How to make "ideal" thin disk of particles

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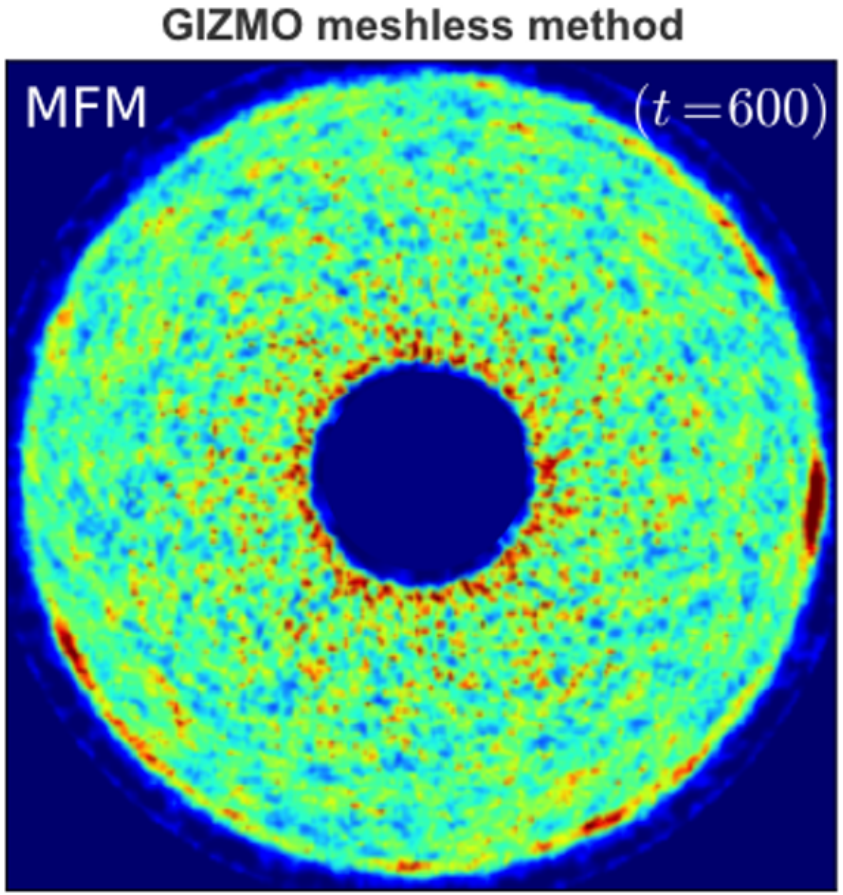
Overview

- What's the problem?
- Previous work: Cartwright et al 2009
- Limitations of C09
- Our solution
- Examples
- Non-uniform disks
- Summary

What's the problem?



- Cold disks suffer the IMAEDA problem.
- An initially uniform disk, made of particles placed in grid, develops huge density fluctuations
- Nothing to do with any real hydrodynamics. Occurs even on pure Keplerian disk.

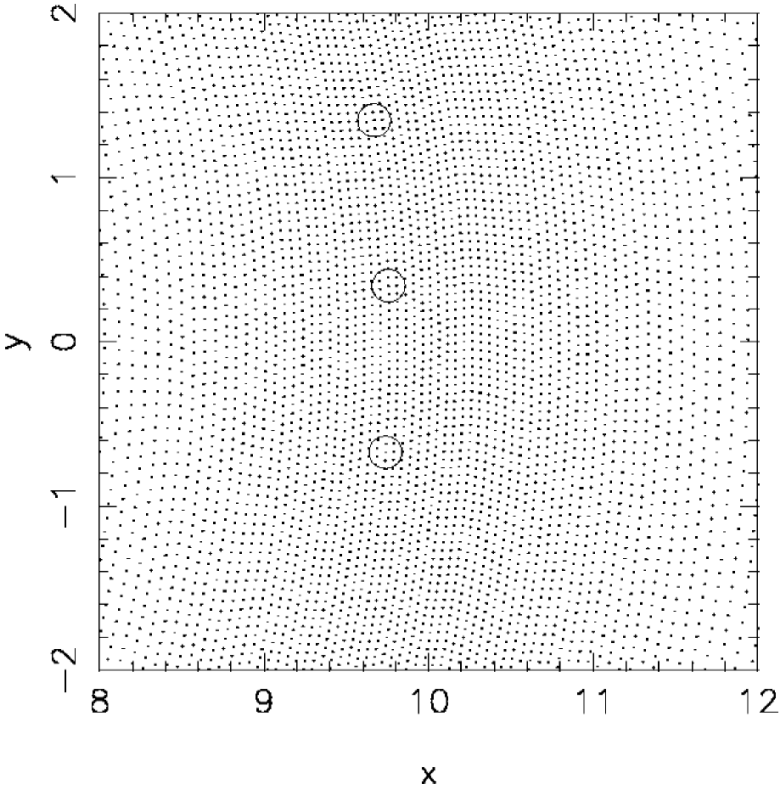
How to avoid this problem?

Simple "solution": If particles are placed on concentric rings, they would not generate fluctuations.

Question: How many particles in one ring? Any simple algorithm?

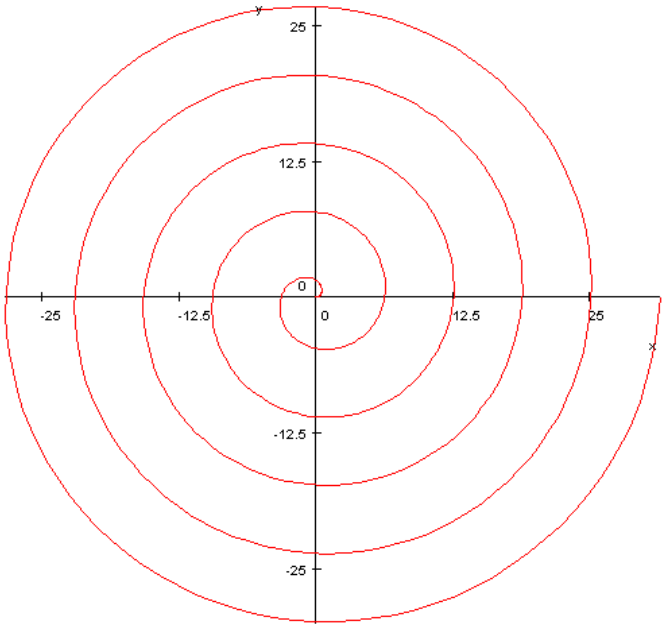
Previous work: Cartwright et al 2009

Cartwright, Stamatellos, and Whitworth 2009, MN 395, 2373



- Draw an Archimedes' spiral ($r = a\theta$)
- Place particles on equal spacing on the spiral

Limitations of C09



- Not really concentric circles, has two "ends"
- Ad-hoc correction (cut chain and move particles to a circle) discussed, but that would cause radial density fluctuations

Our solution

Original idea: Transform Cartesian grid to concentric circles in area-conserving (and topology-conserving) way

A Low Distortion Map Between Disk and Square, Shirley and Chiu, 1997.

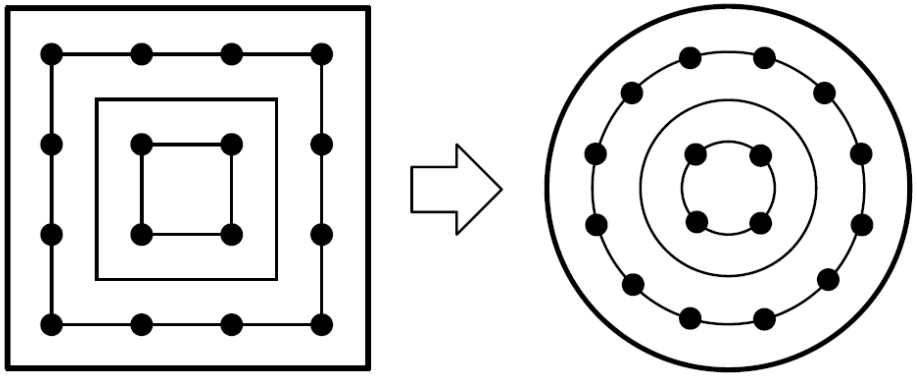
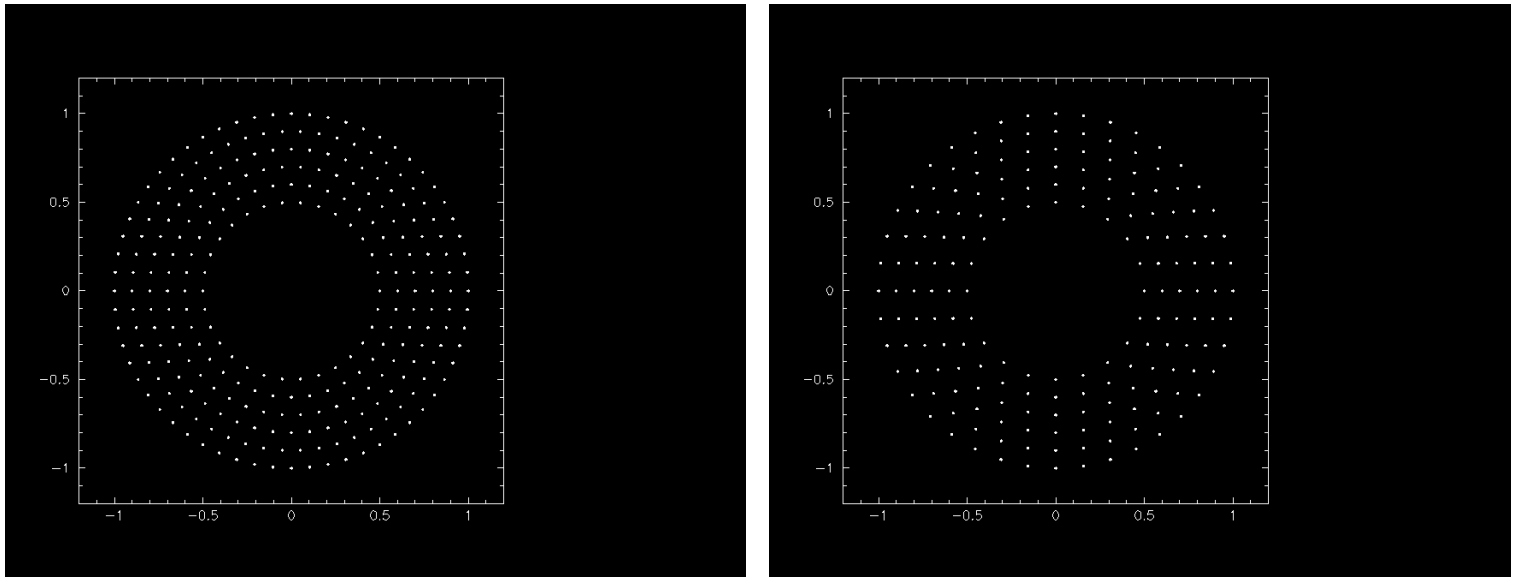


Figure 3: *The concentric map takes concentric square strips to concentric rings.*

Can be easily generalized to any regular n-gon. Hexagon seems to be the best (small distortion, near-isotropic particle distribution)

Examples



Hexagon-based one (left) looks better.

Algorithm

To form a disk of unit radius made of n concentric circles,

1. **each circle has the radius i/n $(0 < i \leq n)$.**
2. **place $6i$ particles to each of circle i.**
3. **If necessary, remove some of inner circles to define an inner edge.**

Non-uniform disks

- **Power-law disks can be generated with simple radial coordinate transformation.**

Summary

- A simple and robust way to place particles on concentric circles and achieve uniform density is proposed.
- Much simpler and more accurate than the method proposed by Cartwright et al. 2009.
- Can be used to generate power-law disks as well.