Radiative transfer on Centroidal Tessellations

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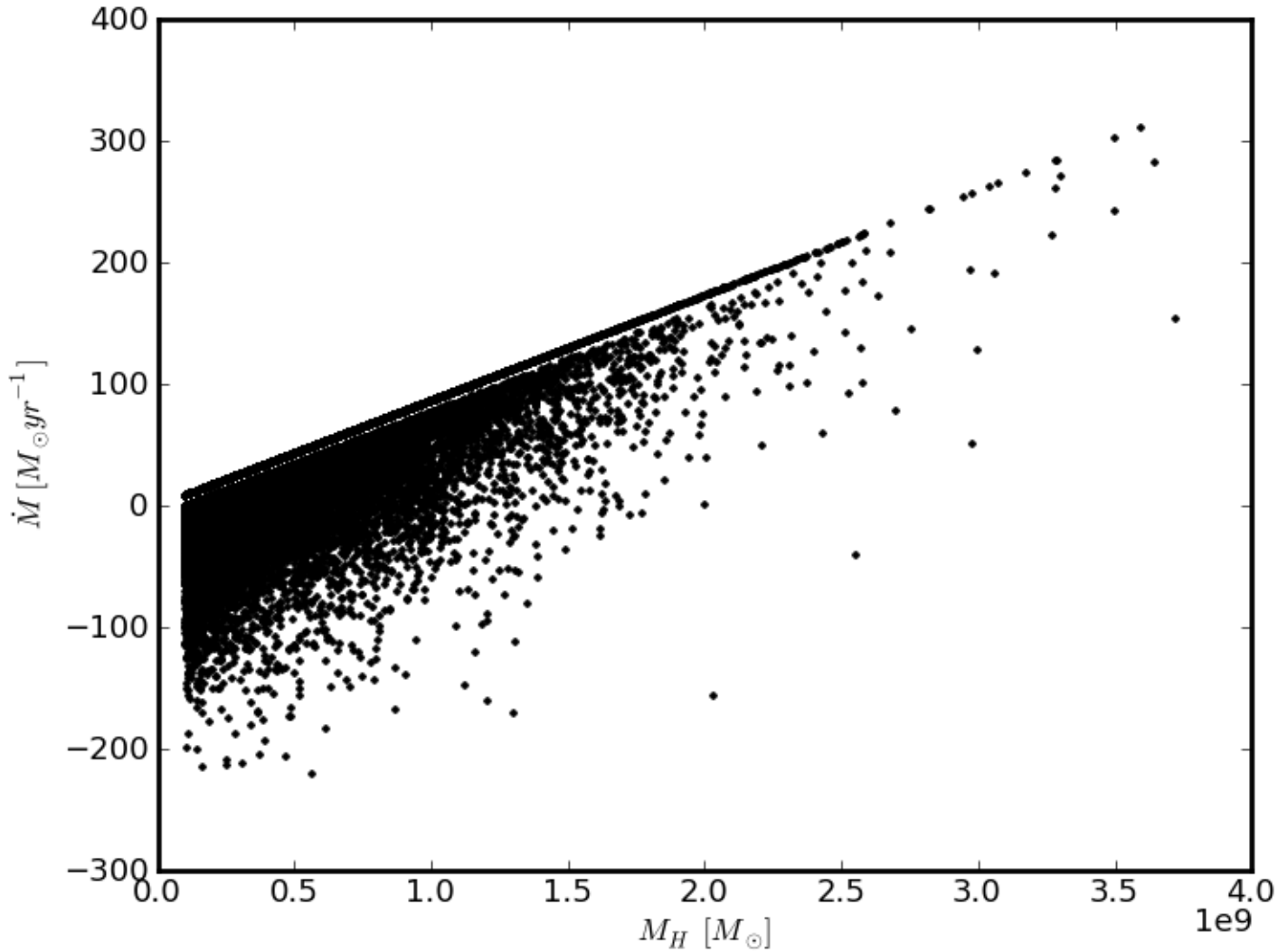
Original plan for today: Comparing luminosity recipes with C2Ray

Different codes use different mechanisms to assign luminosities to halos:

- Proportional to mass
- Proportional to mass growth
- Different semi-analytical models

Original plan for today: Comparing luminosity recipes with C2Ray



Radiative transfer on Centroidal Tessellations

Or: SimpleX algorithm on Centroidal Tessellations

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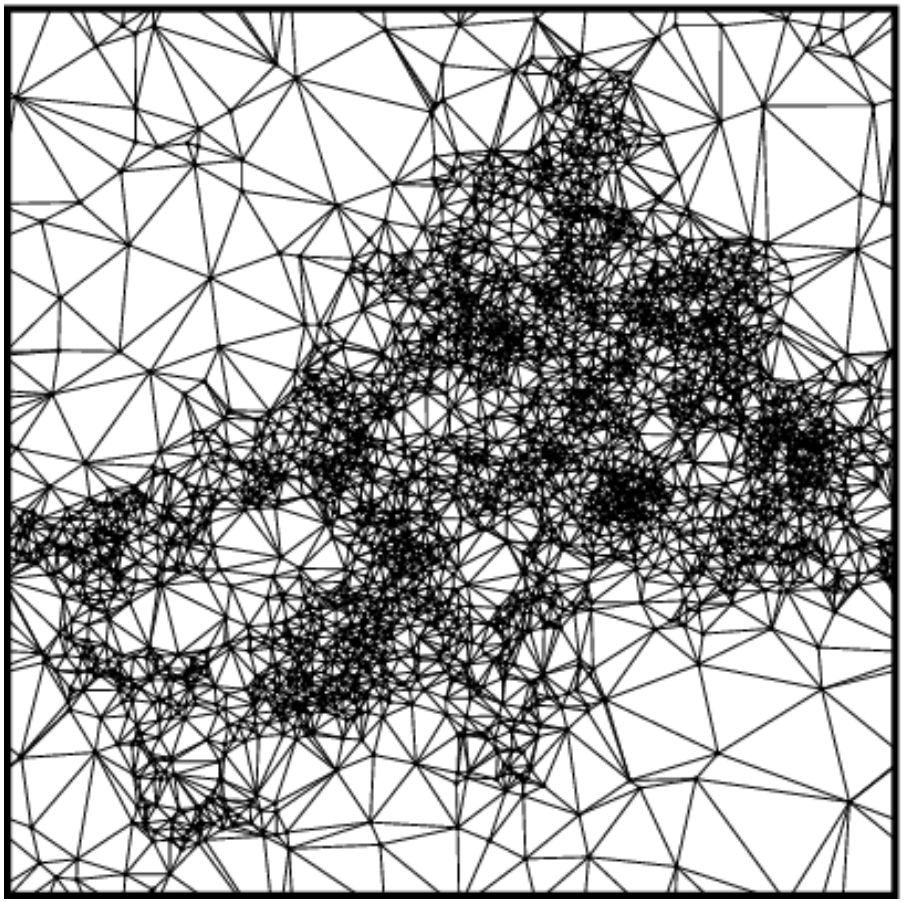
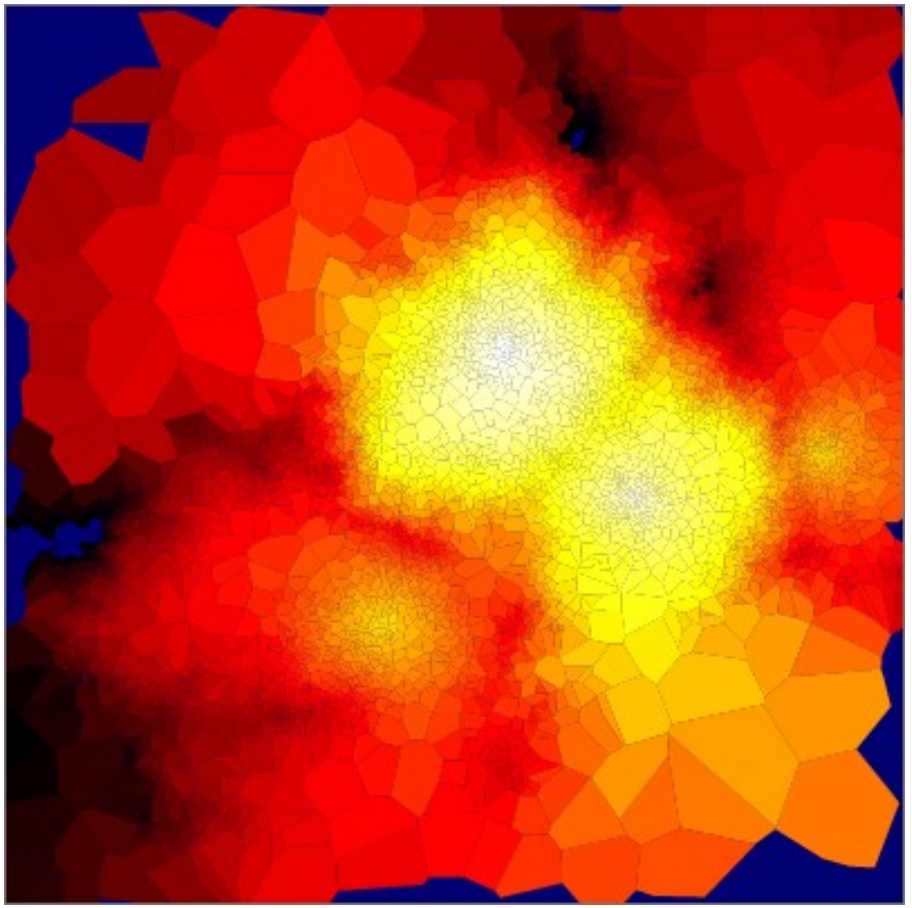
SimpleX

Monte-Carlo approach on unstructered grids



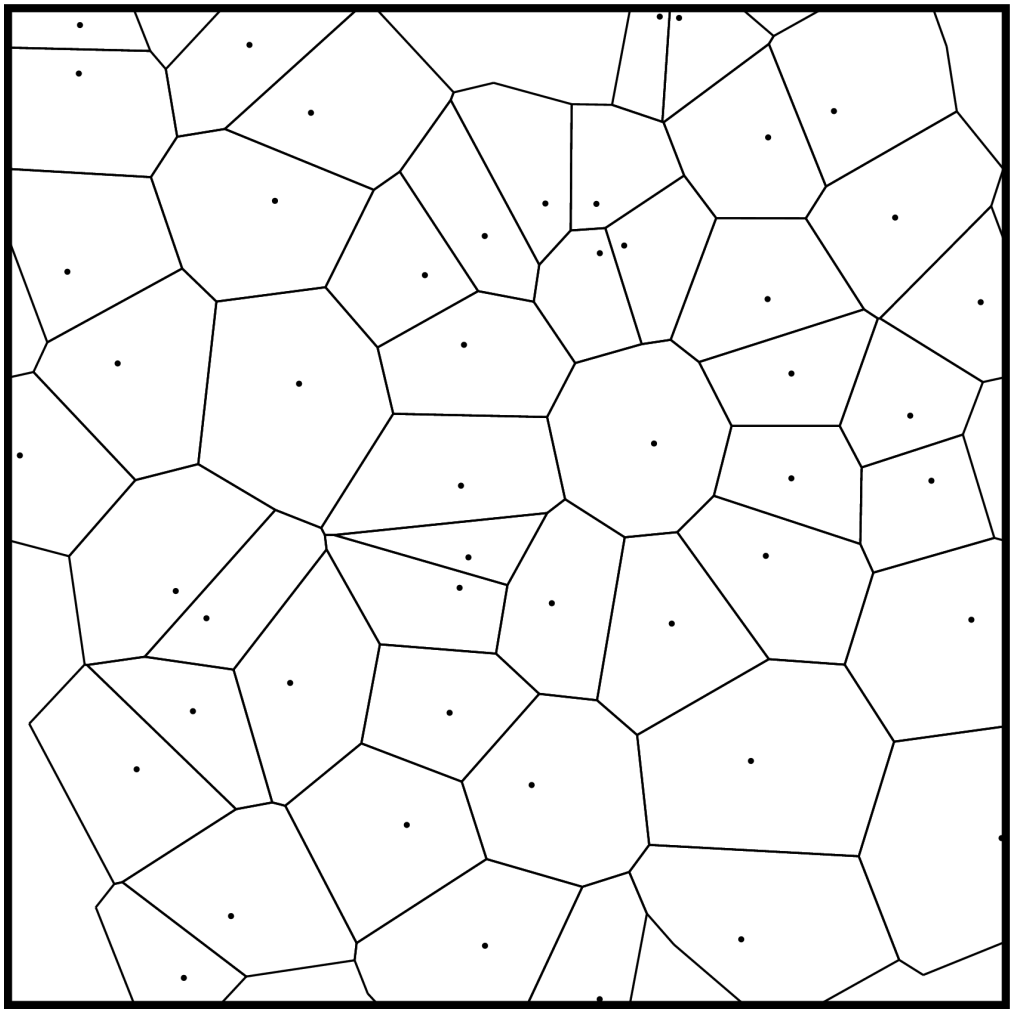


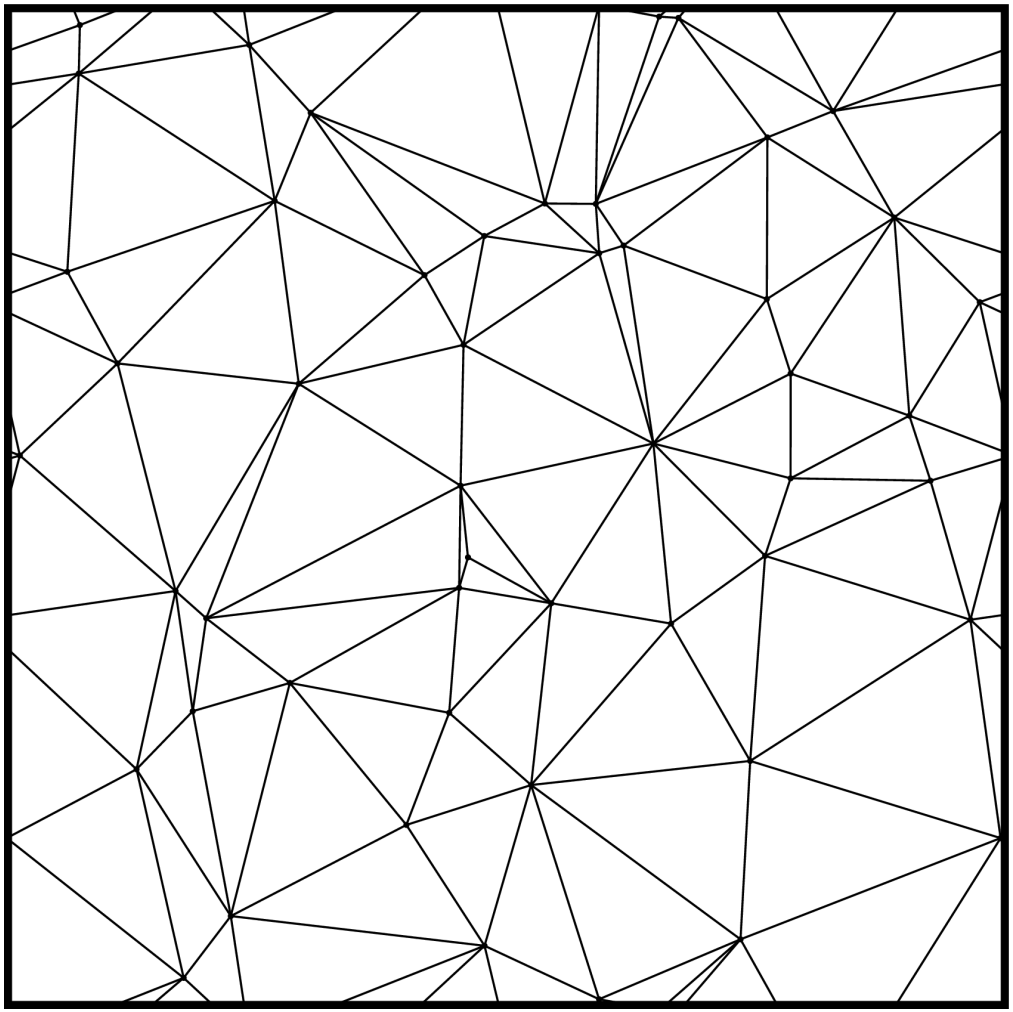
SimpleX (**2003, 2006; J Ritzerveld)**

- Points represent the underlying space of optical depths (eg SPH points)
- The Delaunay triangulation is used to tessellate space and forms the grid
- Photons are transported along the Delaunay edges
- All physics is coupled to the grid
- No inherent symmetries
- Naturally adaptive to just the right resolution

Radiative transfer reduces to sending photon packages along the edges and let them interact at each nucleus.

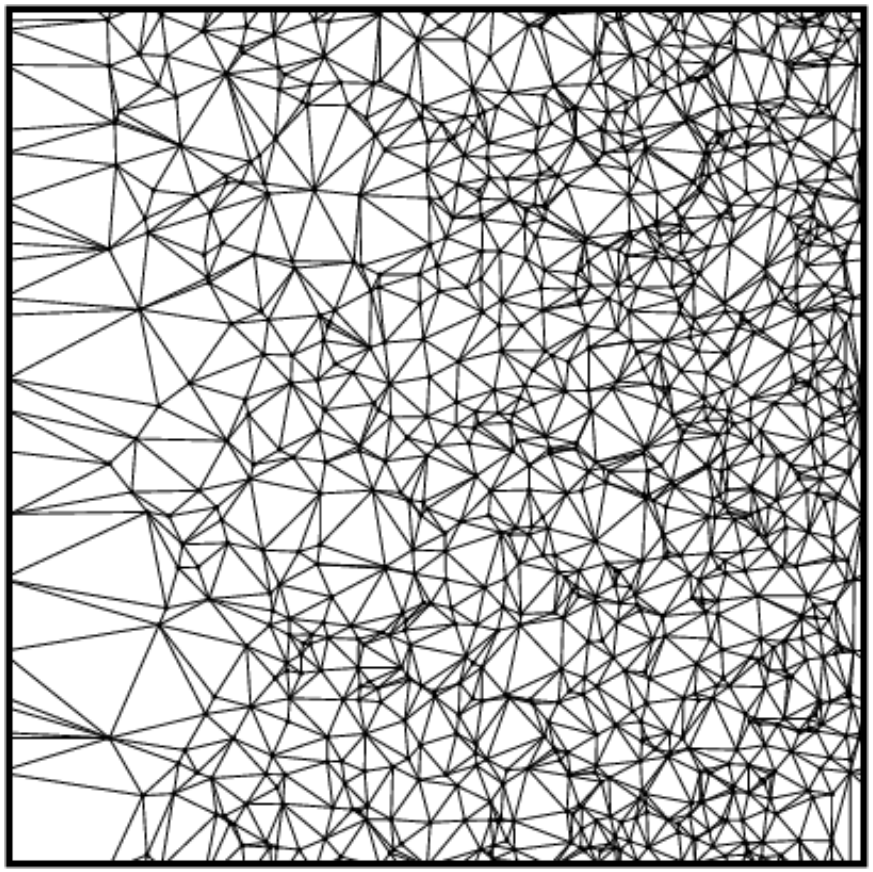
SimpleX (**2003, 2006; J Ritzerveld**)



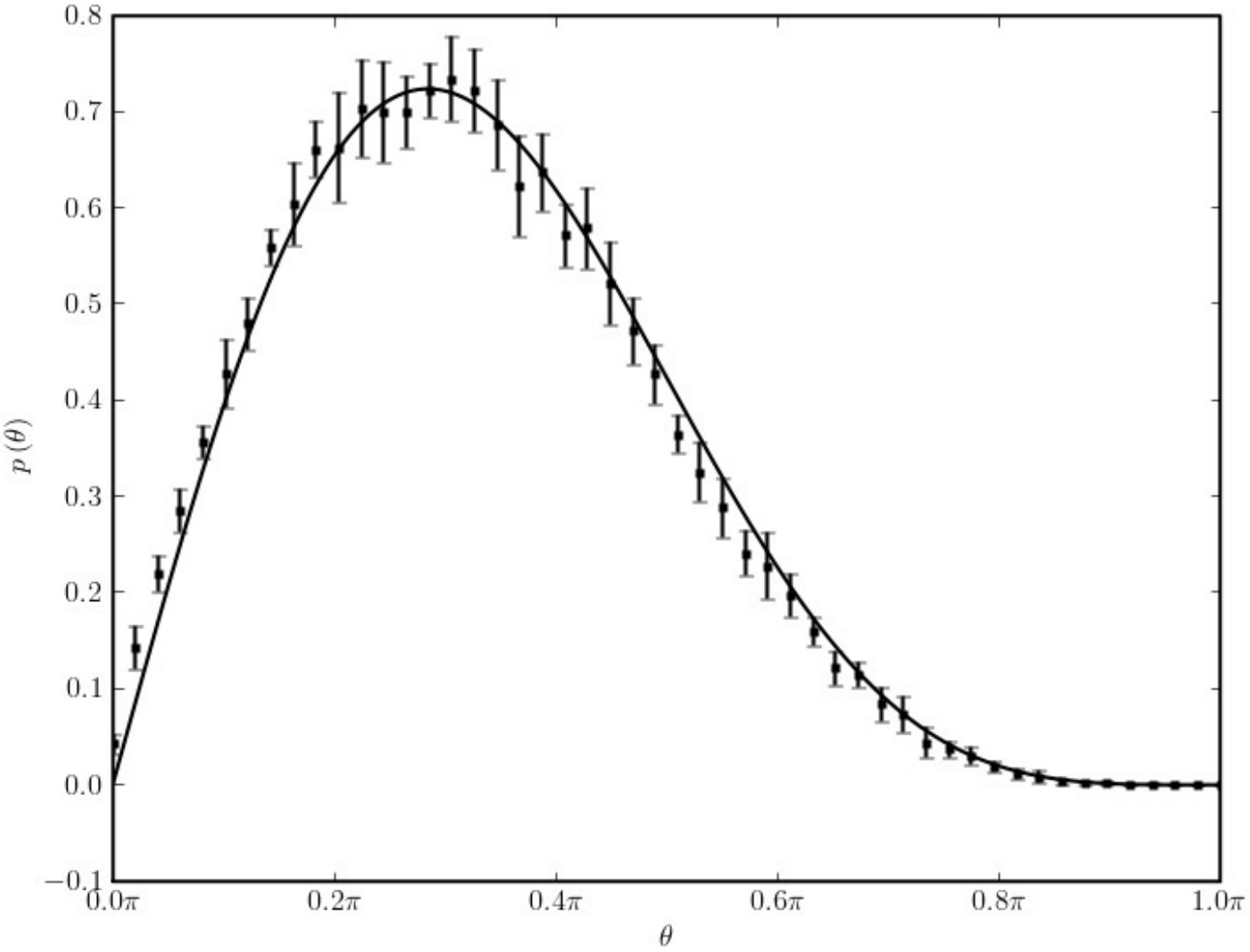


Four problems (Paardekooper 2009, Kuiper 2010)

- Drift
- Clustering
- Deflection
- Decollimation



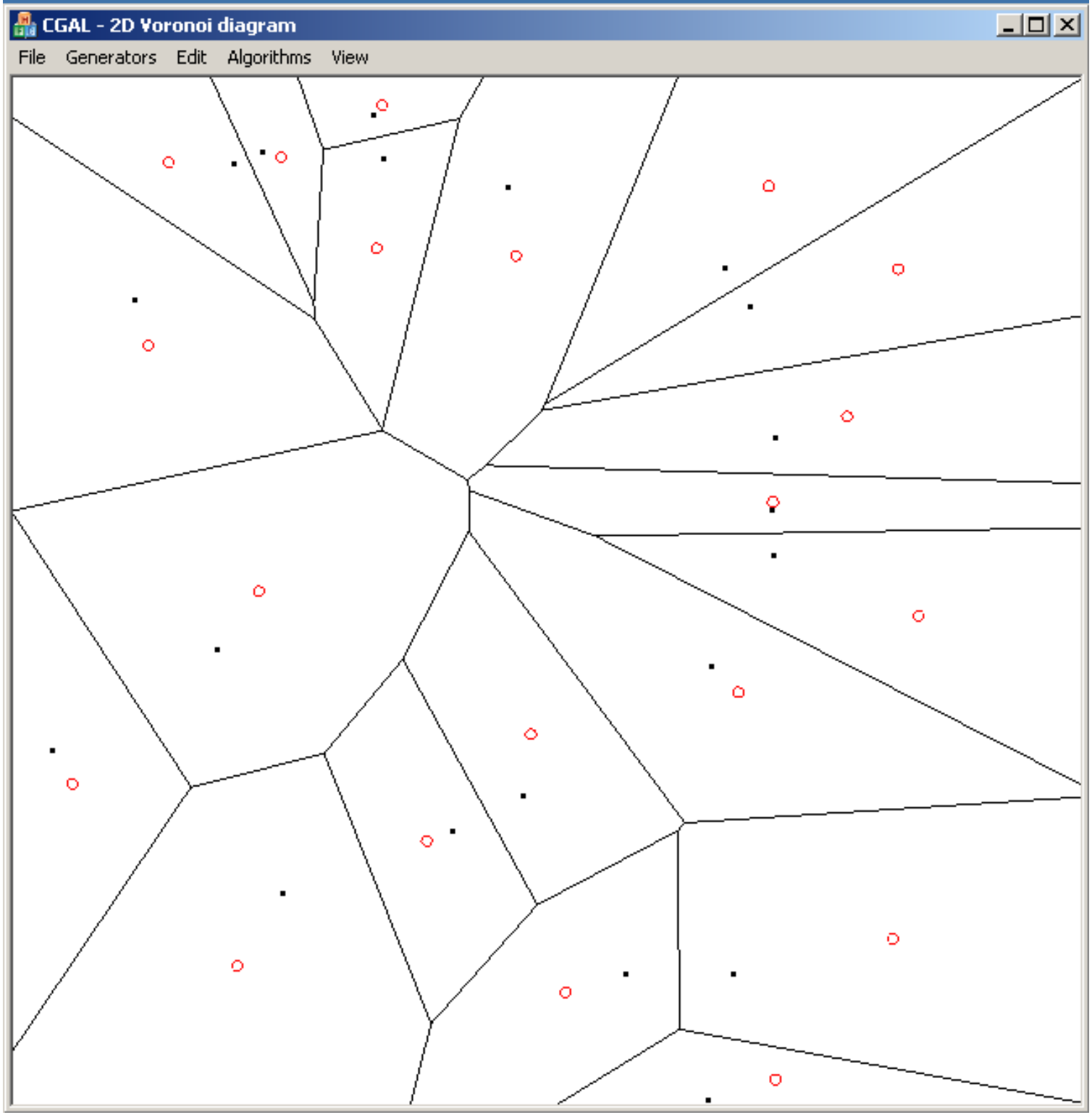
The underlying problem: anisotropy in the grid

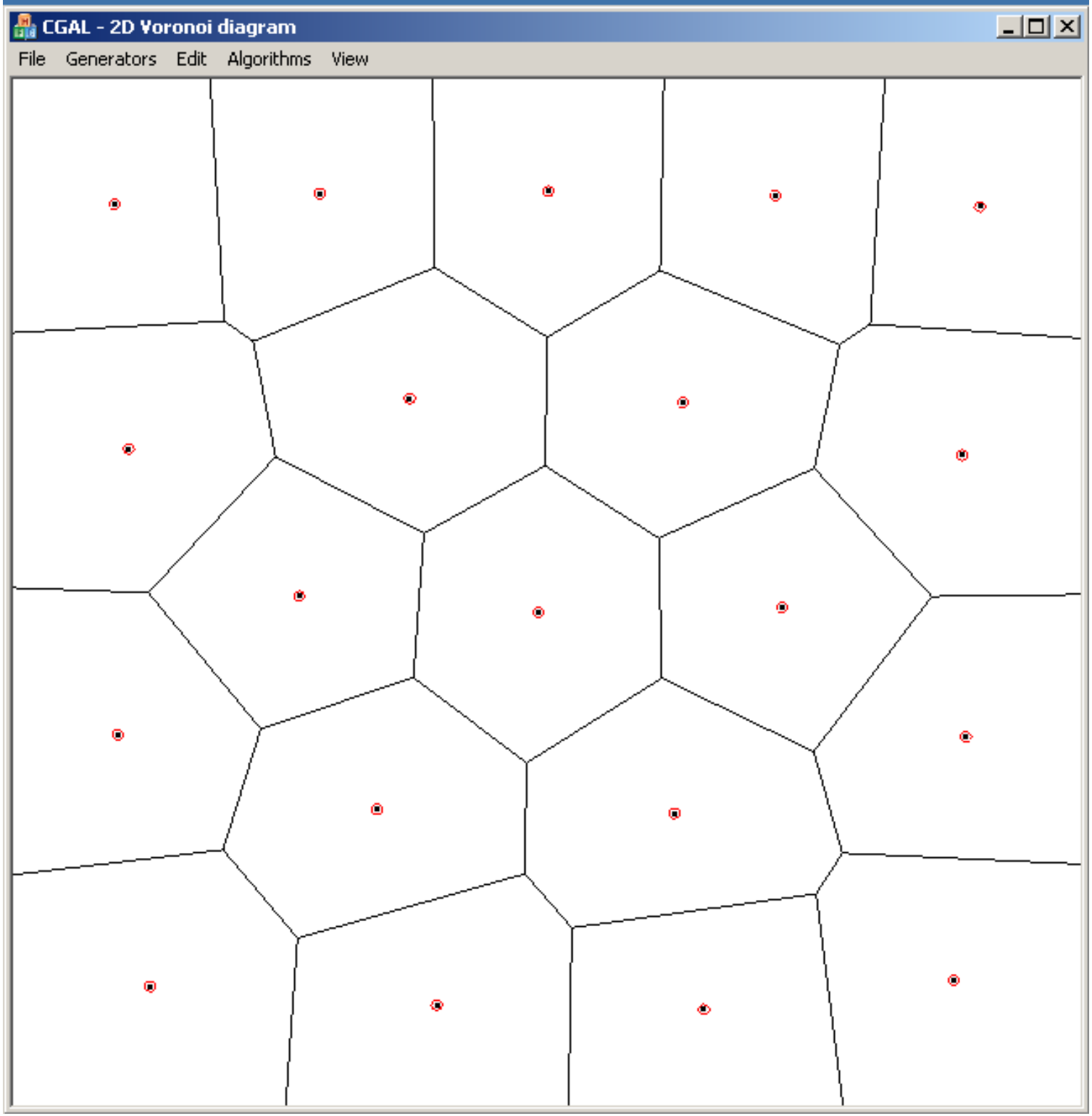


The underlying problem: anisotropy in the grid

A possible solution: *Centroidal Tessellations*

The idea: put the mass centroid on top of the generating nuclei


CGAL - 2D Voronoi diagram
File
Generators
Edit
Algorithms
View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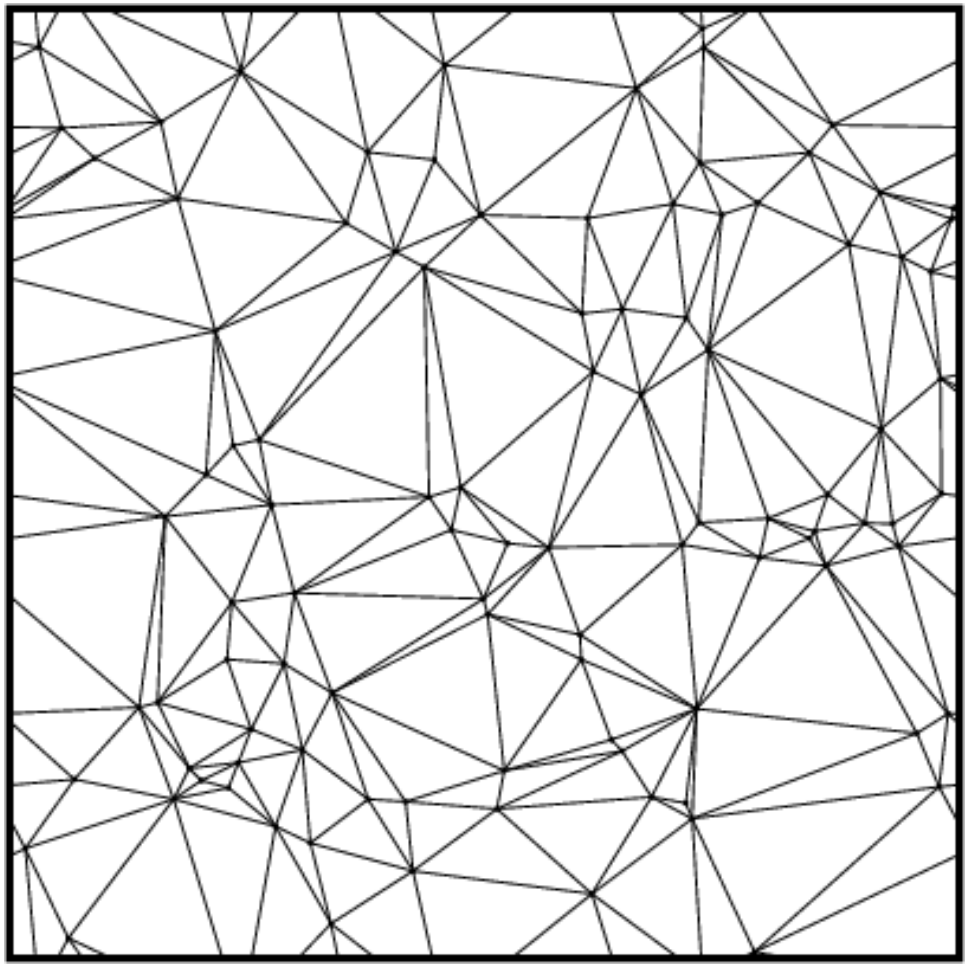
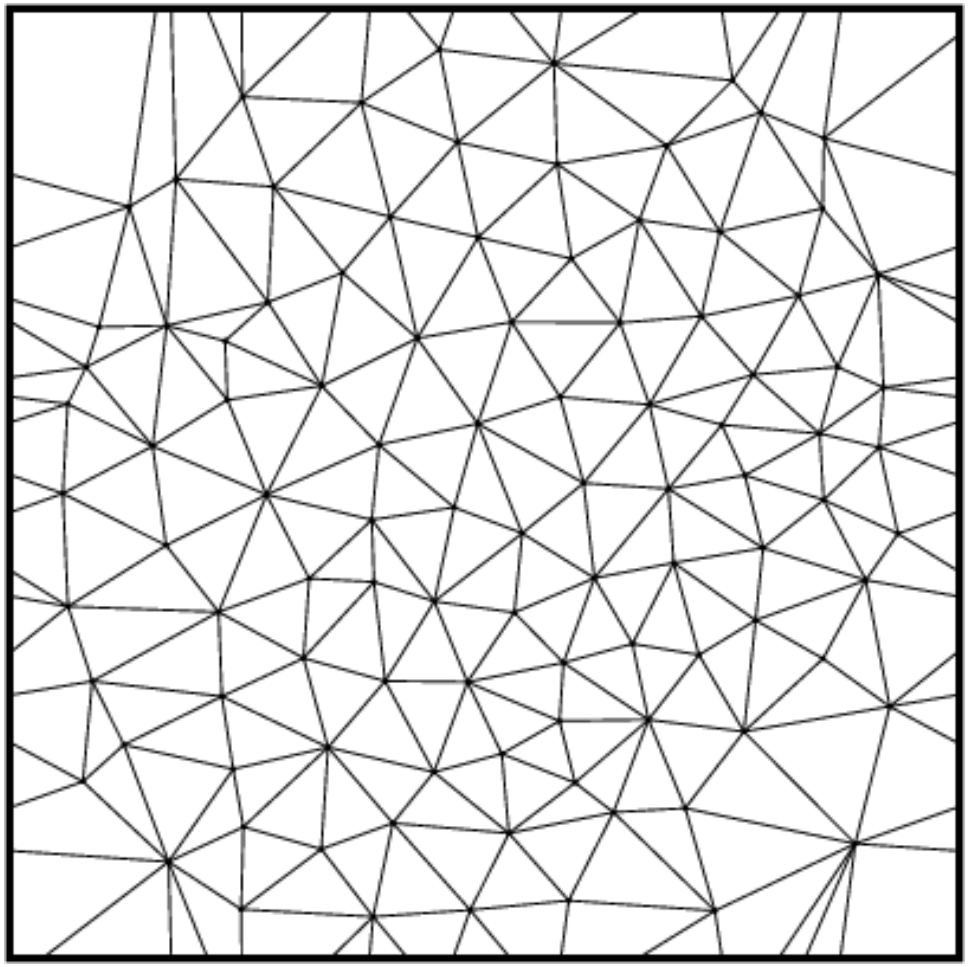
Centroidal Tessellations: applications

- Resource Placement
- Animal behaviour
- Cell Division
- Truncation Errors
- Optimal Quadrature rules
- Data compression in images
- People behaviour in crowds
- Hydrodynamics
- Radiative transfer?

Centroidal Tessellations: examples





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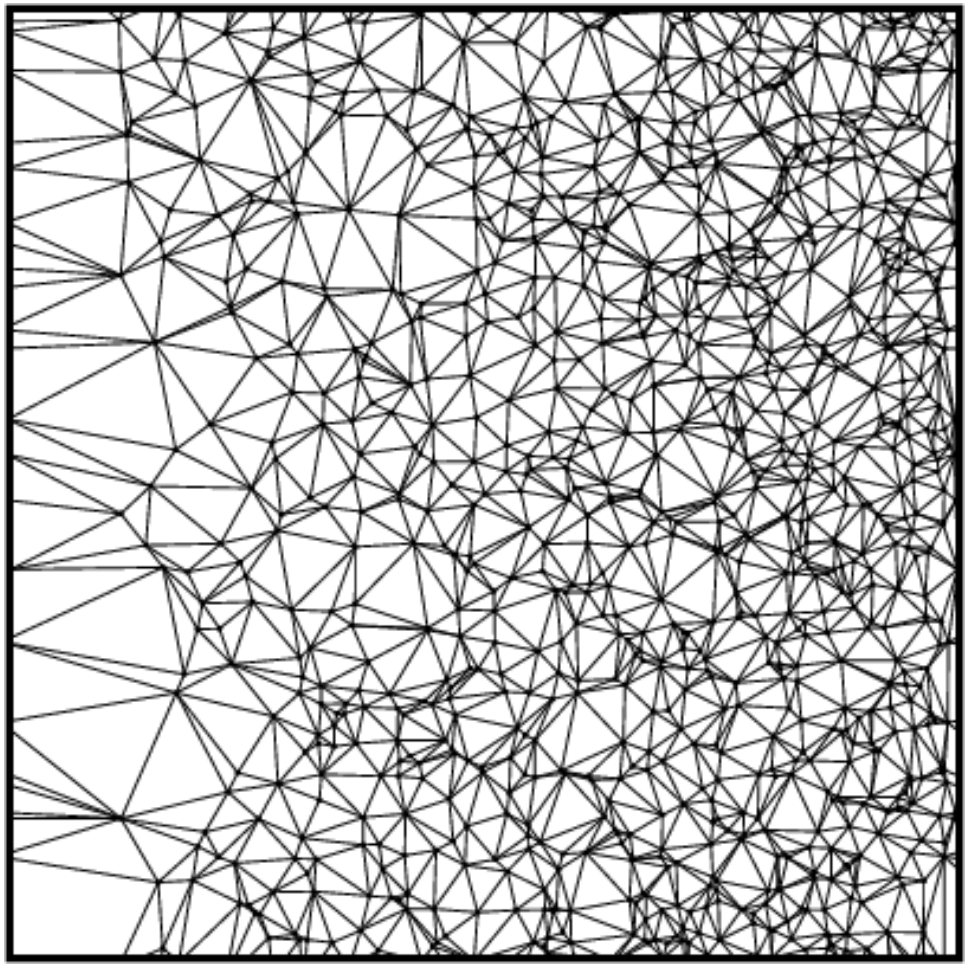

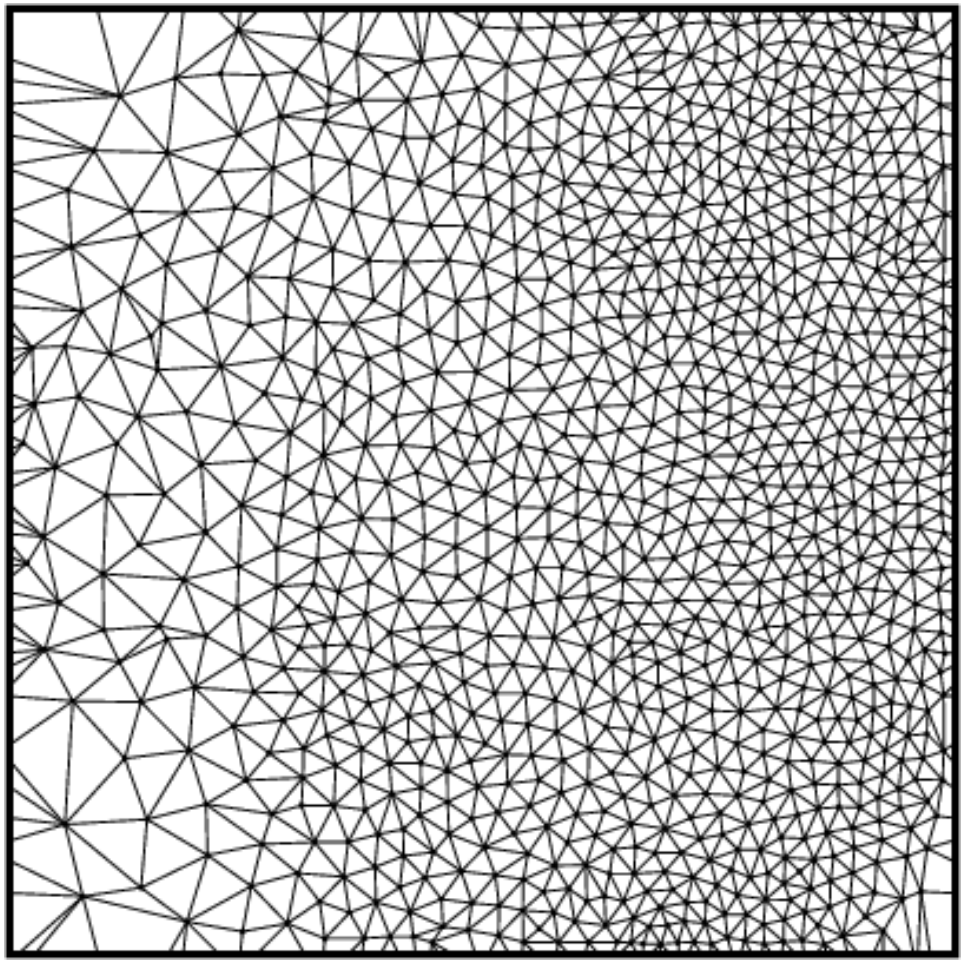

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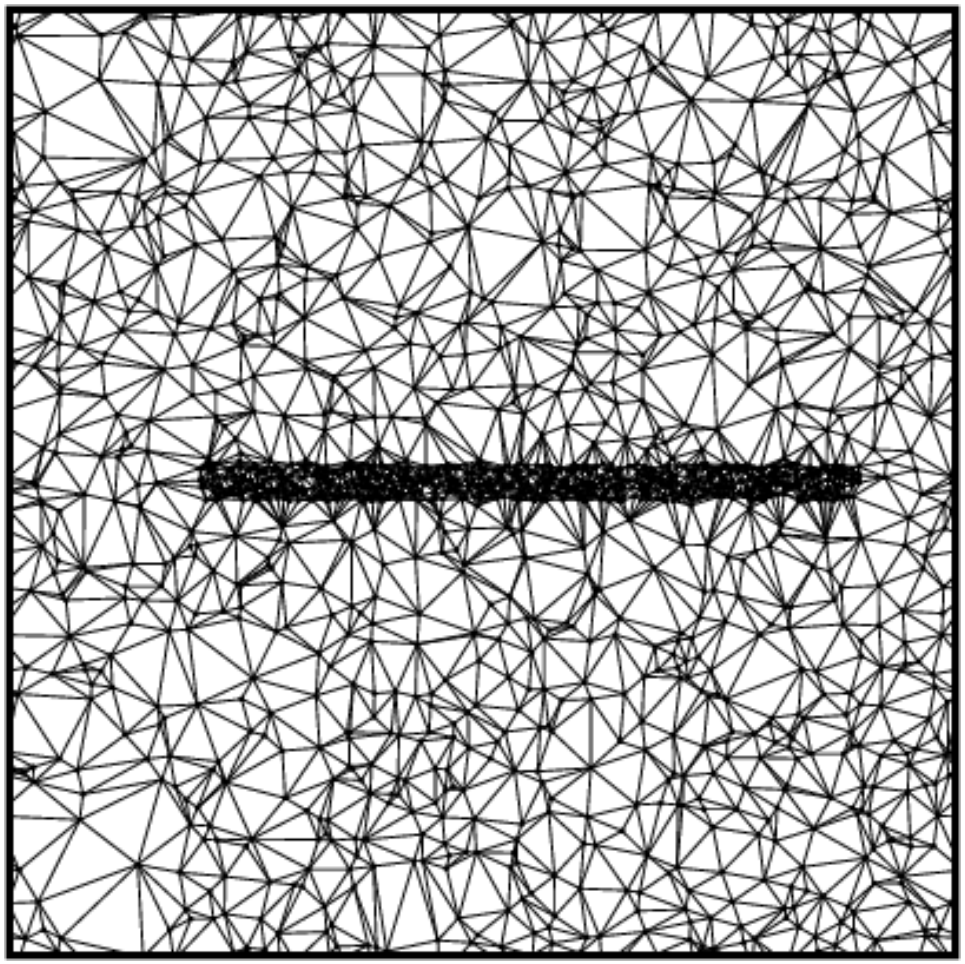
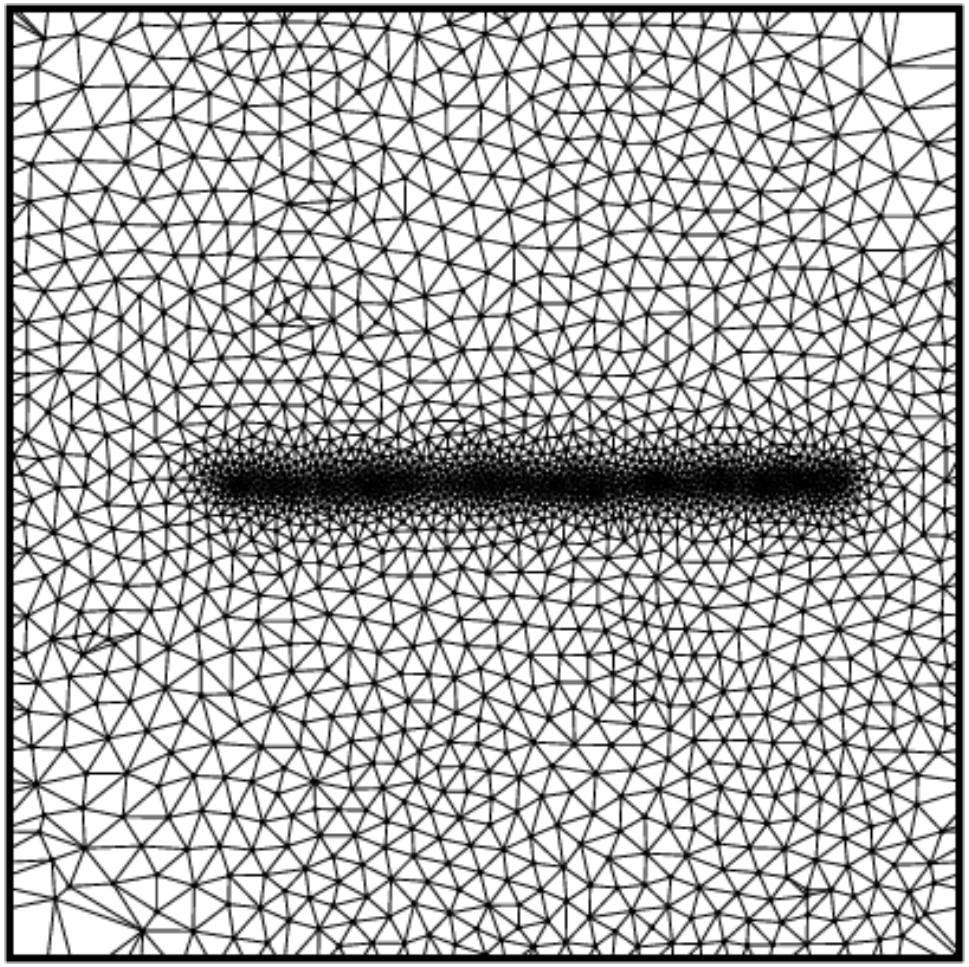
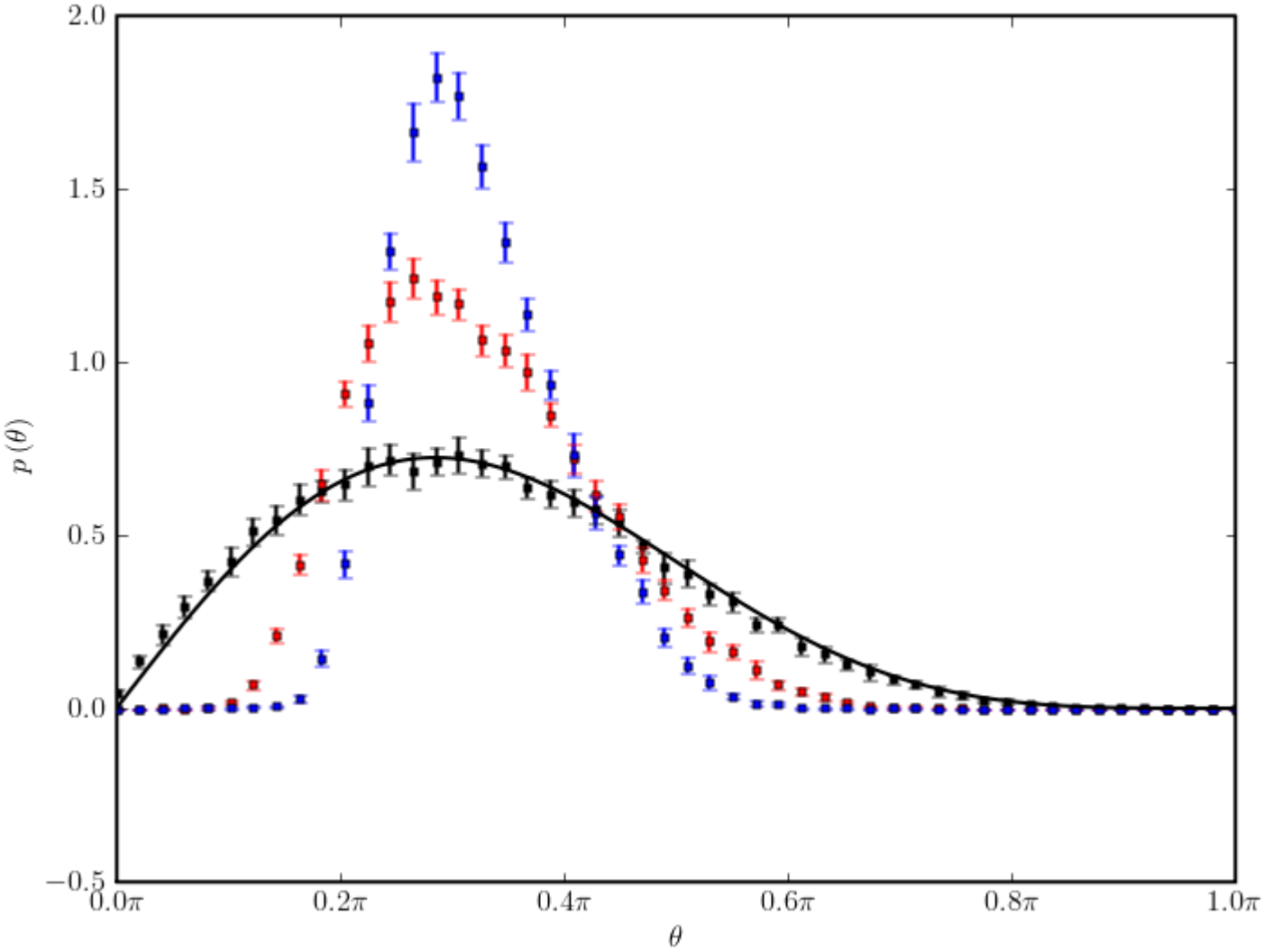
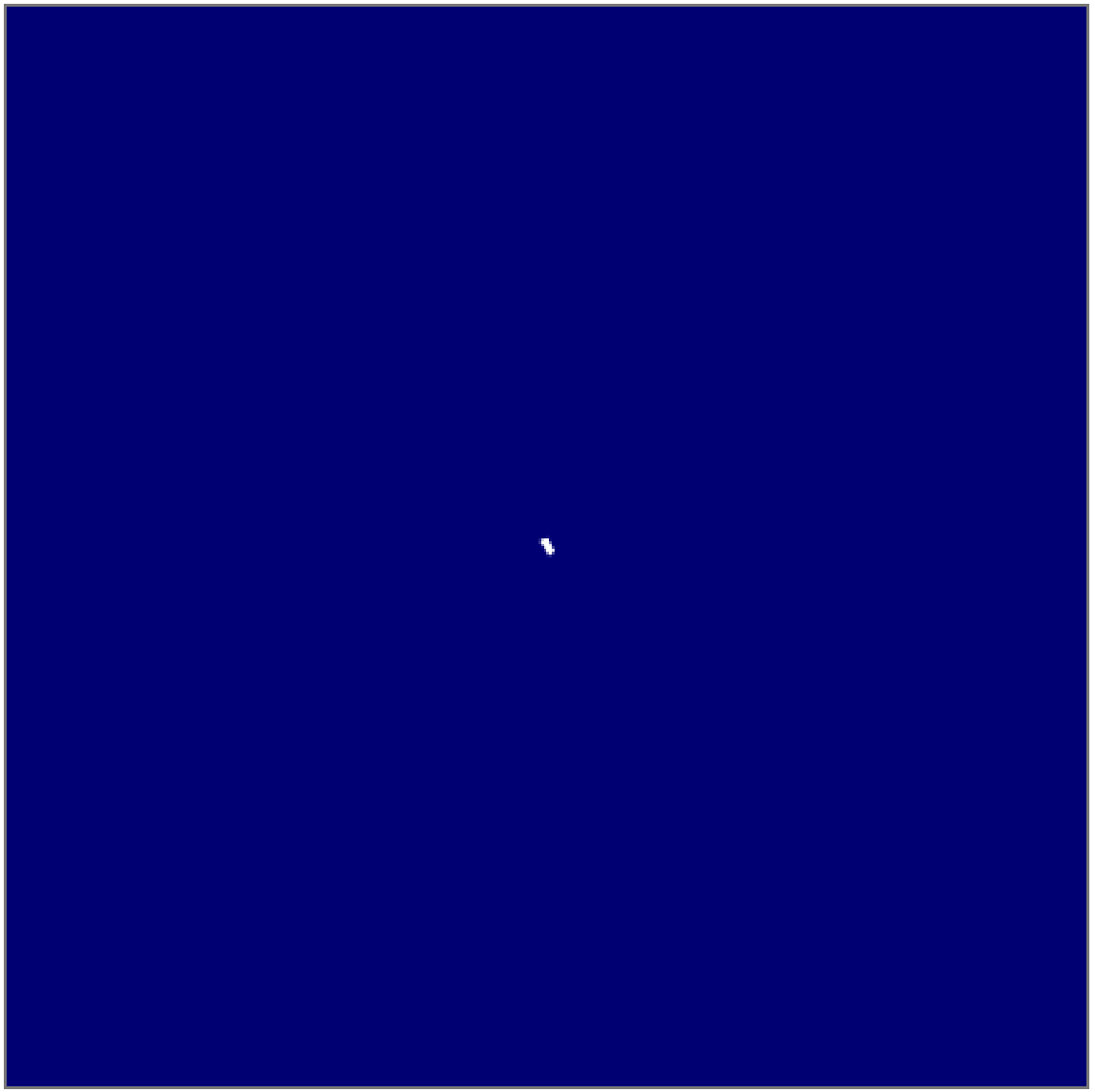




Centroidal Tessellations: angles



Centroidal Tessellations: Stromgen sphere



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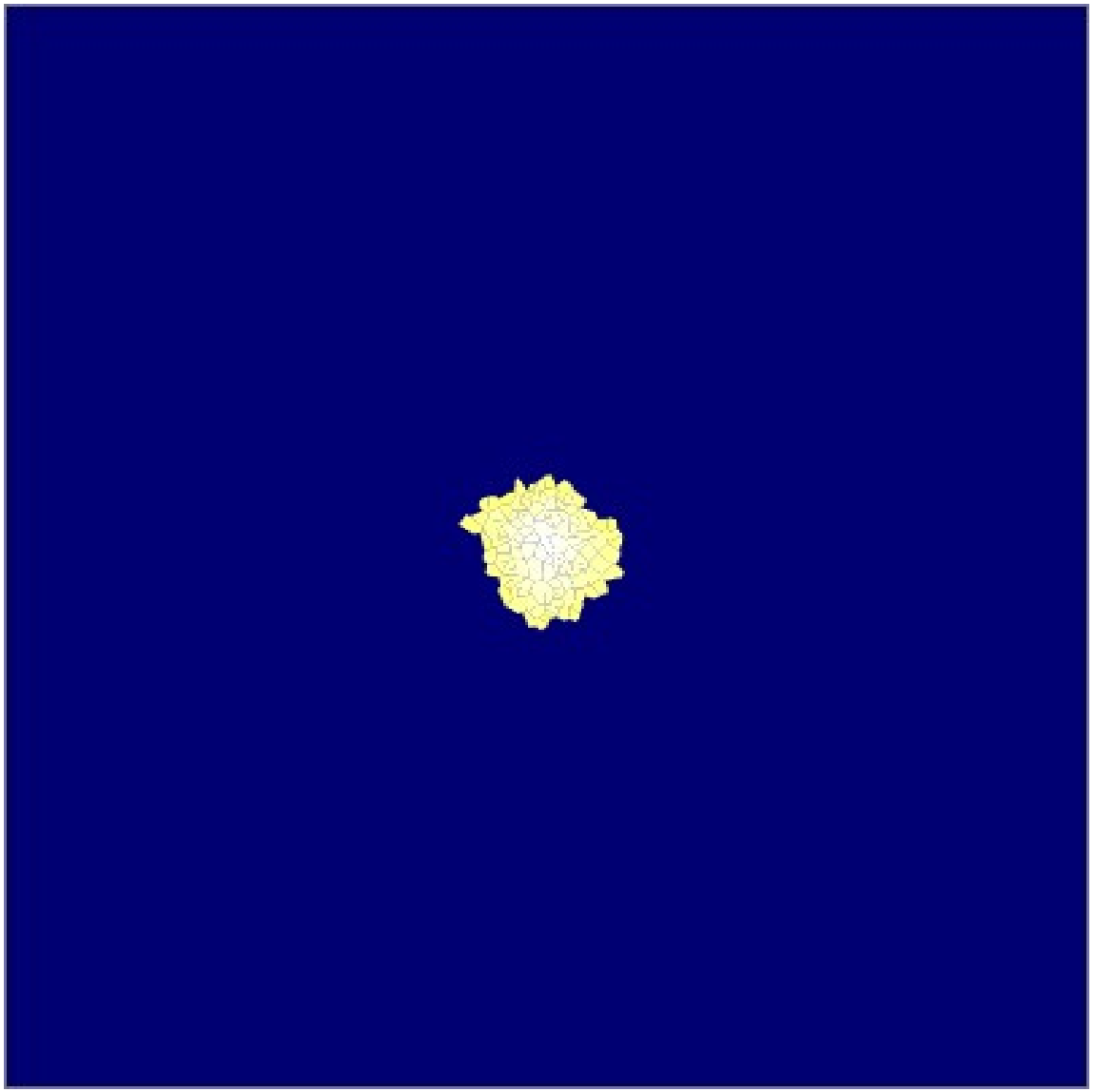

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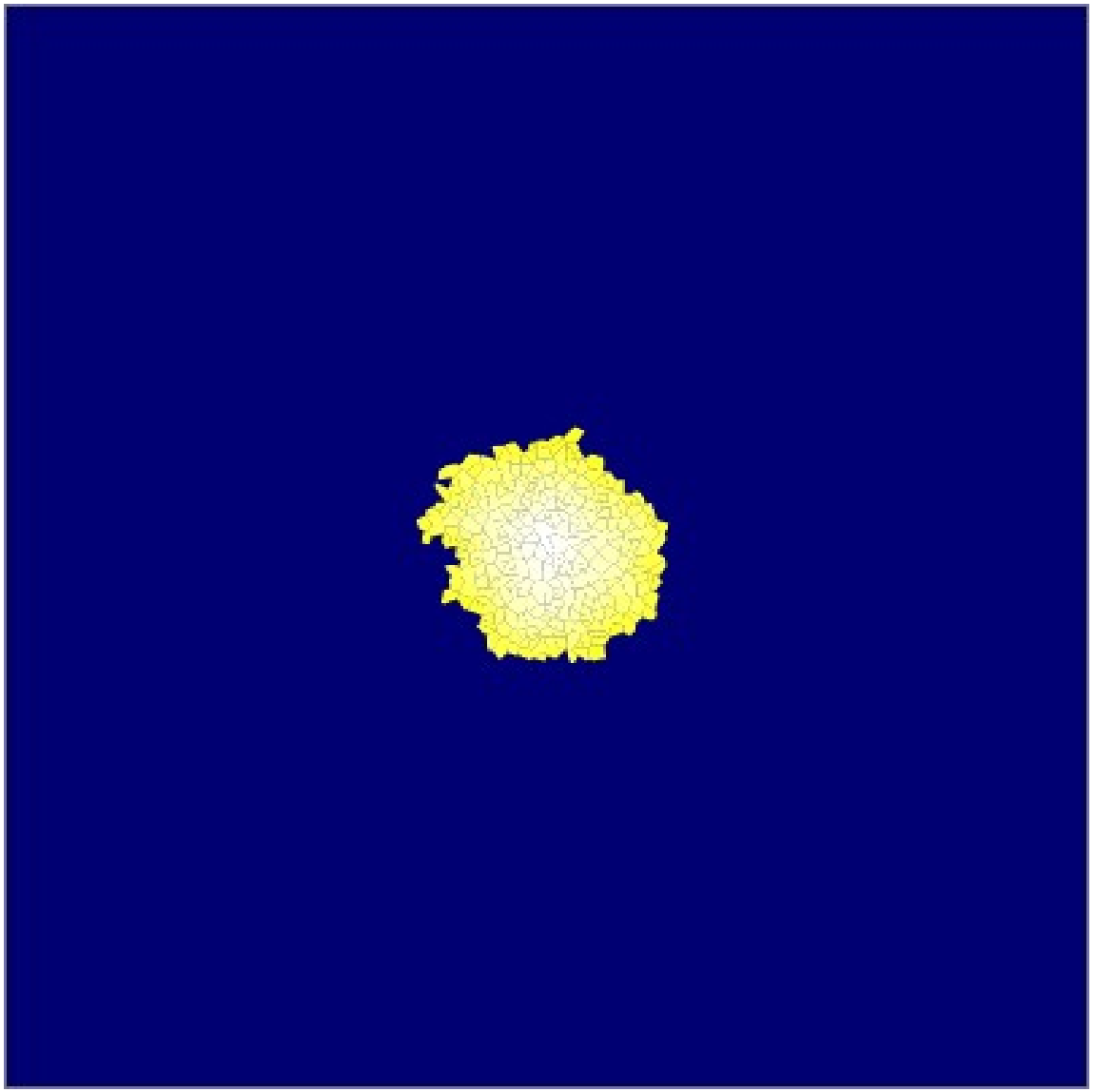

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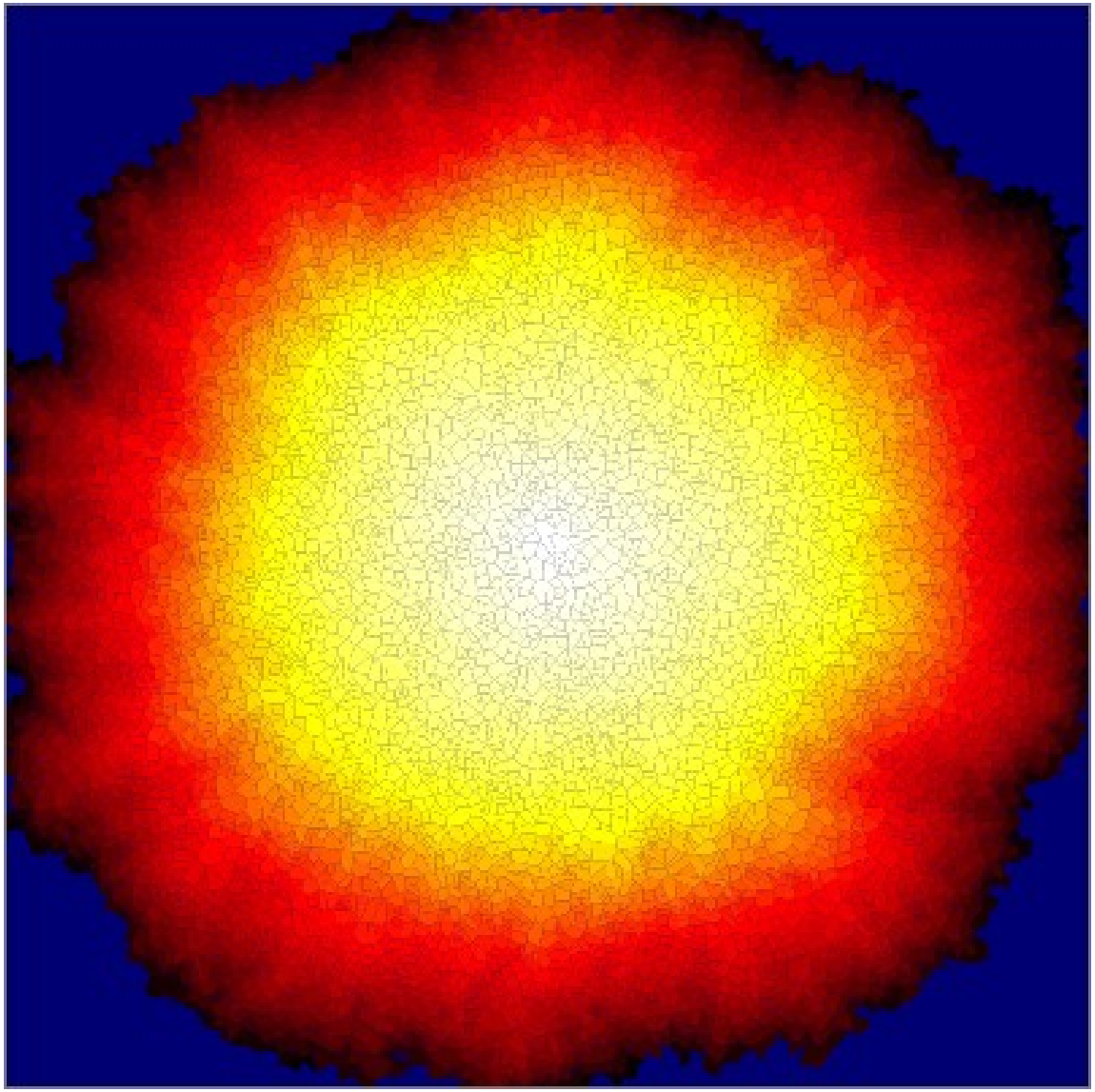
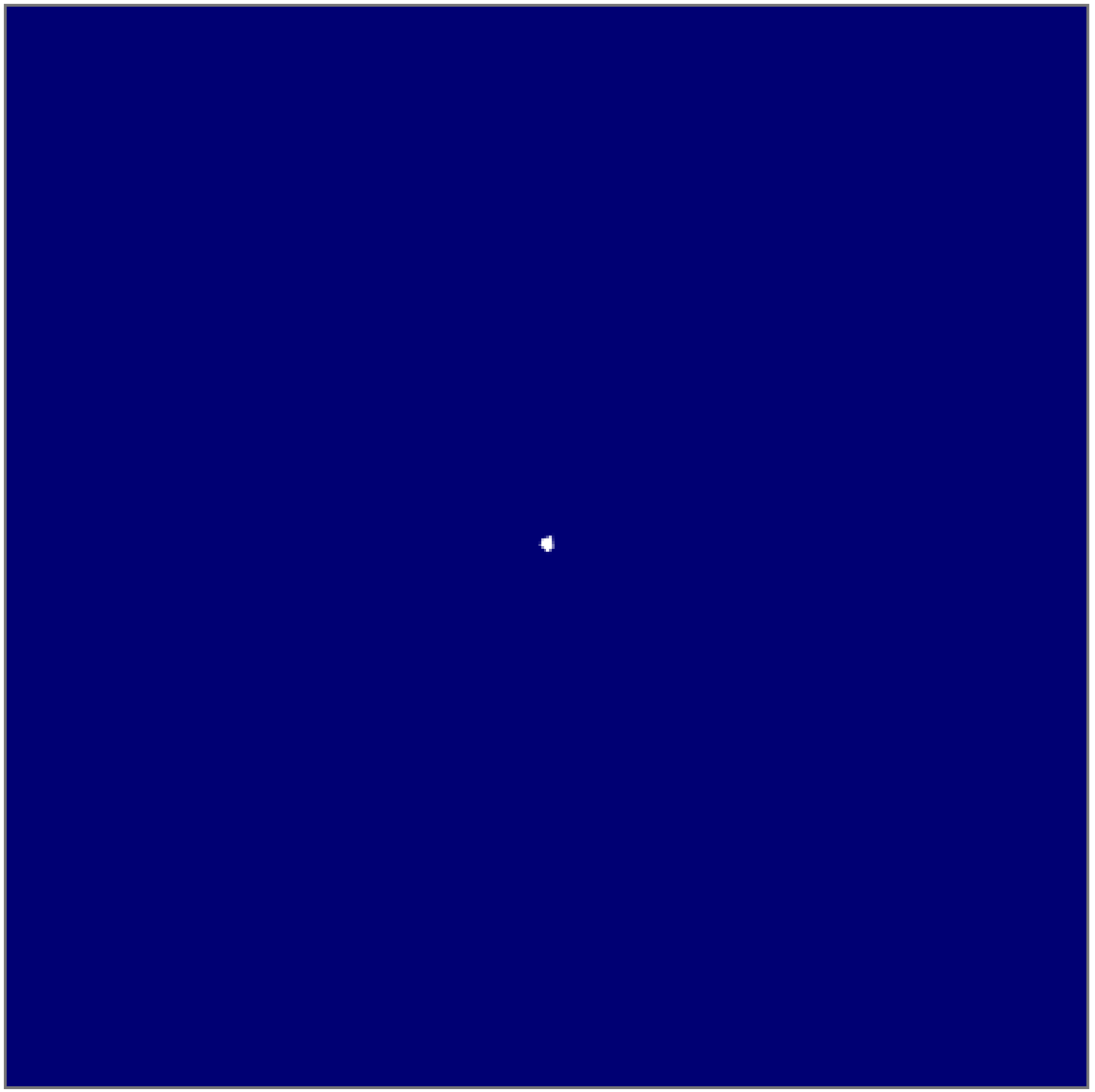


Centroidal Tessellations: 3 x Lloyd



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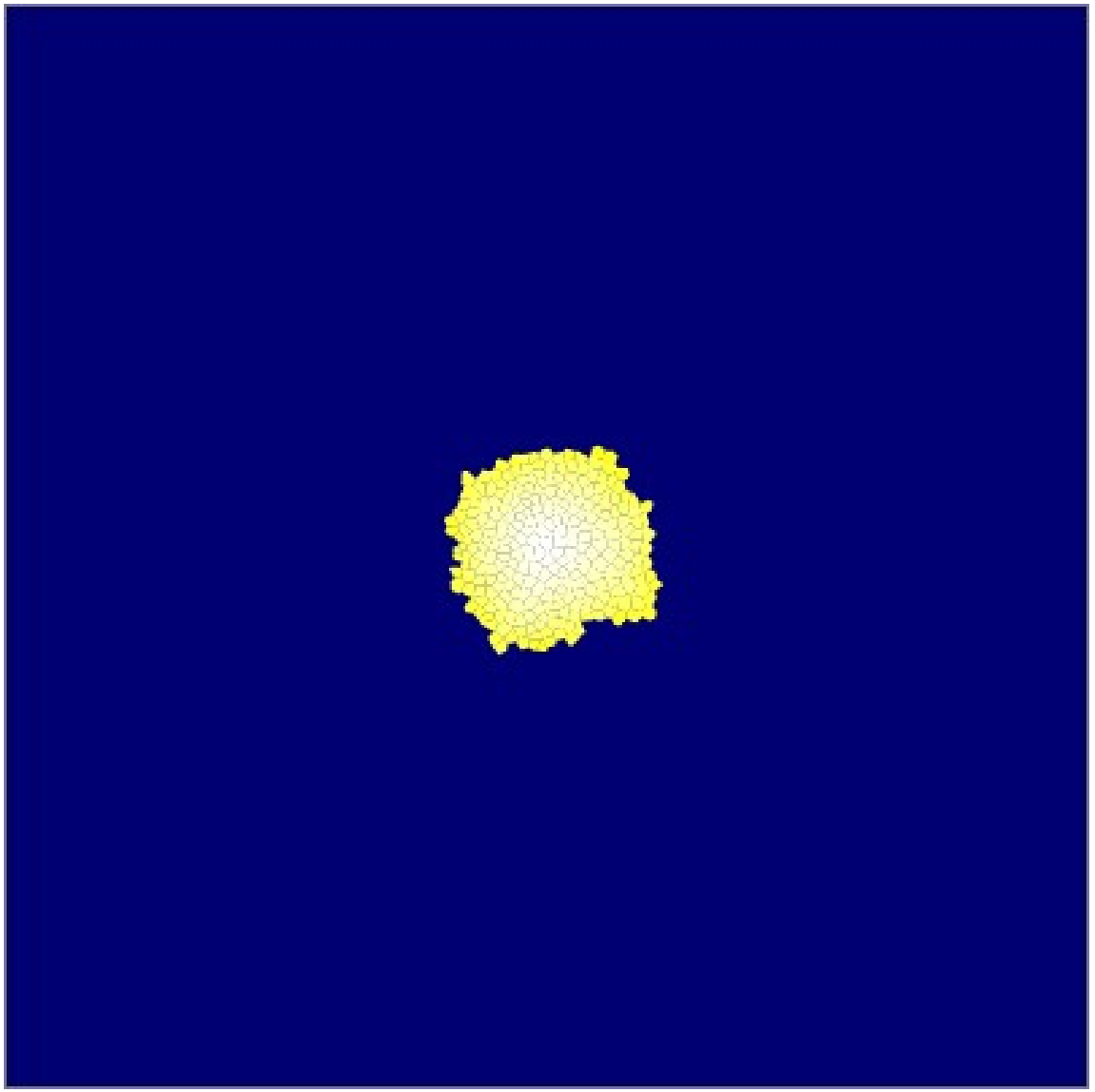

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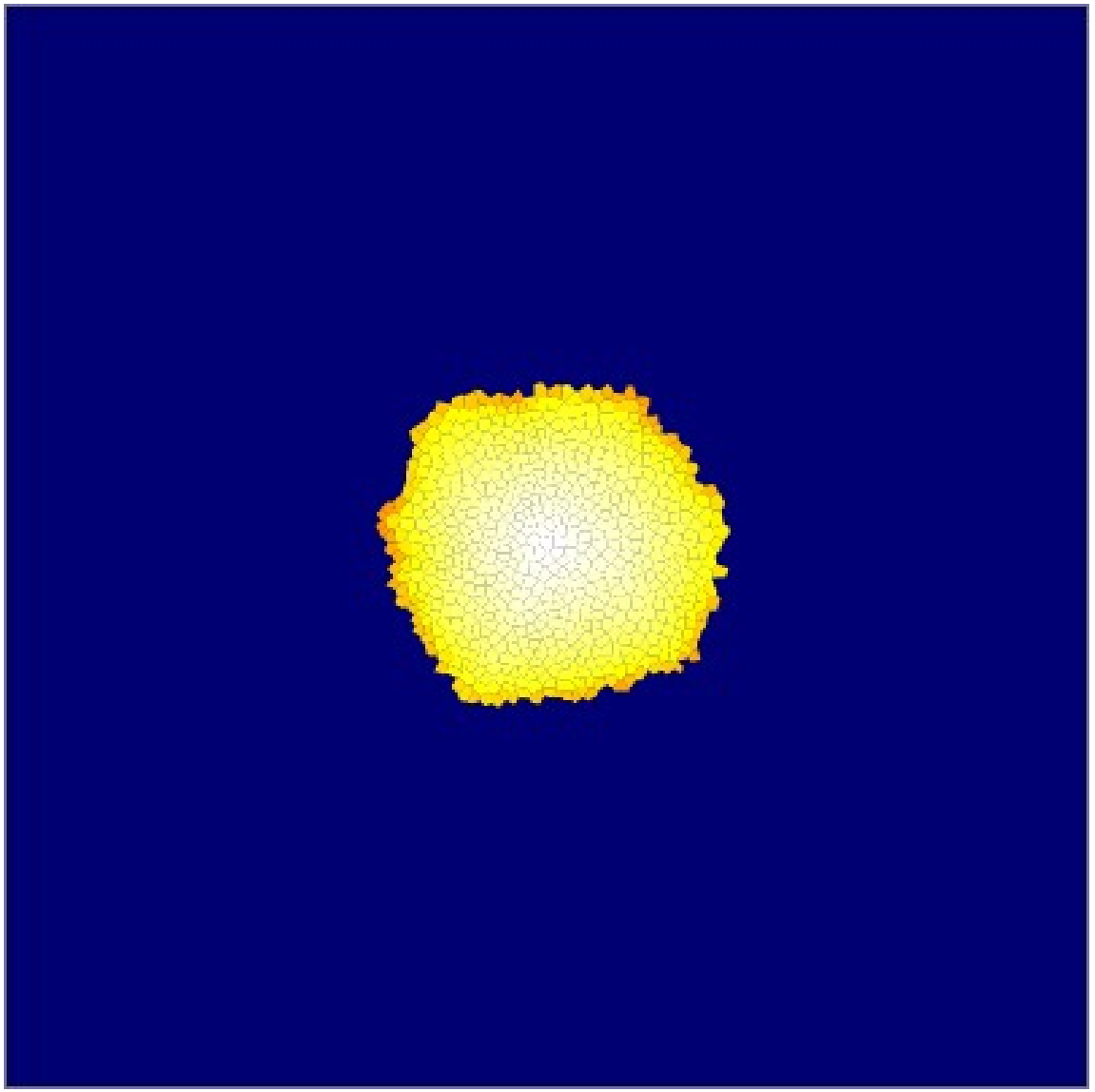

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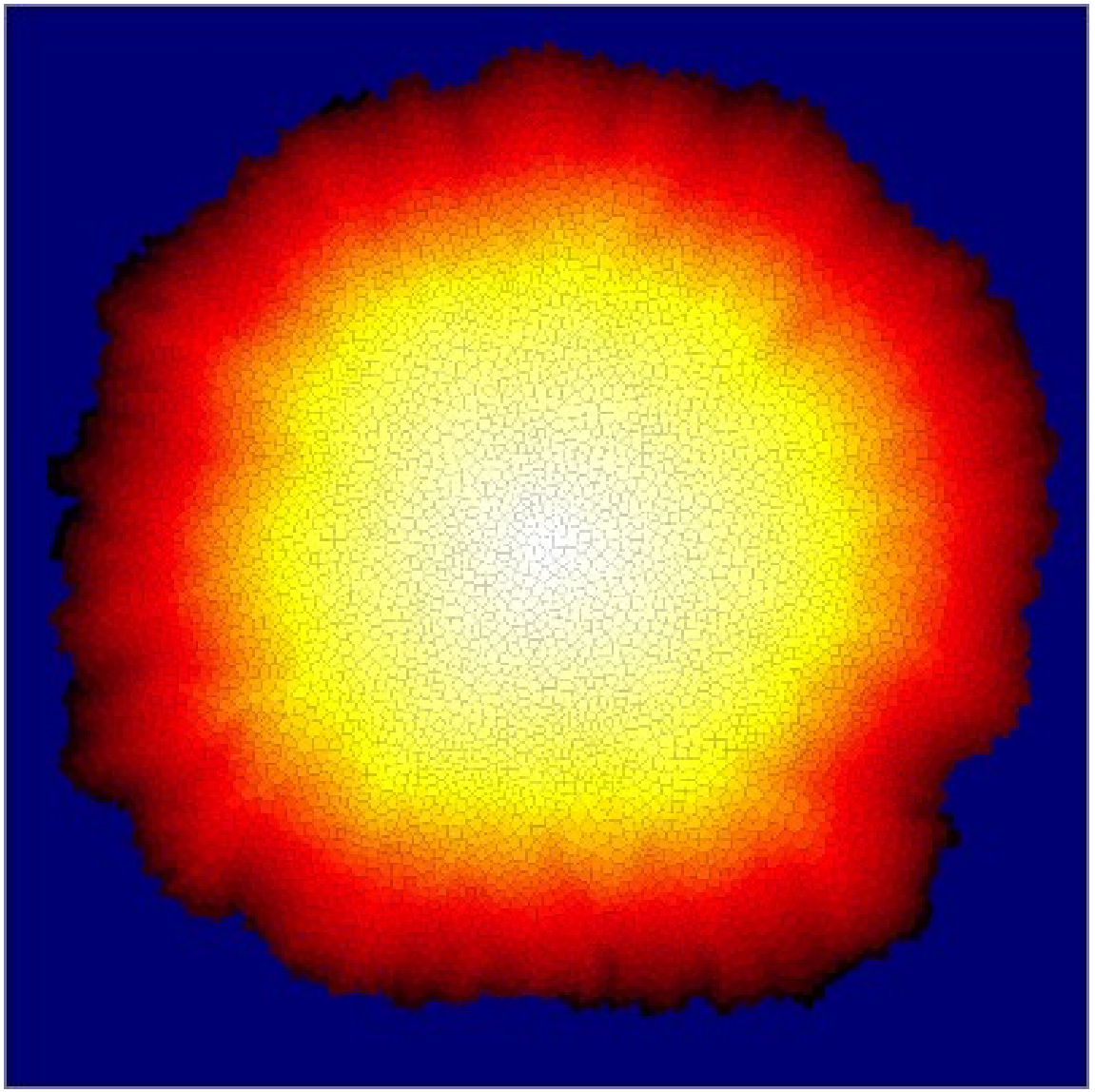
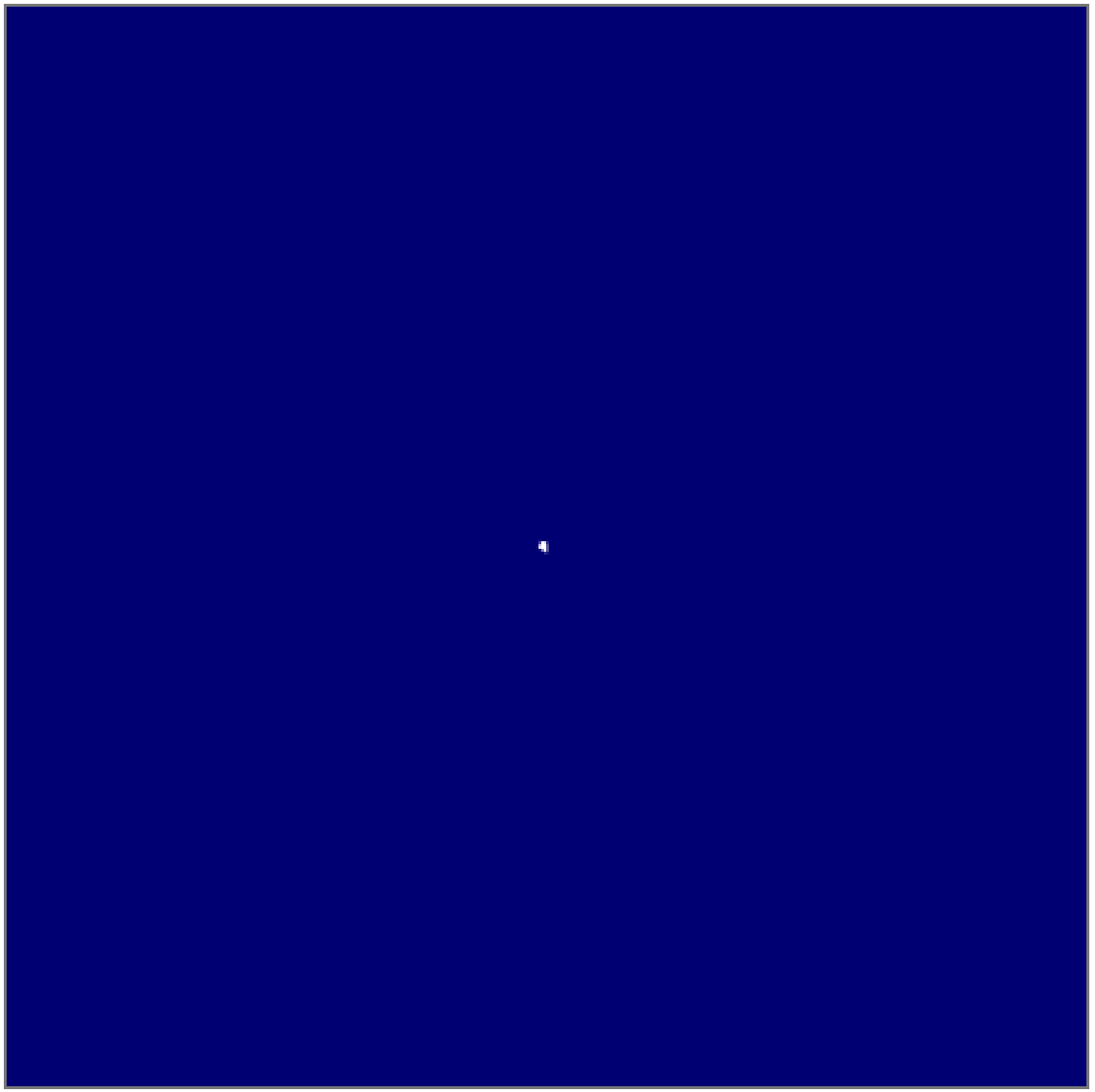


Centroidal Tessellations: 10 x Lloyd



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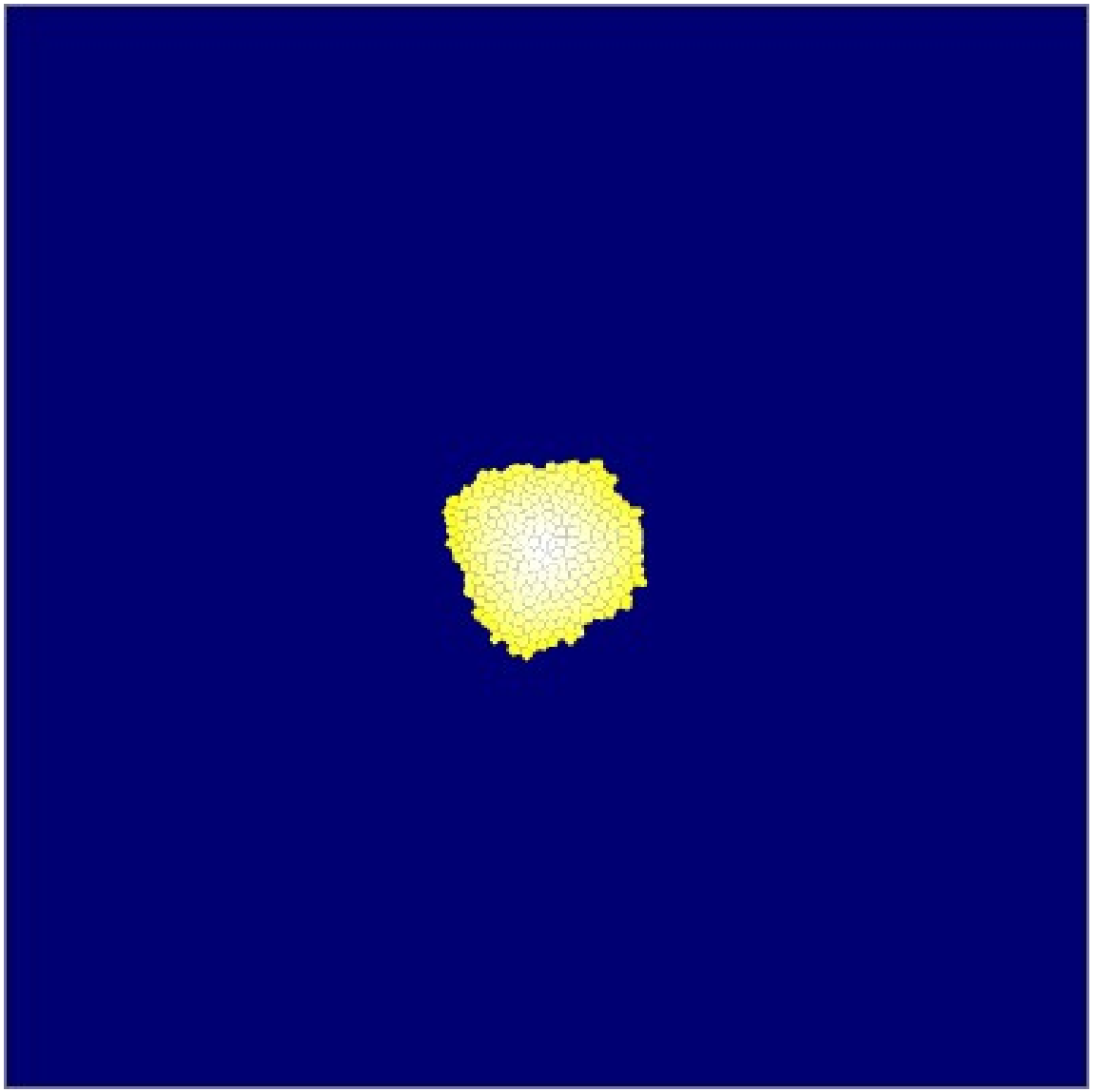

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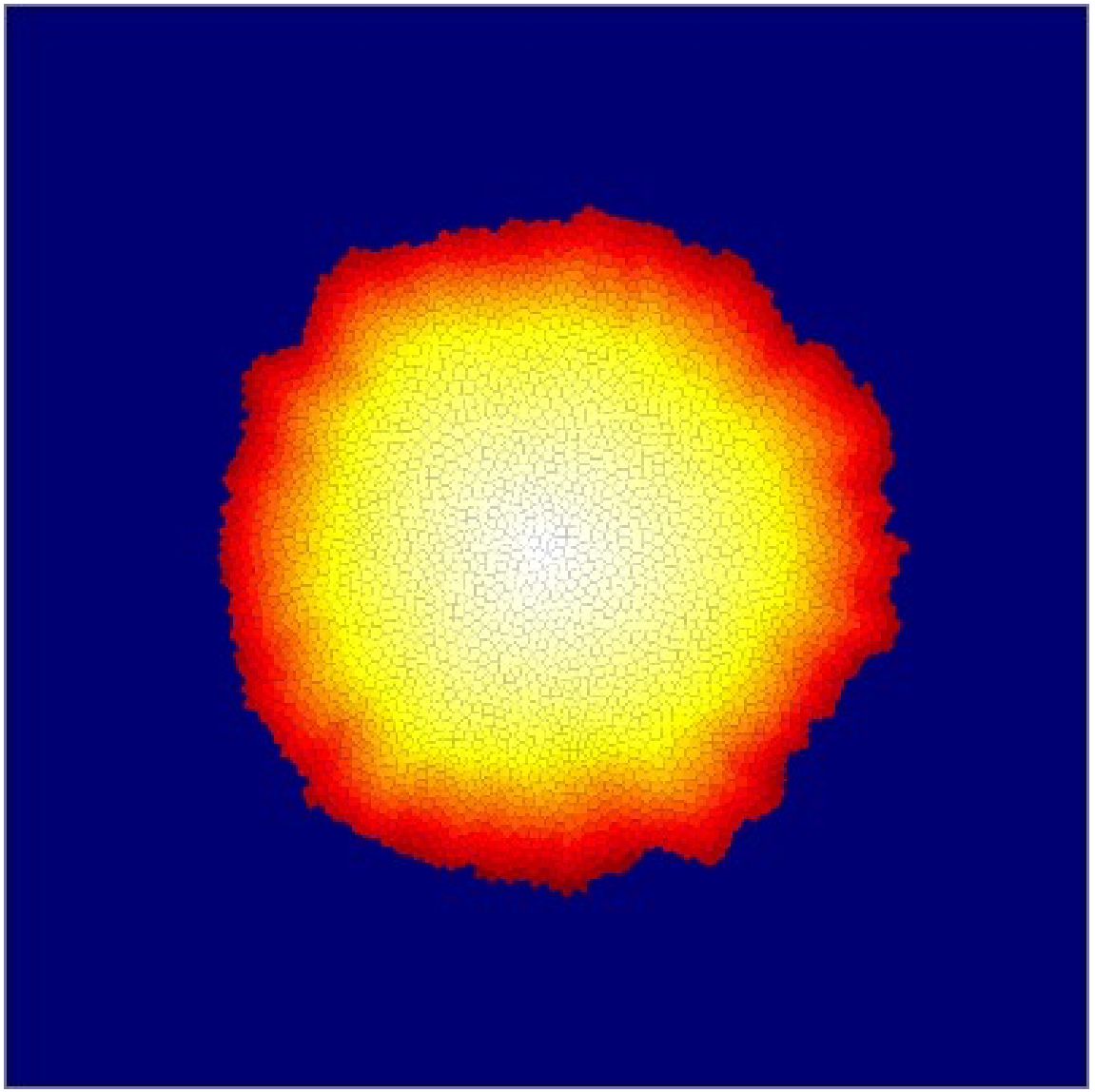

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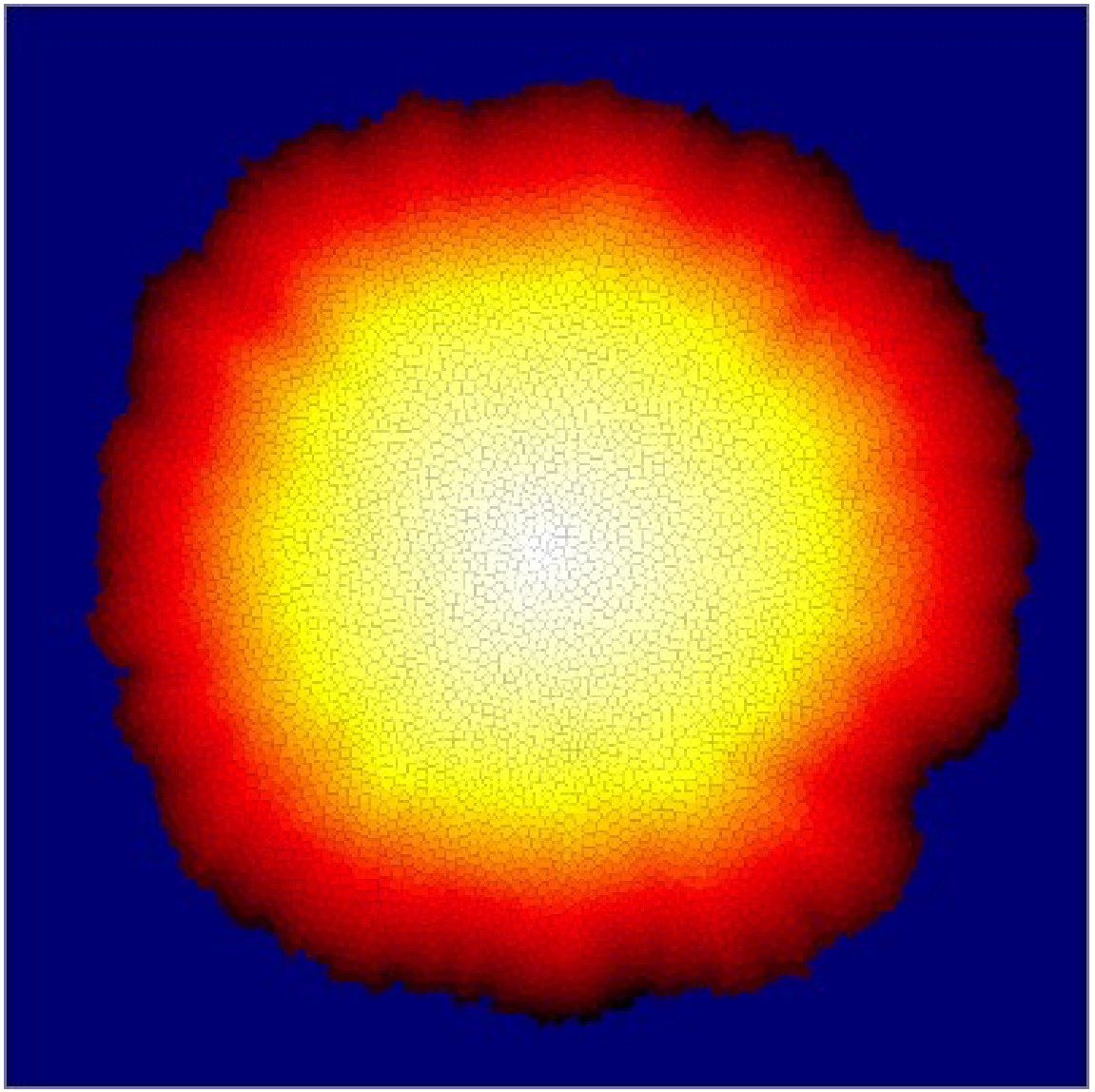

Centroidal Tessellations: conclusions

- Natural extension to ‘normal’ tessellations
- Computationally not very demanding
- Brings problems a bit better under control

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- Natural extension to ‘normal’ tessellations
- Computationally not very demanding
- Brings problems a bit better under control

But:

- Risk of reintroducing unwanted symmetries
- Does not fully solve the observed problems

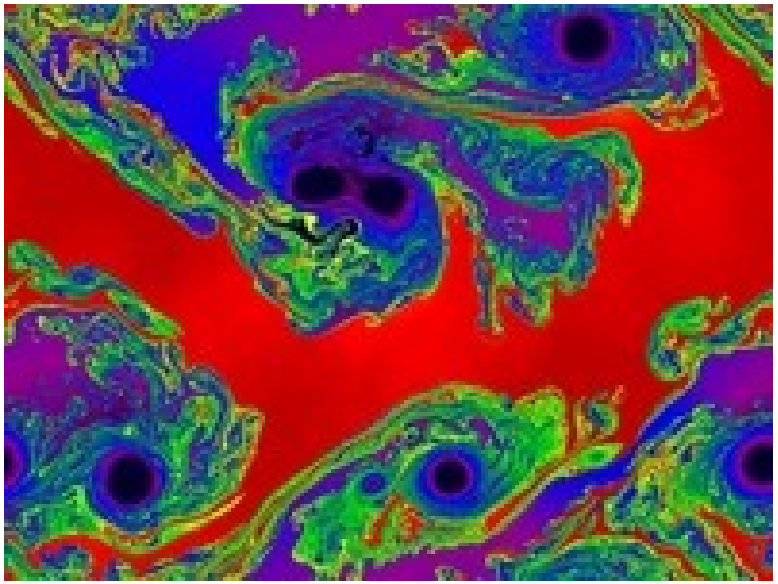
Future: can we do better?

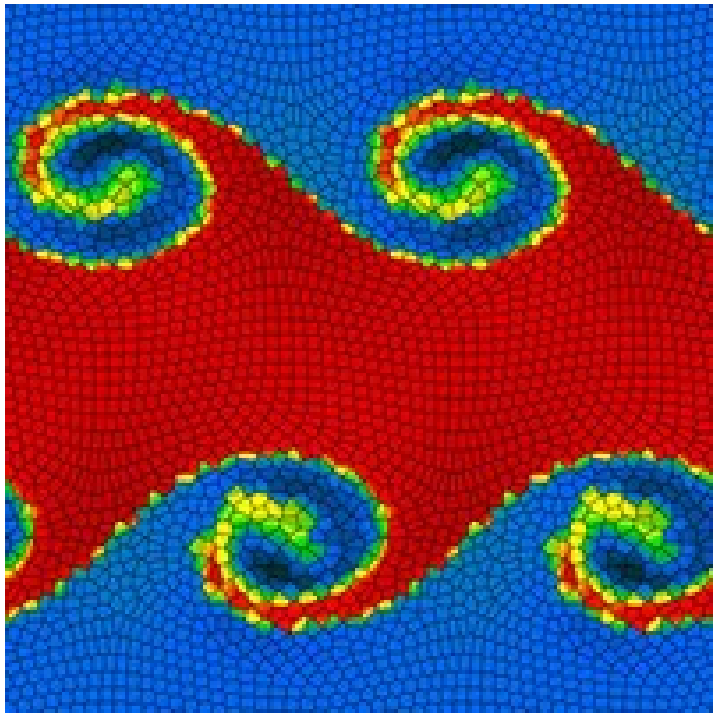
- SimpleX is an extremely easy and straight forward algorithm
- But needs some help to solve problems inherent to the method and the grid
- Especially for ballistic transport this limits or even neutralizes the natural adaptivity of the algorithm

So is there a way to take the next 'evolutionary' step in applying the naturally adaptive unstructured grids?

More and more areas of physics nowadays solve there problems fully on unstructured grids. The algebra is much more complicated, but modern programming languages and fast algorithms that deal with Delaunay tessellations make this feasible. The recent hydrocode *Arepo* by V. Springel is a perfect example of this (V. Springel, MNRAS, 401, 791)

Future: can we do better?





Next step: full radiative transfer on unstructured grids?

Questions?