

# Exchange-Correlation Effects in Axion Structure Formation

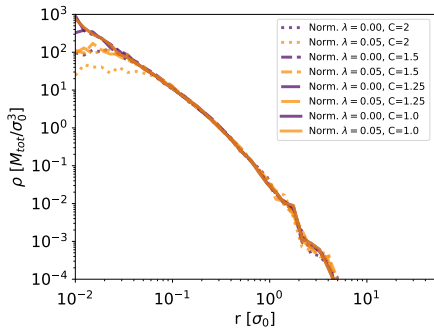
Erik W. Lentz



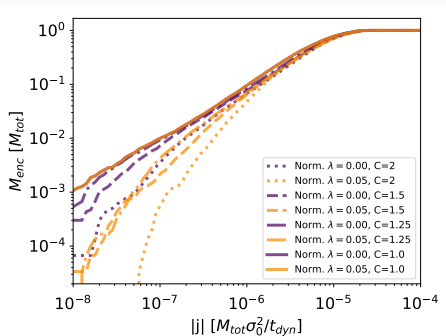
18 June, 2018

# The Take-Away

Relic axion condensates collapse differently than CDM on super-de Broglie scales due to exchange-correlation effects.



(Radial density profiles of of N-Body spherical collapse simulations.)



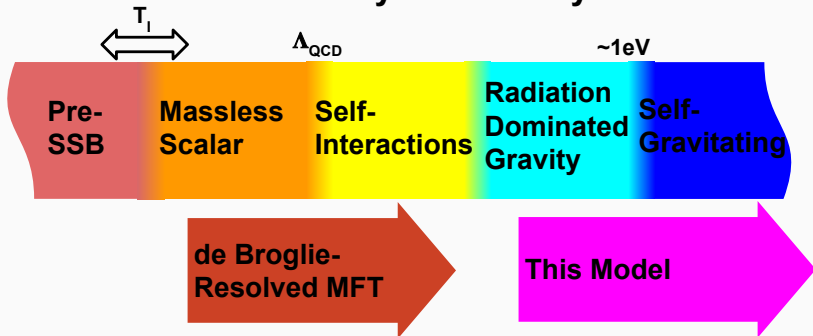
(Enclosed mass angular momentum profiles.)

Lentz, Quinn, Rosenberg (in preparation)

# Quantum Mechanical Axions

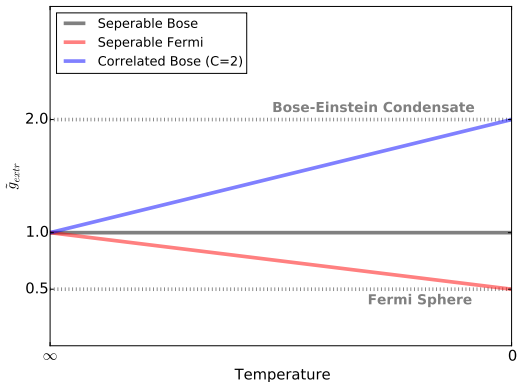
- > Self-gravity dominates during significant structure formation.
- > Quantum mechanics is a sufficient description for the relic axion fluid during this time.

## A Cosmic History of Axion Dynamics



# Exchange-Correlation of Axions

- > Inter-axion gravitation and exchange create highly-correlated condensates.
- > Super-de Broglie dynamics contain **exchange-correlation** contributions:

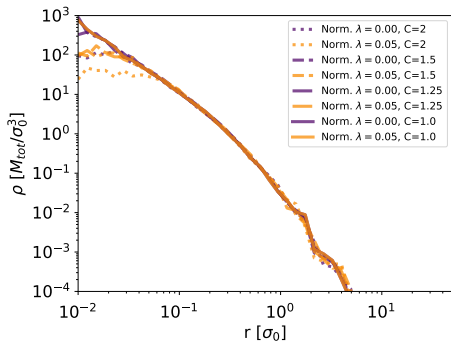


(Correlation in sample systems of identical bosons and fermions, parameterized by temperature.)  
Lentz, Quinn, Rosenberg (in preparation)

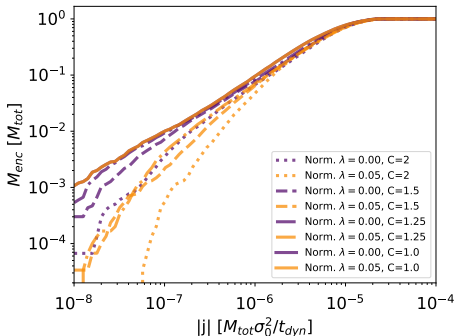
$$\partial_t f_+ + \frac{\vec{v} \cdot \vec{\nabla} f}{a^2} - \vec{\nabla} \Phi \cdot \vec{\nabla}_v f - \int d^6 w_2 \vec{\nabla} \Phi_{12} \cdot \vec{\nabla}_v \left( \frac{C - 1 - \lambda_+ f_+}{1 + \lambda_2 f_+} f \right) = O(\hbar)$$

# N-Body Bose Collapse

N-body simulations already show several unique halo structures.



(Radial density profiles of of N-Body spherical collapse simulations.)



(Enclosed mass angular momentum profiles.)

Lentz, Quinn, Rosenberg (in preparation)

## Summary

Exchange-correlation has a significant impact on structure formation in highly-degenerate and correlated fluids such as axion dark matter.

Visit my poster to see and hear more.

# Acknowledgements

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