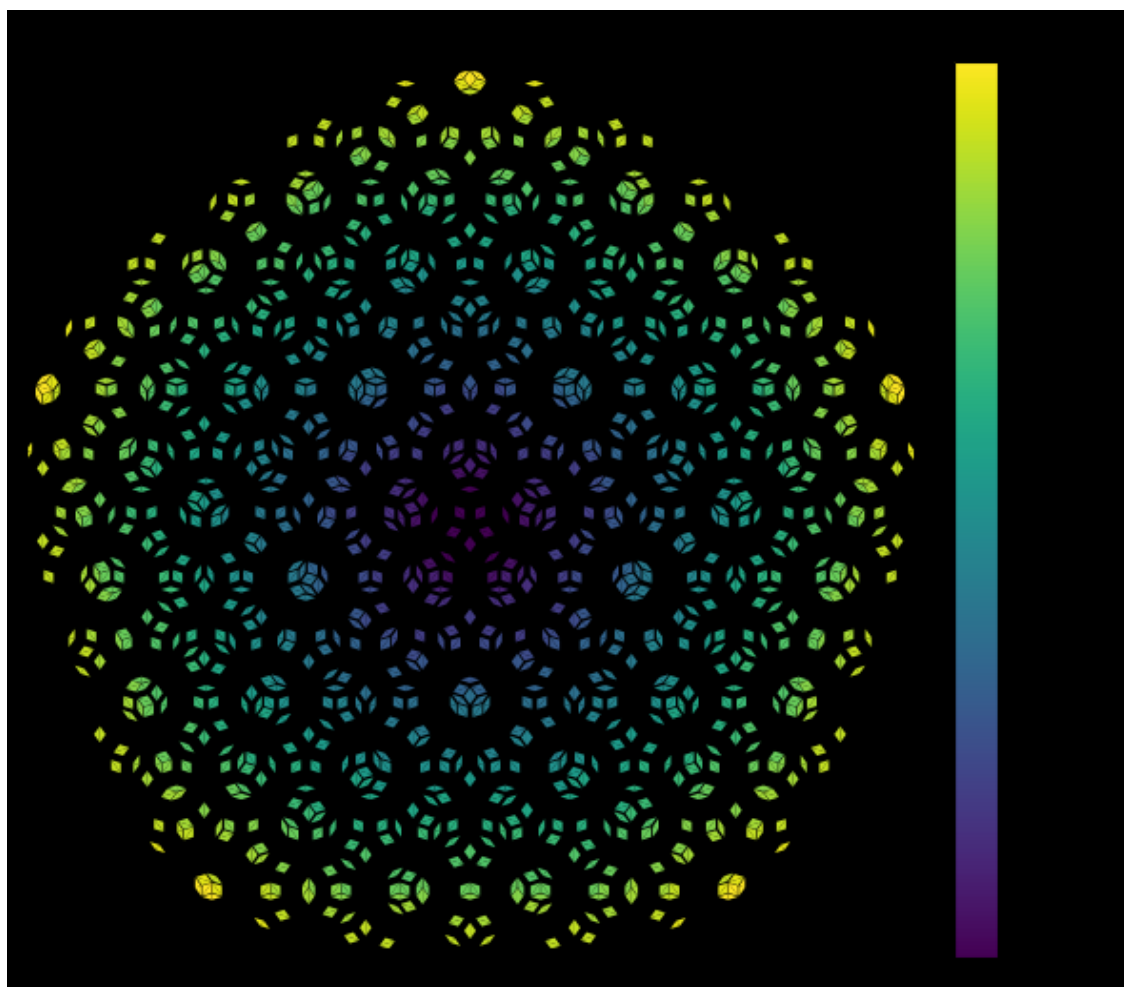


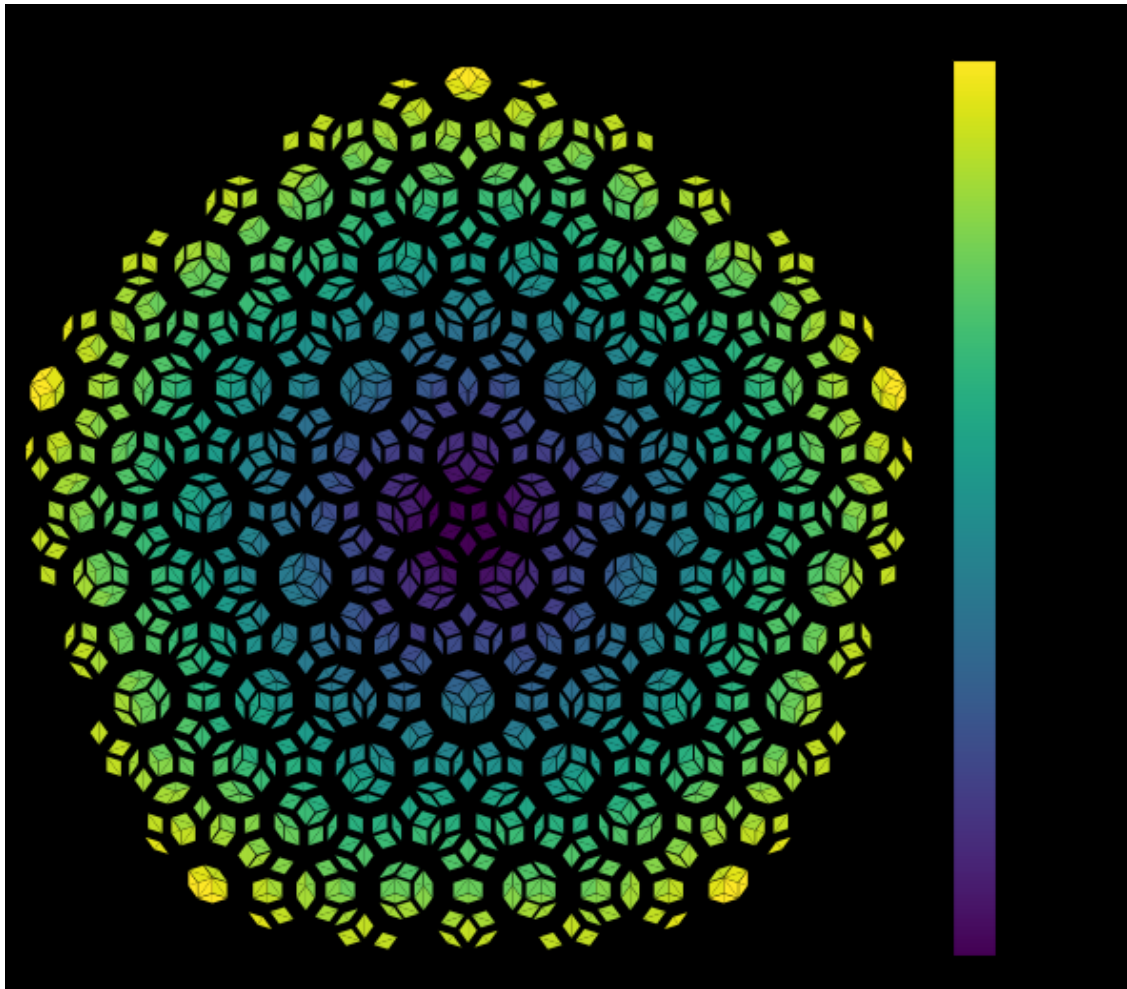


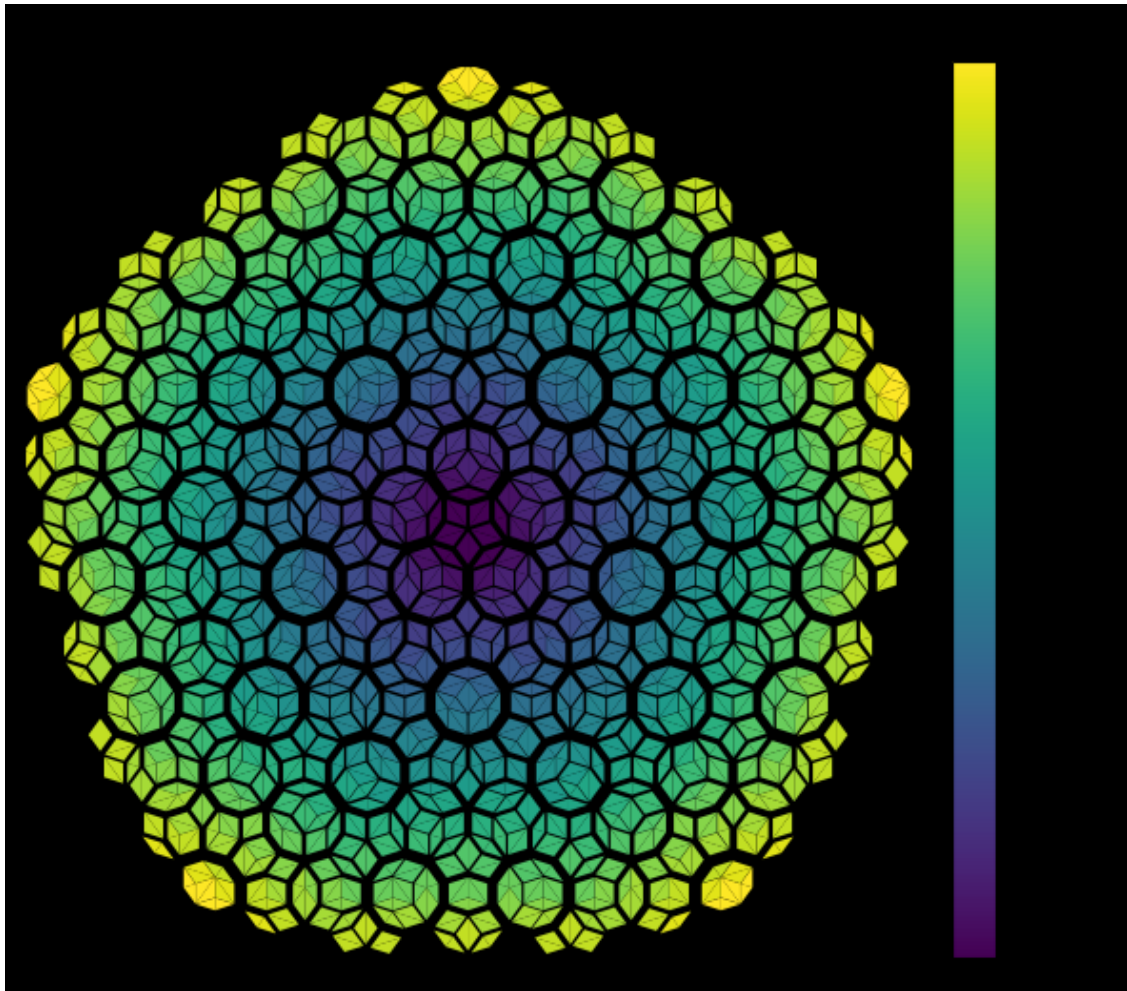


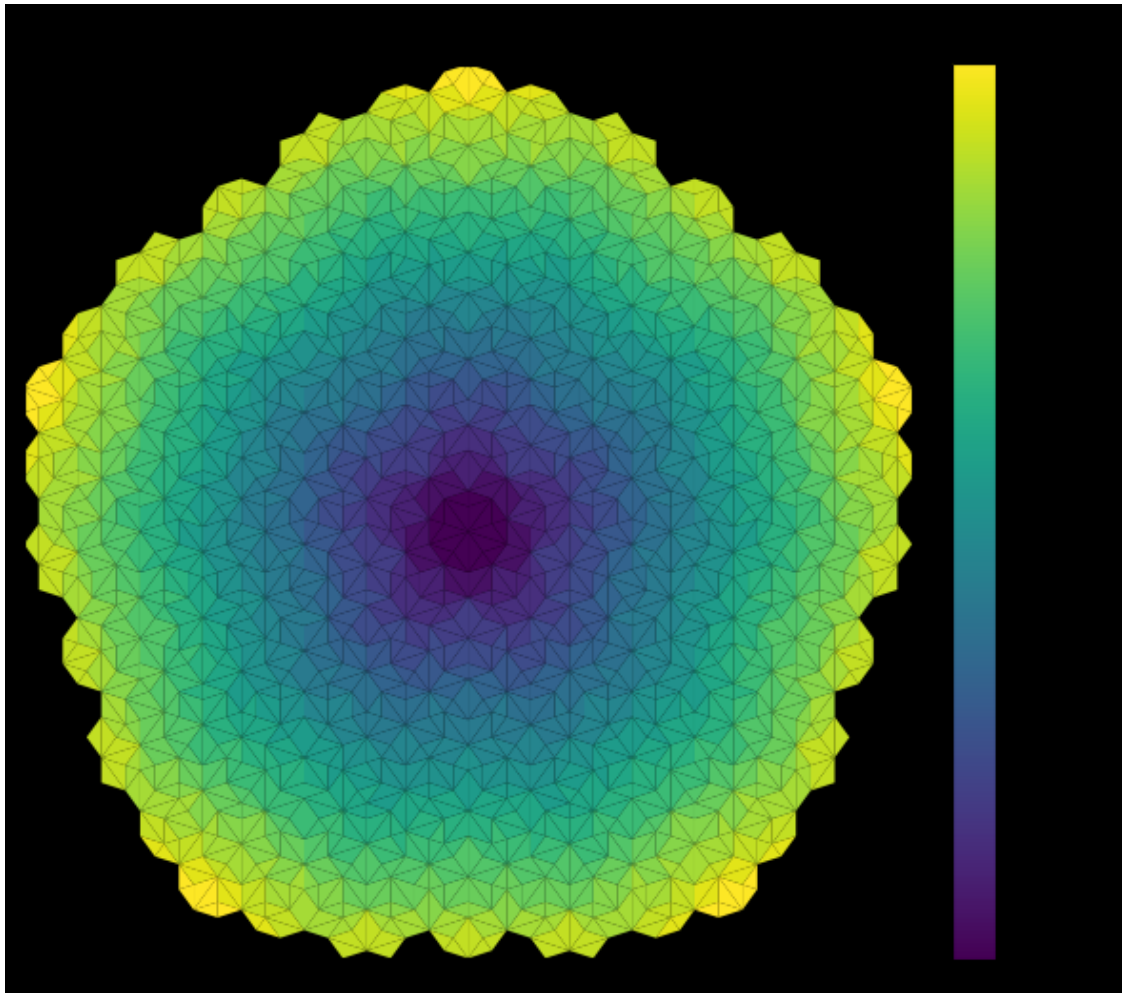












```
[19]: import math
import numpy as np
import matplotlib.pyplot as plt

# -----
# Basic vector helpers (translation of JS functions)
# -----

def dist_sq(a, b):
    x0, y0 = a
    x1, y1 = b
    dx = x0 - x1
    dy = y0 - y1
    return dx*dx + dy*dy

def mul(a, b):
```

```

    return [a[0] * b, a[1] * b]

def dot(a, b):
    # Only use first two components, as in JS
    return a[0] * b[0] + a[1] * b[1]

def sub(a, b):
    return [a[0] - b[0], a[1] - b[1]]

def add(a, b):
    return [a[0] + b[0], a[1] + b[1]]

def trans(a, B):
    # B = [b00, b01, b10, b11]
    return [a[0] * B[0] + a[1] * B[2],
            a[0] * B[1] + a[1] * B[3]]

def line_intersect(x1, y1, x2, y2, x3, y3, x4, y4):
    """
    Port of JS line_intersect:
    returns dict {x, y, seg1, seg2} or None
    """

    denom = (y4 - y3)*(x2 - x1) - (x4 - x3)*(y2 - y1)
    if denom == 0:
        return None
    ua = ((x4 - x3)*(y1 - y3) - (y4 - y3)*(x1 - x3)) / denom
    ub = ((x2 - x1)*(y1 - y3) - (y2 - y1)*(x1 - x3)) / denom
    x = x1 + ua * (x2 - x1)
    y = y1 + ua * (y2 - y1)
    return {
        "x": x,
        "y": y,
        "seg1": (0 <= ua <= 1),
        "seg2": (0 <= ub <= 1),
    }

# -----
# PointSet for approximate membership (translation of create_point_set)
# -----

class PointSet:
    def __init__(self):
        self.point_set = set()

    def _key(self, a):
        return (round(a[0] * 1_000_000), round(a[1] * 1_000_000))

```

```

def add(self, a):
    self.point_set.add(self._key(a))

def ask(self, a):
    ax, ay = self._key(a)
    for dy in (-1, 0, 1):
        for dx in (-1, 0, 1):
            if (ax + dx, ay + dy) in self.point_set:
                return True
    return False

# -----
# Core Penrose R2 generation (single pass of tile_floor)
# -----

def generate_penrose_r2(width=800, height=800, offset=(0.0, 0.0),
                        rr=0.2, gap_div=30.0):
    """
    Translation of tile_floor(c, offset) from JS into Python.

    Returns:
        kites, darts
    where each is a list of polygons, and each polygon is a list of (x, y)
    ↪ tuples.
    """
    ox, oy = offset
    # Background radius and spacing
    r = math.sqrt((width/2)**2 + (height/2)**2)
    gap = 2*r / gap_div
    center = [width/2.0, height/2.0]

    # rr is the same "random" / perturb factor (here deterministic)
    perterb = rr * -gap

    # Construct the 5 directions es
    es = []
    angle = 0.0
    while angle < 2*math.pi - 1e-9:
        es.append([-math.sin(angle), math.cos(angle), perterb])
        angle += 2*math.pi/5.0

    # Build line families in each direction
    liness = []
    for e in es:
        lines = []

```

```

liness.append(lines)
# matrix M
M = [e[1], -e[0], e[0], e[1]]

# per-line "pert" shift
tmp_dot = dot(e, [ox, oy]) # only first 2 components used
pert = -(tmp_dot % gap) + e[2]

y = -r + pert
while y <= r:
    a = [-r, y]
    b = [ r, y]
    a = trans(a, M)
    b = trans(b, M)
    a = add(a, center)
    b = add(b, center)
    lines.append([a, b])
    y += gap

# Now compute intersections to build rhombs, then kites & darts
point_set = PointSet()
thin_rhomb = []

e_scale = 0.4

# --- Find all intersections of lines from direction i and ii ---
for i in range(len(liness)):
    for ii in range(i+1, len(liness)):
        lines_a = liness[i]
        lines_b = liness[ii]
        for a_idx in range(len(lines_a)):
            for b_idx in range(len(lines_b)):
                a = lines_a[a_idx]
                b = lines_b[b_idx]
                r_int = line_intersect(a[0][0], a[0][1], a[1][0], a[1][1],
                                       b[0][0], b[0][1], b[1][0], b[1][1])

                if r_int is None:
                    continue
                if not (r_int["seg1"] and r_int["seg2"]):
                    continue

                rx, ry = r_int["x"], r_int["y"]

                # Build corners as in JS
                corners = [[0.0, 0.0] for _ in range(4)]
                for ei, e in enumerate(es):
                    # Note offset is added BEFORE removing e[2], as in JS

```

```

temp = add(sub([rx, ry], center), [ox, oy])
iii = (dot(e, temp) - e[2]) / gap

if ei == i:
    iii = round(iii)
    v = mul(e, iii * gap * e_scale)
    corners[0] = add(corners[0], v)
    corners[1] = add(corners[1], v)
    iii -= 1
    v2 = mul(e, iii * gap * e_scale)
    corners[2] = add(corners[2], v2)
    corners[3] = add(corners[3], v2)
elif ei == ii:
    iii = round(iii)
    v = mul(e, iii * gap * e_scale)
    corners[0] = add(corners[0], v)
    corners[2] = add(corners[2], v)
    iii -= 1
    v2 = mul(e, iii * gap * e_scale)
    corners[1] = add(corners[1], v2)
    corners[3] = add(corners[3], v2)
else:
    iii = math.floor(iii)
    v = mul(e, iii * gap * e_scale)
    for cc in range(4):
        corners[cc] = add(corners[cc], v)

# After loop, shift corners by (-offset + center)
for ci in range(4):
    corners[ci] = add(sub(corners[ci], [ox, oy]), center)

# swap corners[0] and corners[1]
corners[0], corners[1] = corners[1], corners[0]

diff = ((i - ii) + 5) % 5
if diff == 2 or diff == 3:
    # thin rhombs
    thin_rhombs.append(corners)
else:
    # fat rhombs → add vertices to point_set
    for c in corners:
        point_set.add(c)

# Now convert thin rhombs into kites and darts
kites_ps = PointSet()
kites_list = []
darts_list = []

```



```

deg36 = math.radians(36)
deg54 = math.radians(54)
deg18 = math.radians(18)

tan54 = math.tan(deg54)
cos36 = math.cos(deg36)
sin36 = math.sin(deg36)
cos18 = math.cos(deg18)
sin18 = math.sin(deg18)

kite_color = (127/255.0, 21/255.0, 84/255.0, 1.0)
dart_color = (183/255.0, 157/255.0, 112/255.0, 1.0)

for t in thin_rhomb:
    # We'll operate on a local copy to avoid surprising aliasing
    t = [list(p) for p in t]

    def to_rhomb(x):
        # x is [u, v]
        a_vec = sub(t[2], t[0])
        # matrix from a_vec: [a.x, a.y, -a.y, a.x]
        M = [a_vec[0], a_vec[1], -a_vec[1], a_vec[0]]
        uv = trans(x, M)
        return add(uv, t[0])

    # Two possible patterns as in JS:
    a = to_rhomb([0.5, 0.5 * tan54])
    if point_set.ask(a):
        # pattern 1
        if dist_sq(t[1], a) > dist_sq(t[3], a):
            t[3] = a
            further = t[1]
        else:
            t[1] = a
            further = t[3]

    # record kite
    kites_list.append([tuple(p) for p in t])

    dx = 0.5 * math.sin(deg36) / math.cos(deg18)
    check1 = to_rhomb([0.5 - dx,
                        -0.5*cos36/math.cos(deg18) - 0.5*sin18/math.
↪cos(deg18)])
    if point_set.ask(check1):
        if not kites_ps.ask(t[0]):
            kites_ps.add(t[0])

```

```

        v = [0.5*math.cos(deg54)/math.cos(deg18),
              0.5*math.sin(deg54)/math.cos(deg18)]
        p = [
            t[0],
            further,
            to_rhomb([-v[0], -v[1]]),
            to_rhomb([-v[0], v[1]]),
        ]
        darts_list.append([tuple(q) for q in p])

    check2 = to_rhomb([0.5 + dx,
                      -0.5*cos36/math.cos(deg18) - 0.5*sin18/math.
↪cos(deg18)])
    if point_set.ask(check2):
        if not kites_ps.ask(t[2]):
            kites_ps.add(t[2])
            v = [1 + 0.5*math.cos(deg54)/math.cos(deg18),
                  0.5*math.sin(deg54)/math.cos(deg18)]
            p = [
                t[2],
                further,
                to_rhomb([v[0], -v[1]]),
                to_rhomb([v[0], v[1]]),
            ]
            darts_list.append([tuple(q) for q in p])

    else:
        # pattern 2
        a = to_rhomb([0.5, -0.5 * tan54])
        if point_set.ask(a):
            if dist_sq(t[1], a) > dist_sq(t[3], a):
                t[3] = a
                further = t[1]
            else:
                t[1] = a
                further = t[3]

        kites_list.append([tuple(p) for p in t])

    dx = 0.5 * math.sin(deg36) / math.cos(deg18)
    check1 = to_rhomb([0.5 - dx,
                      0.5*cos36/math.cos(deg18) + 0.5*sin18/math.
↪cos(deg18)])
    if point_set.ask(check1):
        if not kites_ps.ask(t[0]):
            kites_ps.add(t[0])
            v = [0.5*math.cos(deg54)/math.cos(deg18),

```

```

        0.5*math.sin(deg54)/math.cos(deg18)]
    p = [
        t[0],
        further,
        to_rhomb([-v[0], v[1]]),
        to_rhomb([-v[0], -v[1]]),
    ]
    darts_list.append([tuple(q) for q in p])

    check2 = to_rhomb([0.5 + dx,
        0.5*cos36/math.cos(deg18) + 0.5*sin18/math.
↪cos(deg18)])
    if point_set.ask(check2):
        if not kites_ps.ask(t[2]):
            kites_ps.add(t[2])
            v = [1 + 0.5*math.cos(deg54)/math.cos(deg18),
                0.5*math.sin(deg54)/math.cos(deg18)]
            p = [
                t[2],
                further,
                to_rhomb([v[0], v[1]]),
                to_rhomb([v[0], -v[1]]),
            ]
            darts_list.append([tuple(q) for q in p])

    return kites_list, darts_list

# -----
# Connectivity filter: remove detached parts
# -----

def polygons_connected(p1, p2, eps=1e-3):
    """
    Two polygons are 'connected' if they share a vertex within eps.
    """
    for x0, y0 in p1:
        for x1, y1 in p2:
            dx = x0 - x1
            dy = y0 - y1
            if dx*dx + dy*dy <= eps*eps:
                return True
    return False

def connected_components(polygons, eps=1e-3):
    """

```

*Return list of components, where each component is a list of polygon indices.*

*Simple  $O(N^2)$  BFS; fine for moderate  $N$ .*

*"""*

```
n = len(polygons)
visited = [False] * n
comps = []

for start in range(n):
    if visited[start]:
        continue
    queue = [start]
    visited[start] = True
    comp = [start]
    while queue:
        i = queue.pop()
        for j in range(n):
            if visited[j]:
                continue
            if polygons_connected(polygons[i], polygons[j], eps=eps):
                visited[j] = True
                queue.append(j)
                comp.append(j)
        comps.append(comp)
return comps
```

```
def filter_detached(kites, darts, keep_component=0, eps=1e-3):
```

*"""*

*Combine kites + darts, compute connected components, and keep only polygons in the specified component (sorted by size descending).*

*"""*

```
all_polys = list(kites) + list(darts)
if not all_polys:
    return [], []

comps = connected_components(all_polys, eps=eps)
# sort components by size descending
comps_sorted = sorted(comps, key=lambda c: len(c), reverse=True)

if keep_component >= len(comps_sorted):
    keep_component = len(comps_sorted) - 1

keep_indices = set(comps_sorted[keep_component])

n_k = len(kites)
new_kites = []
new_darts = []
```

```

for idx in keep_indices:
    if idx < n_k:
        new_kites.append(all_polys[idx])
    else:
        new_darts.append(all_polys[idx])
return new_kites, new_darts

# -----
# Plotting
# -----

def plot_penrose_r2(width=800, height=800, offset=(0.0, 0.0),
                    rr=0.2, gap_div=30.0, keep_component=0,
                    figsize=(8, 8), dpi=100):
    """
    Generate and plot the Penrose R2 tiling, filtered to keep only one connected
    component (removing detached parts).

    keep_component:
        0 = largest connected component (default)
        1 = second largest
        etc.
    """
    kites, darts = generate_penrose_r2(width, height, offset, rr, gap_div)
    kites, darts = filter_detached(kites, darts,
                                    keep_component=keep_component,
                                    eps=1e-3)

    fig, ax = plt.subplots(figsize=figsize, dpi=dpi)

    kite_color = (127/255.0, 21/255.0, 84/255.0, 1.0)
    dart_color = (183/255.0, 157/255.0, 112/255.0, 1.0)

    # draw background like JS fillRect magenta
    ax.set_facecolor((1.0, 0.0, 1.0, 1.0))

    # Draw kites and darts
    for poly in kites:
        xs = [p[0] for p in poly] + [poly[0][0]]
        ys = [p[1] for p in poly] + [poly[0][1]]
        ax.fill(xs, ys, color=kite_color, edgecolor="black", linewidth=0.5)

    for poly in darts:
        xs = [p[0] for p in poly] + [poly[0][0]]
        ys = [p[1] for p in poly] + [poly[0][1]]
        ax.fill(xs, ys, color=dart_color, edgecolor="black", linewidth=0.5)

```

```

ax.set_aspect("equal", "box")
ax.set_xlim(0, width)
ax.set_ylim(height, 0) # flip y to mimic canvas browser coords
ax.set_xticks([])
ax.set_yticks([])
ax.set_title(f"Penrose R2 tiling (component {keep_component})")
plt.tight_layout()
plt.show()

# -----
# Example usage
# -----

if __name__ == "__main__":
    # Change keep_component (0, 1, 2, ...) to select which connected
    # cluster you keep. 0 means the largest one (no detached parts).
    plot_penrose_r2(width=800, height=800, keep_component=0)

```

Penrose R2 tiling (component 0)

