Axion Structure Formation

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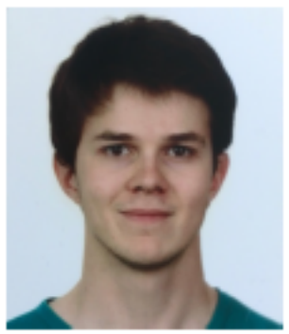
Plan Of The Talk

- GRChombo
- What is an Axion Star and why do we care?
- Axion Structure Formation
- Conclusions

GRChombo - Numerical Relativity Code with AMR

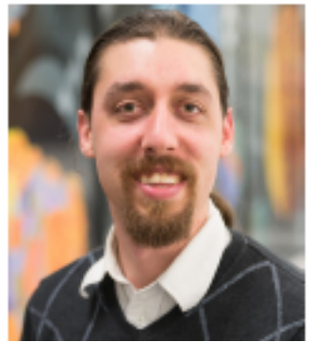








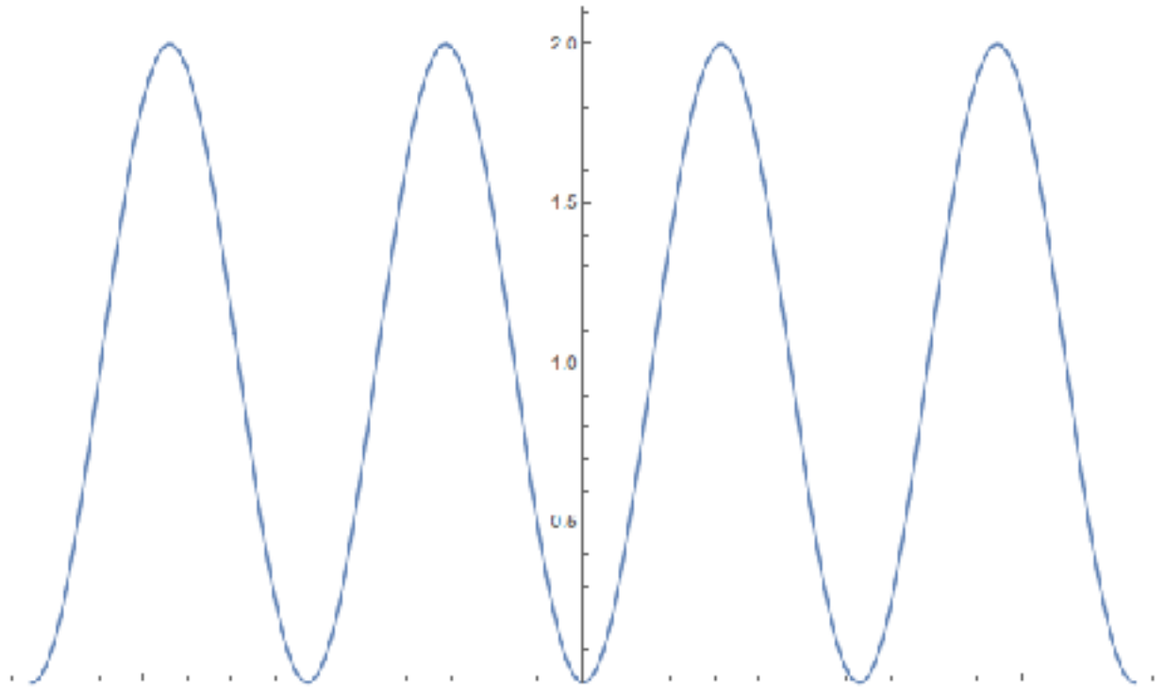



Axion Stars - What Are They?

- Dark Matter (DM) composed of Axions

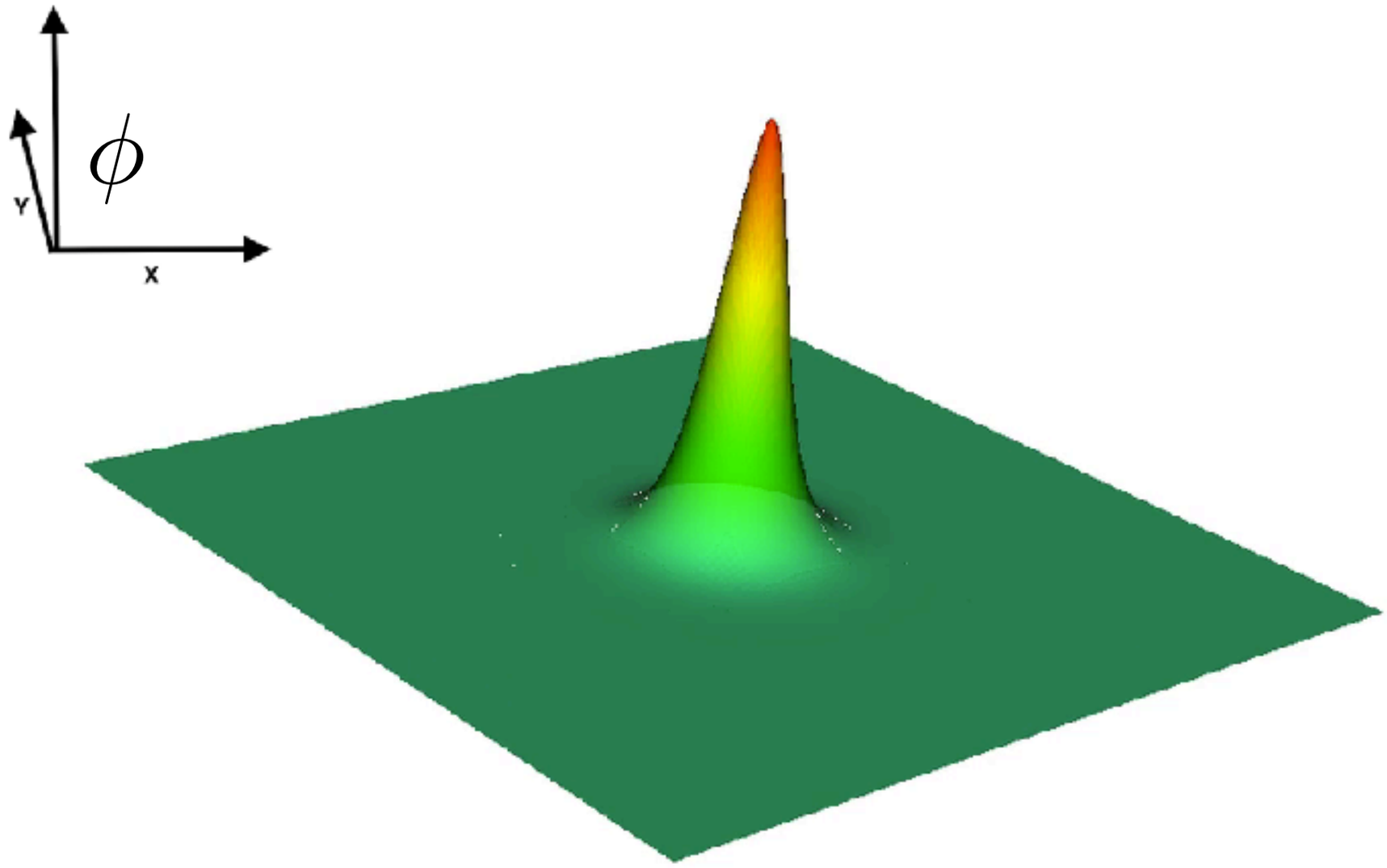
$$V(\phi) = m_a^2 f_a^2 \left(1 - cos\left(\frac{\phi}{f_a}\right)\right)$$

- Classical field undergoing coherent oscillations around a quadratic potential minimum



- Below the Jeans Scale DM perturbations are supported by gradient energy - Axion Stars

Axion Stars - What Do They Look Like?



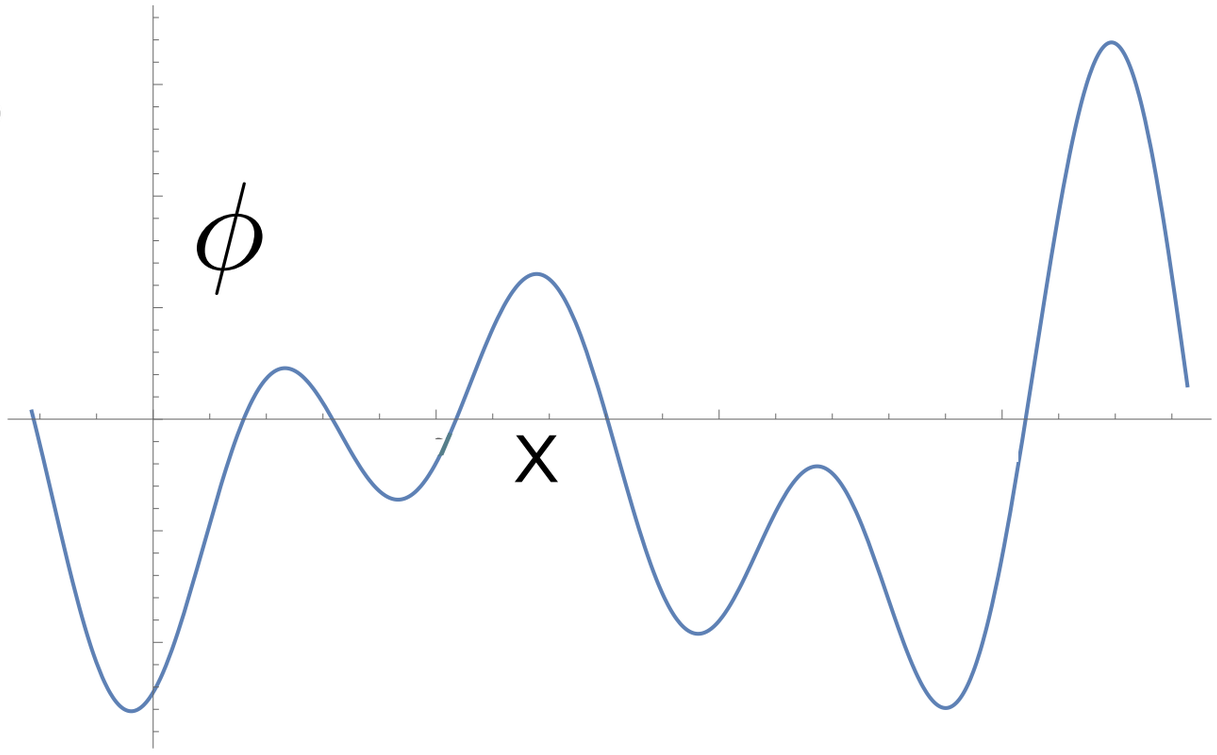
Numerical Simulation by Thomas Helfer KCL @Thomas_italy

Axion Stars - Why Do We Care?

- Expected to be the smallest dark matter structures
- Seed structure formation
- Axion stars can be the seeds of Super Massive Blackholes (SMBh)

Axion Structure Formation - Initial Conditions

- Can we form Axion Stars from ‘Random’ Initial conditions
- Numerically simulate using GRChombo
- What other structure can we form?
- How efficient is the process?



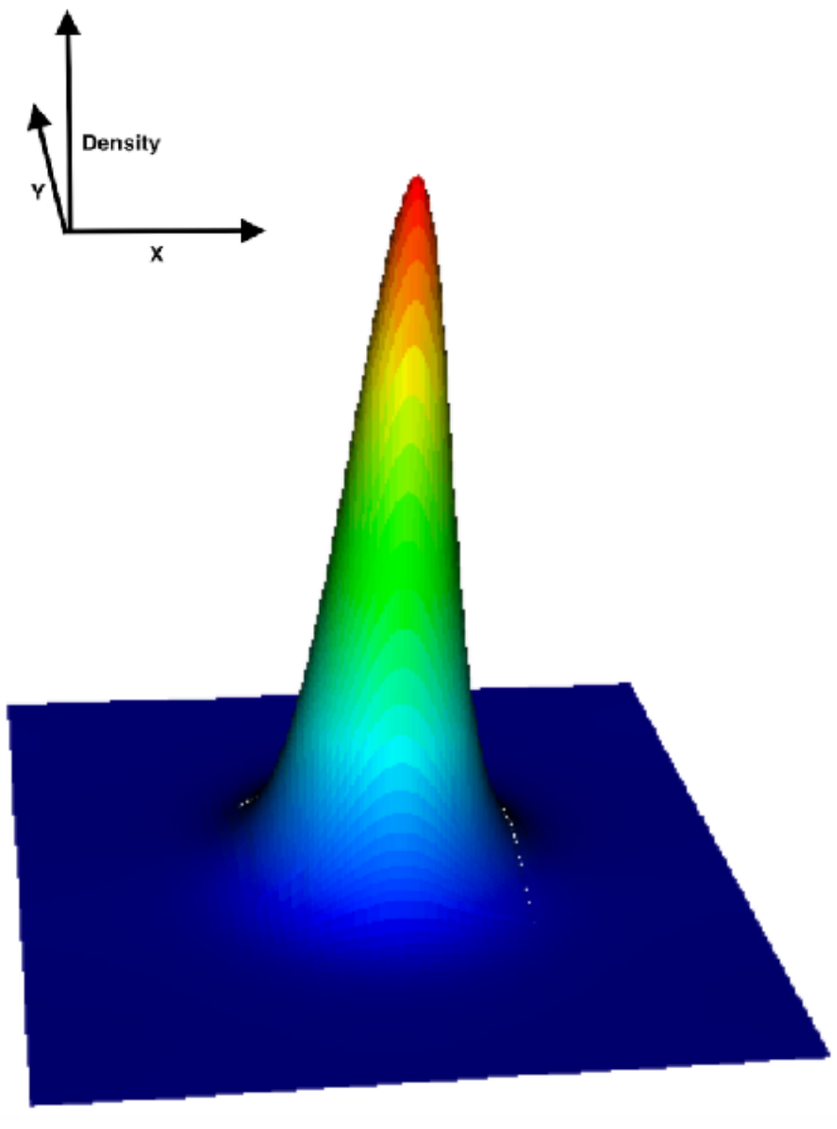
Random Initial Conditions

Axion Structure Formation - 3 Outcomes

Axion Star

$f > f_{crit}$

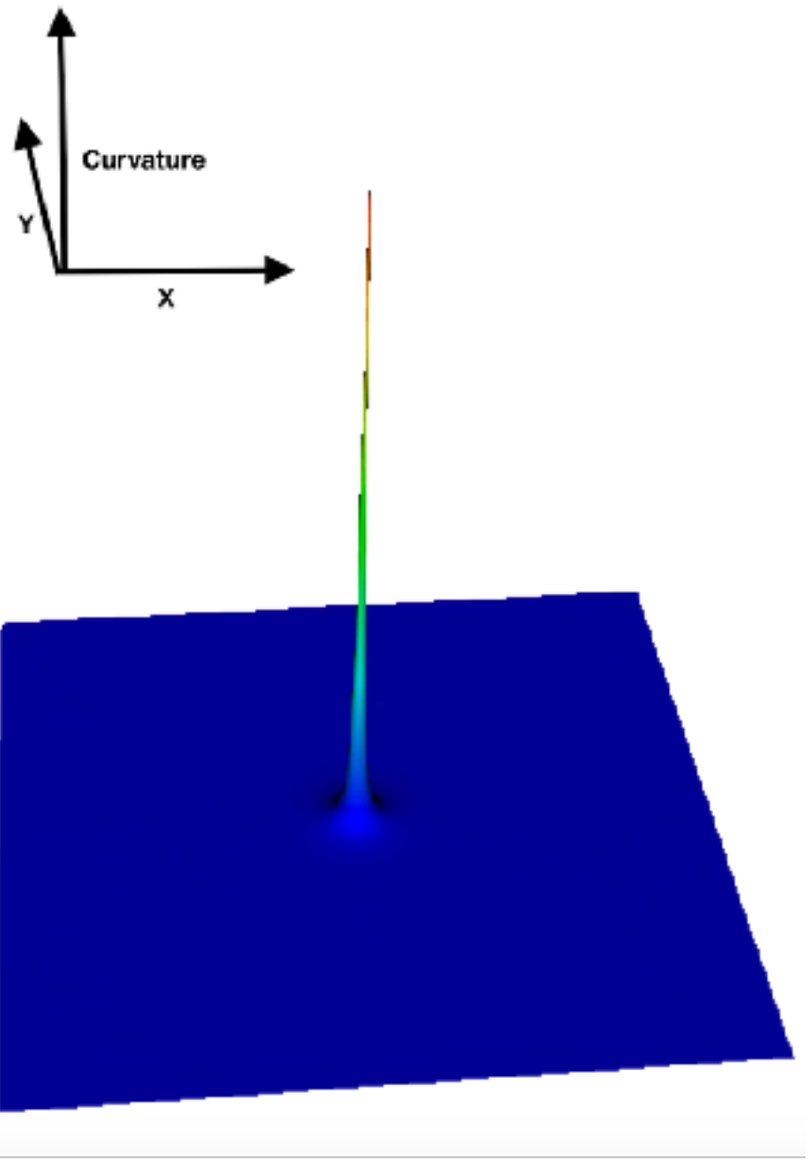
$M < M_{crit}$



Black hole

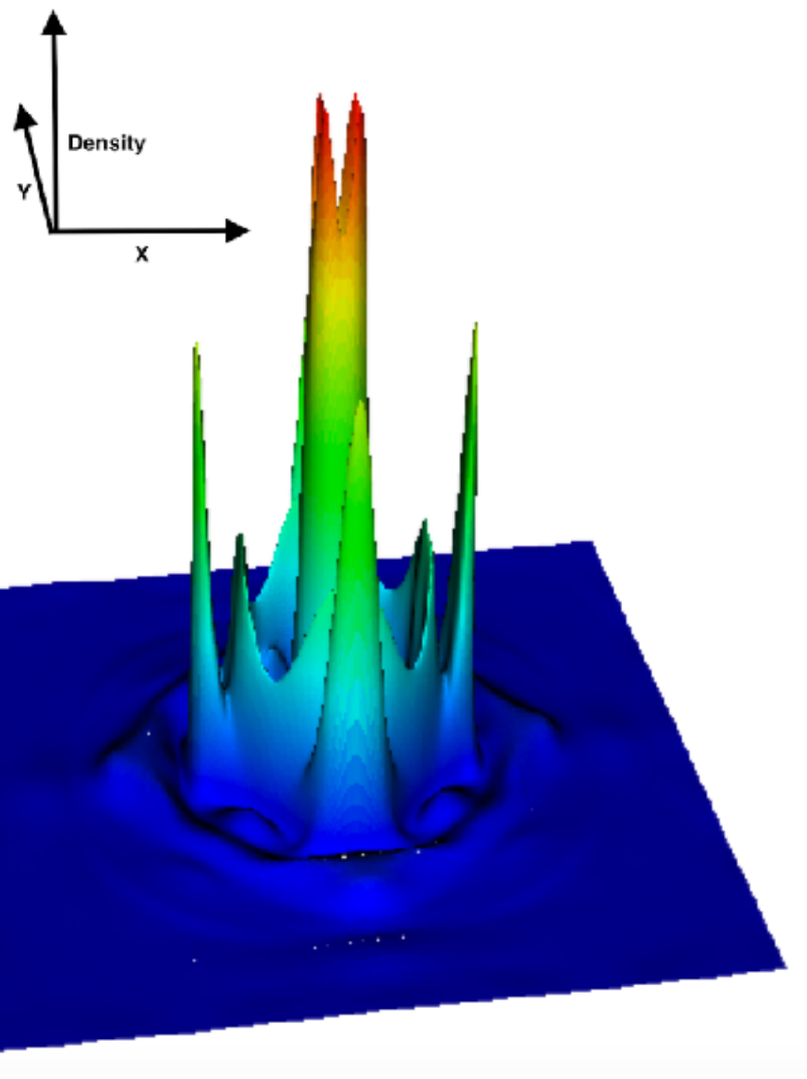
$f > f_{crit}$

$M > M_{crit}$

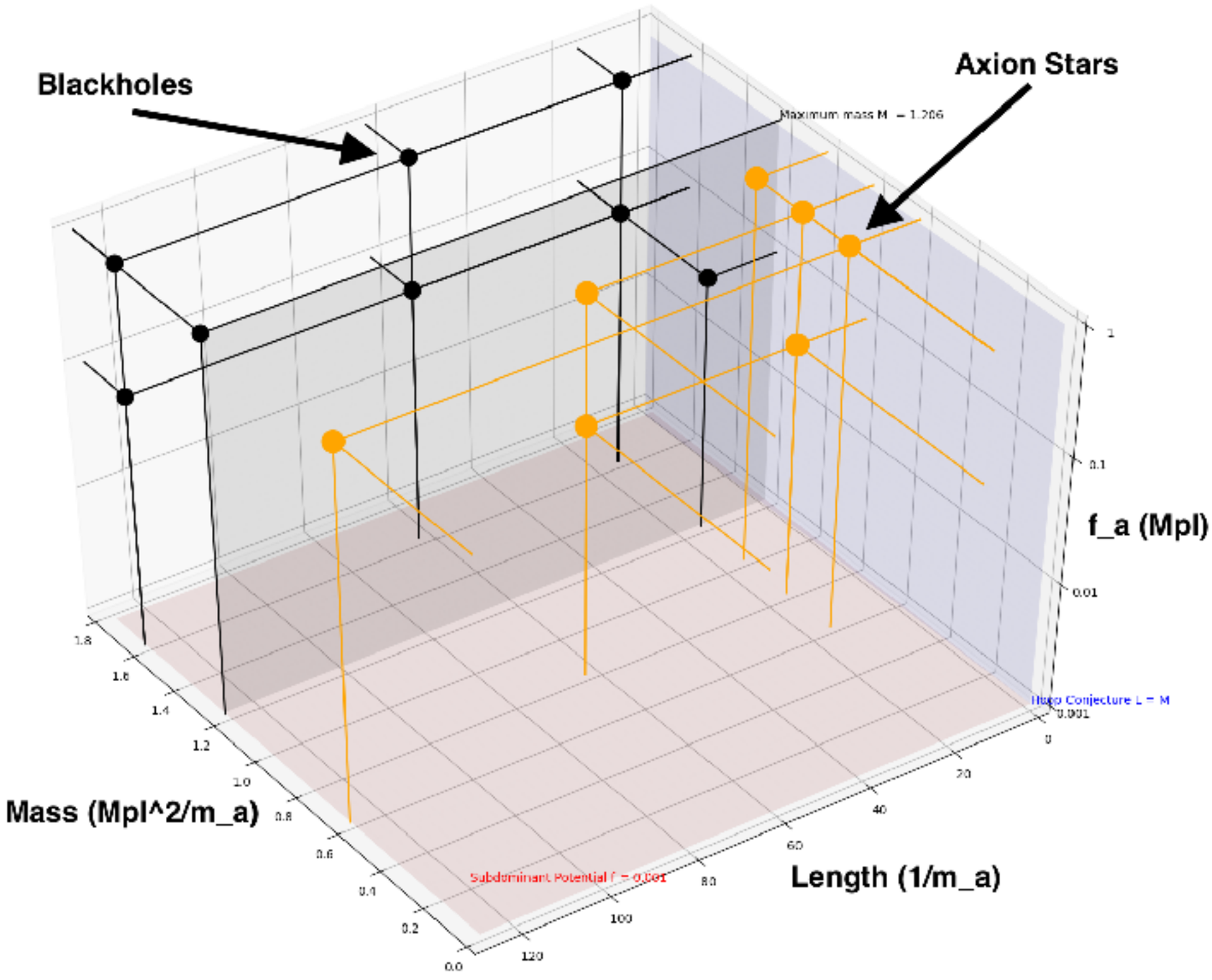


Unknown

$f < f_{crit}$



Axion Structure Formation - Provisional Results



Conclusions

- We can form Axion Stars and Blackholes
- Below a critical Symmetry Breaking Scale (f_a) simulations still in progress - do not look like Axion Stars or Blackholes
- Future - Gravitational waves from Axion Star Inspirals and Ultra Relativistic Collisions