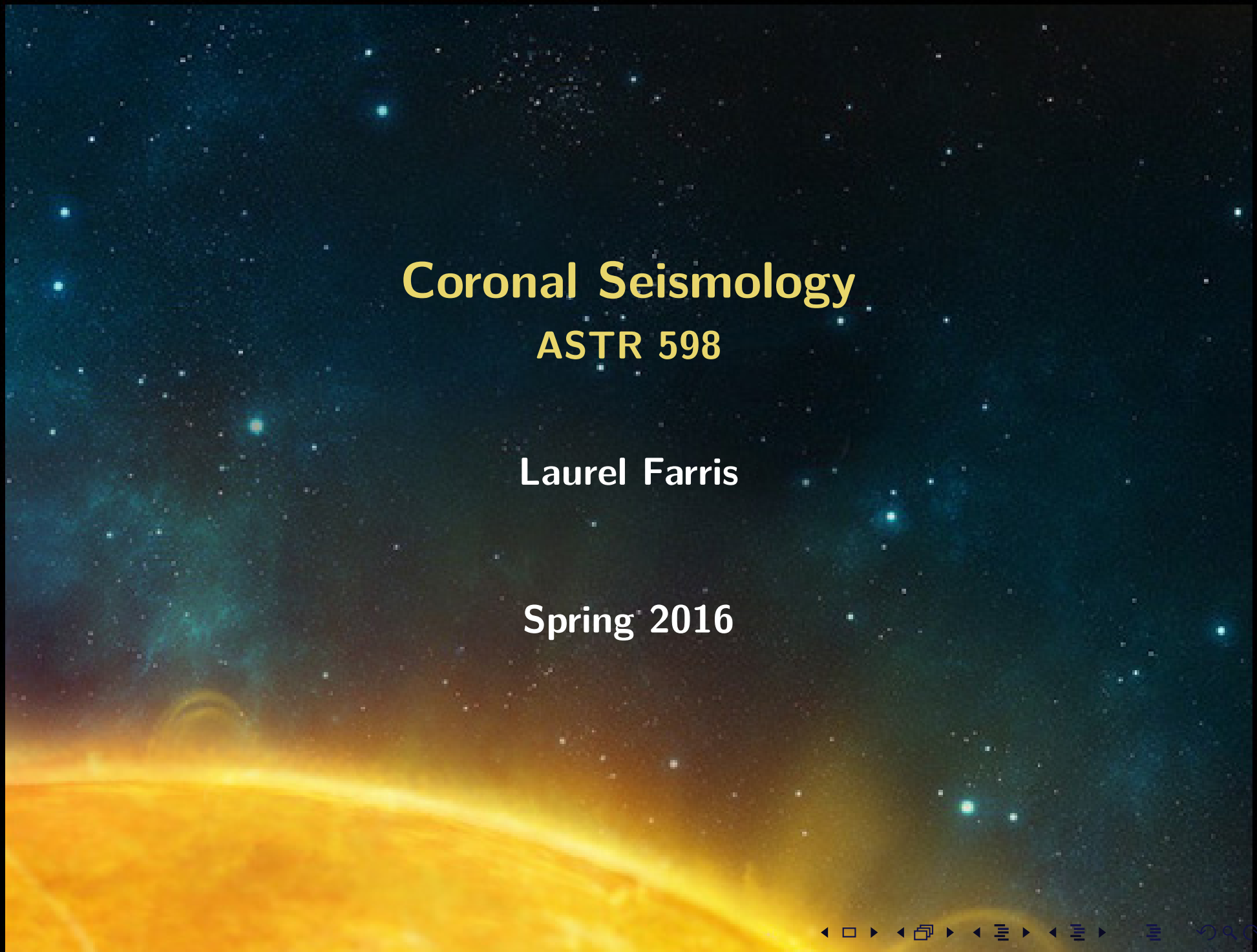


Coronal Seismology

ASTR 598

Laurel Farris

Spring 2016

Coronal seismology

Technique and motivation

Motivation:

- Coronal heating problem
- Constraining flare/CME environment

Problem: properties of the corona, such as magnetic field strength, densities, and Alfvén velocities, are difficult to measure.

Solution: coronal seismology.

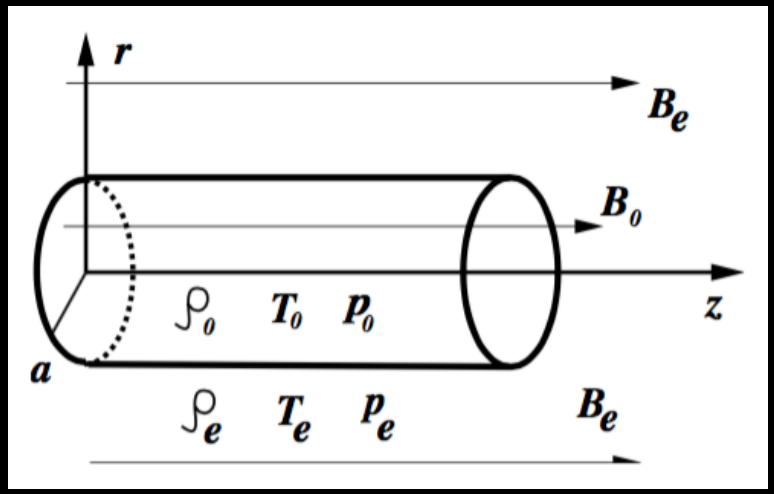
- Observe disturbances in the corona, and measure:
  - Period
  - Velocity
  - Timescales
- Compare observed quantities to MHD theory to identify the type of wave or mode.
- Insert observed properties into appropriate equations to derive coronal parameters.

Current questions:

- How are these disturbances initiated?
- How are they damped, and what determines the timescales?

Magnetohydrodynamics (MHD)

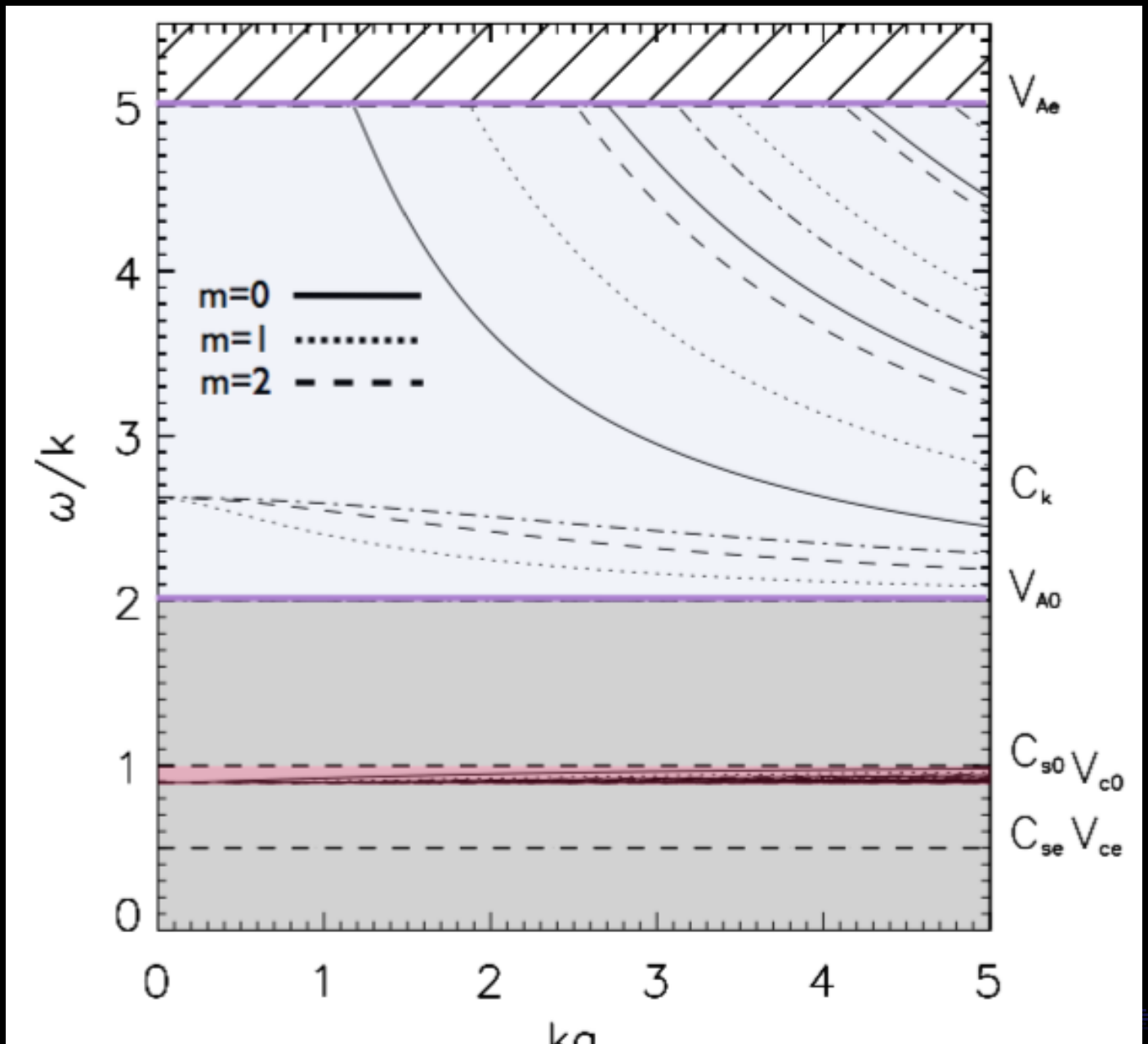
Theory



- Corona should support MHD oscillations
- Loop modeled by straight flux tube in uniform magnetic field.
- Characteristic speeds are determined by the environment
- Density, temperature inside loop different from outside loop
- Non-ideal effects: gravitational stratification, loop curvature, inhomogeneity in magnetic field strength (considered negligible).

Dispersion diagram

Solutions to dispersion relation



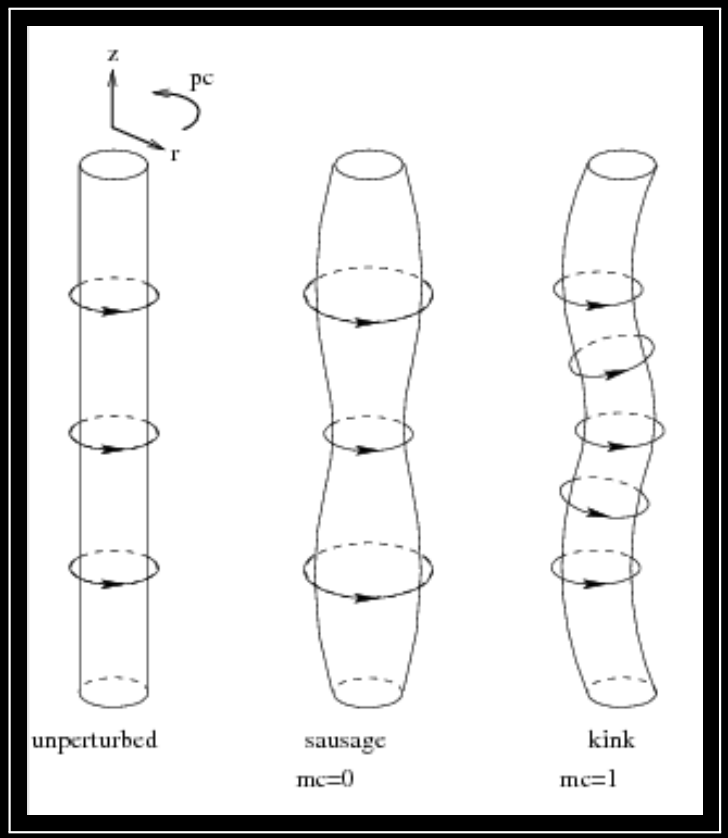
Magnetohydrodynamics (MHD)

Two mode categories

1. Magnetoacoustic $C_s = \sqrt{\frac{\gamma P}{\rho}}$
   - Fast $k_{A_0} < C_{fast} < C_{A_e}$
   - Slow $C_{T_0} < C_{slow} < C_{s_0}$
2. Alfvén $V_A = \frac{B}{\mu_0 \rho}$

Fast standing oscillations

Kinks vs. Sausages



Kink

- loop spatial displacement
- Asymmetric
- No intensity change
- $k\sigma \ll 1$, or $\sigma \ll \lambda$

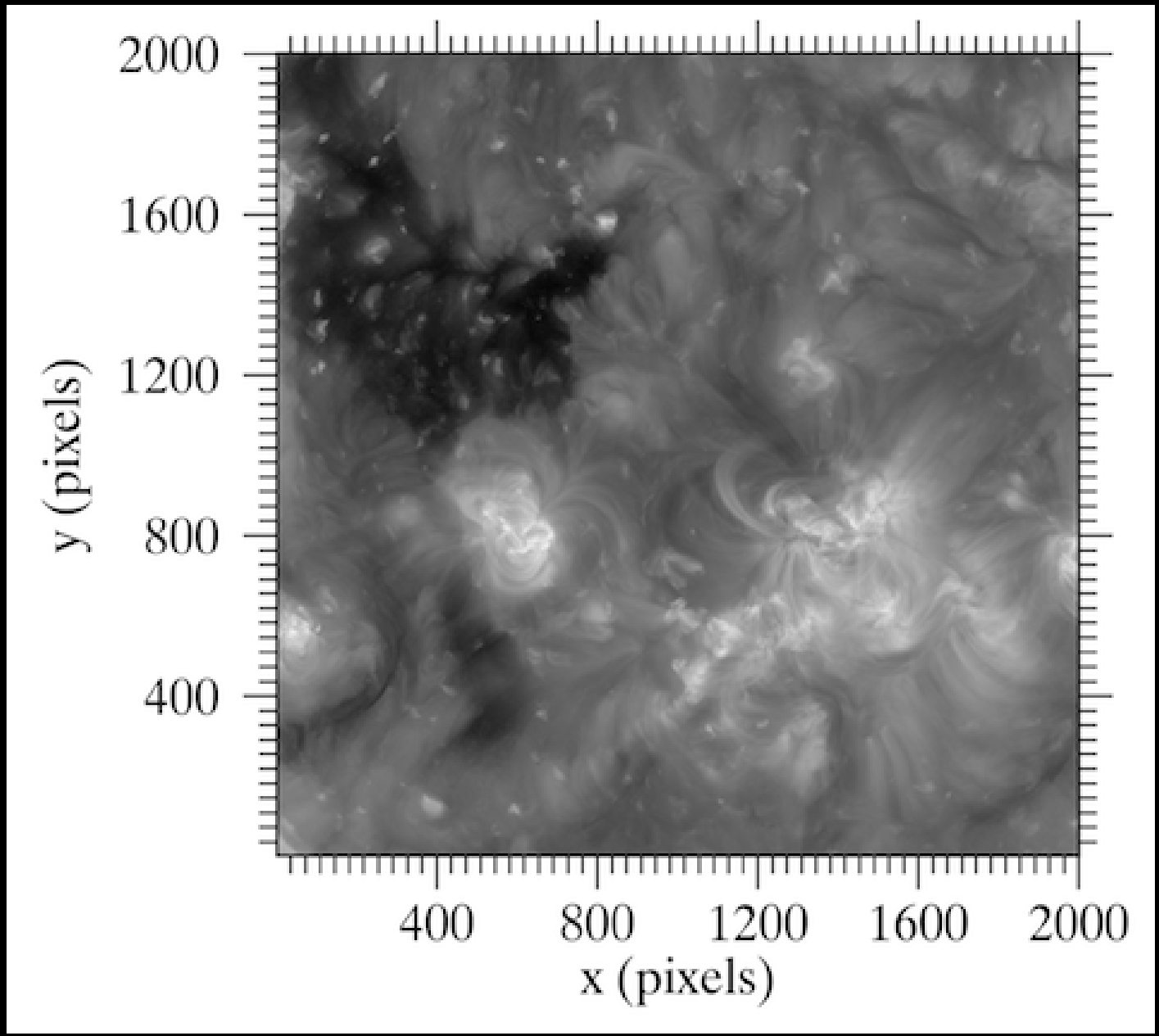
Sausage

- No loop spatial displacement
- Symmetric
- Intensity change
  $\rightarrow$ density change
- $\lambda \sim \sigma$
- long-wavelength limit

Important Properties

	period	**wavelength**	**velocity**
kink osc	value	value	value
sausage osc	value	value	value
acoustic osc	value	value	value
acoustic waves	value	value	value
fast waves	value	value	value
torsional modes	10 m	value	1000 km s^{-1}

Research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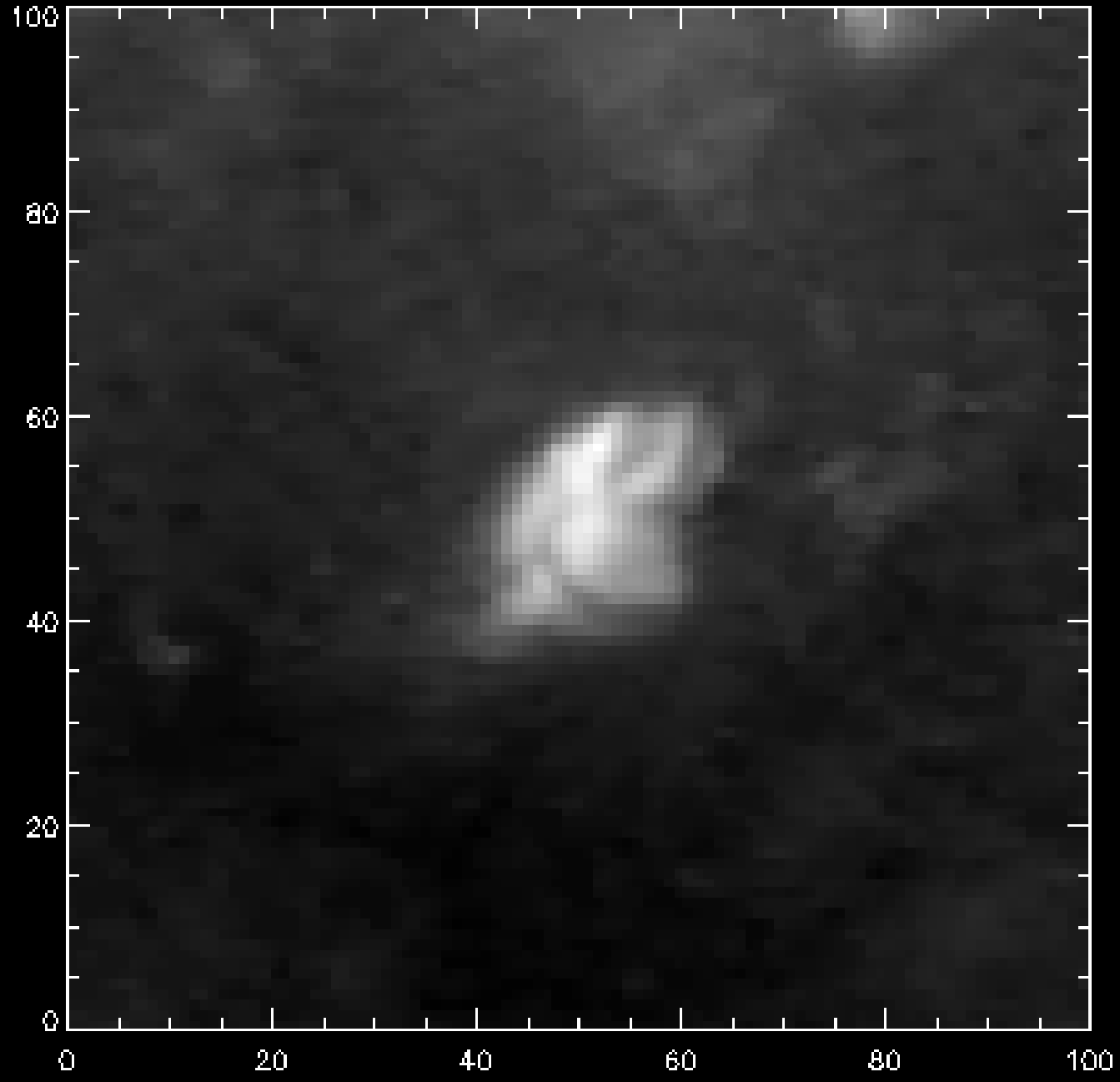
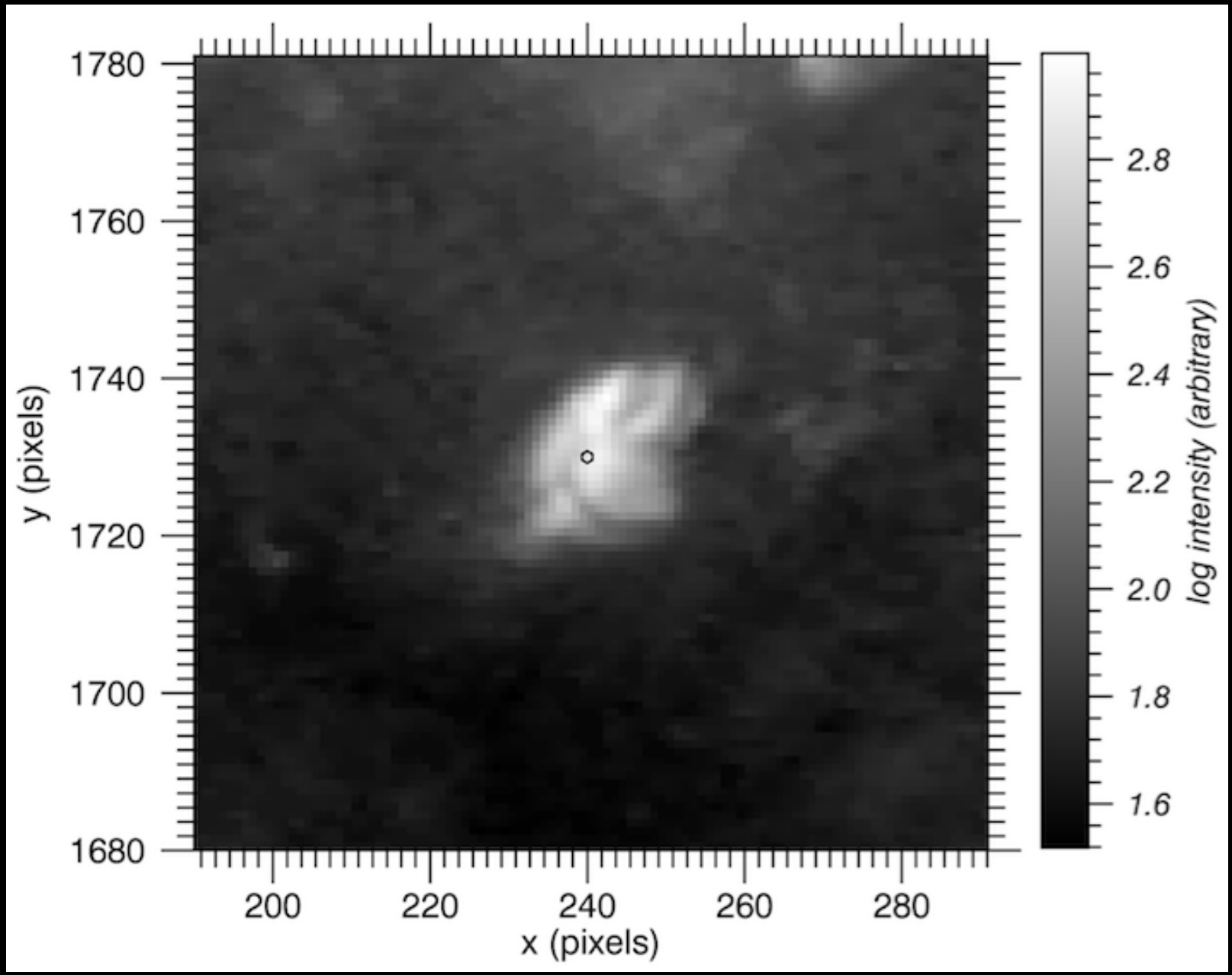
1600
1200
800
400
y (pixels)
400
800
1200
1600
2000
x (pixels)

Research



Research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1760
1740
1720
1700
1680
y (pixels)
200
220
240
260
280
x (pixels)
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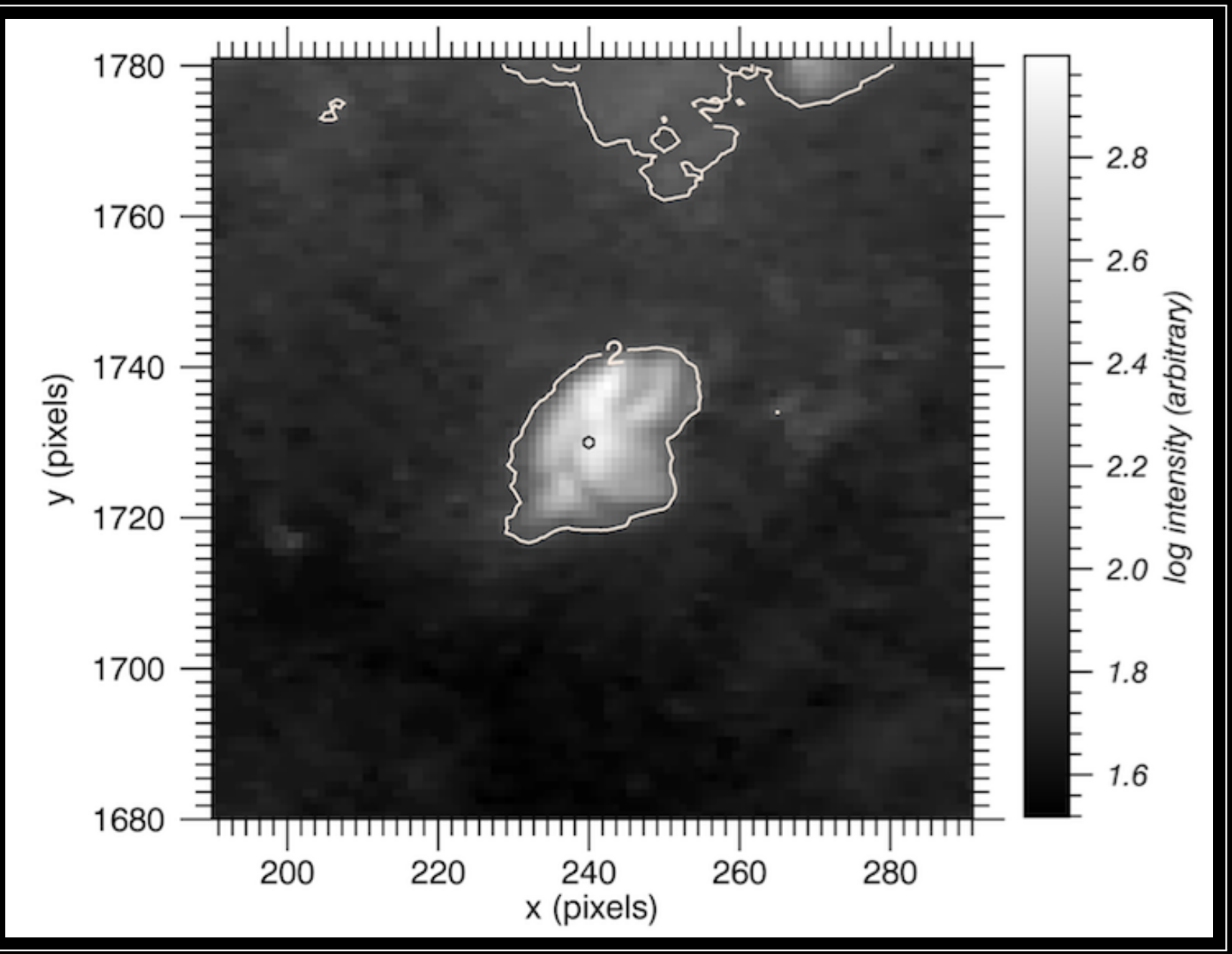
2.6
2.4
2.2
2.0
1.8
1.6
log intensity (arbitrary)

Research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y (pixels)
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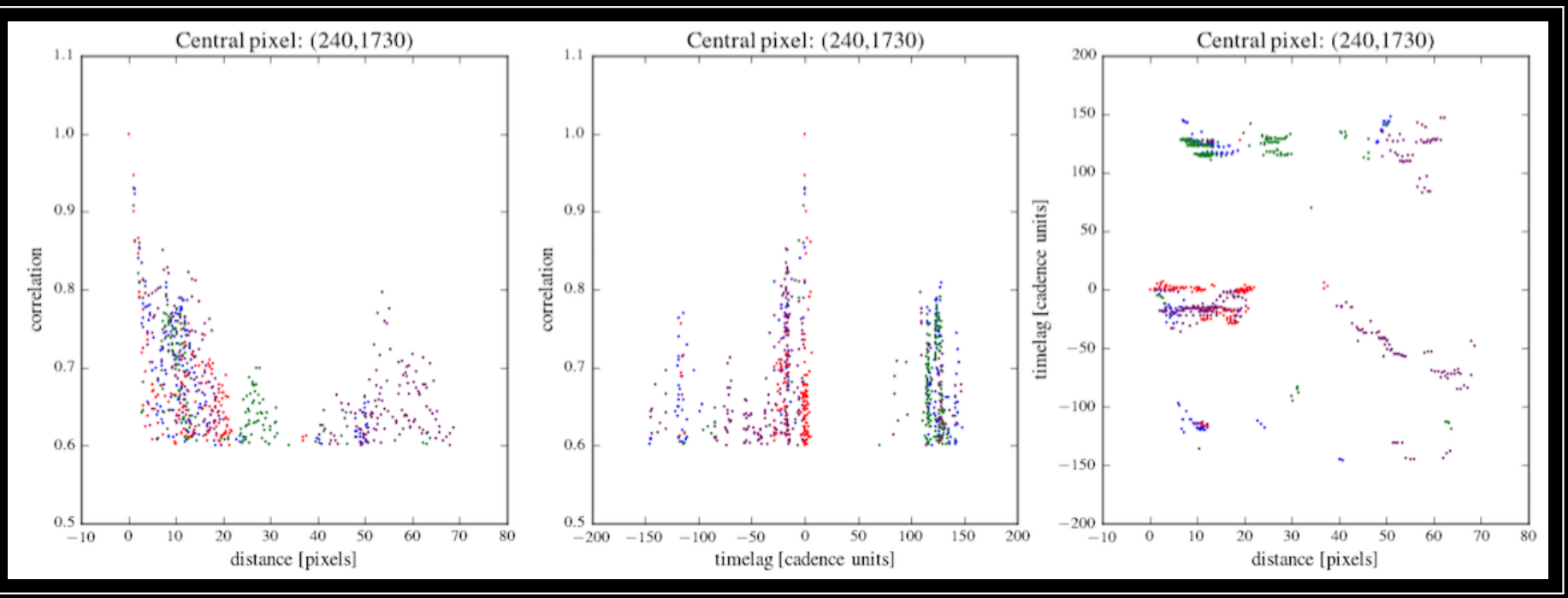
1.8
1.6
log intensity (arbitrary)

Research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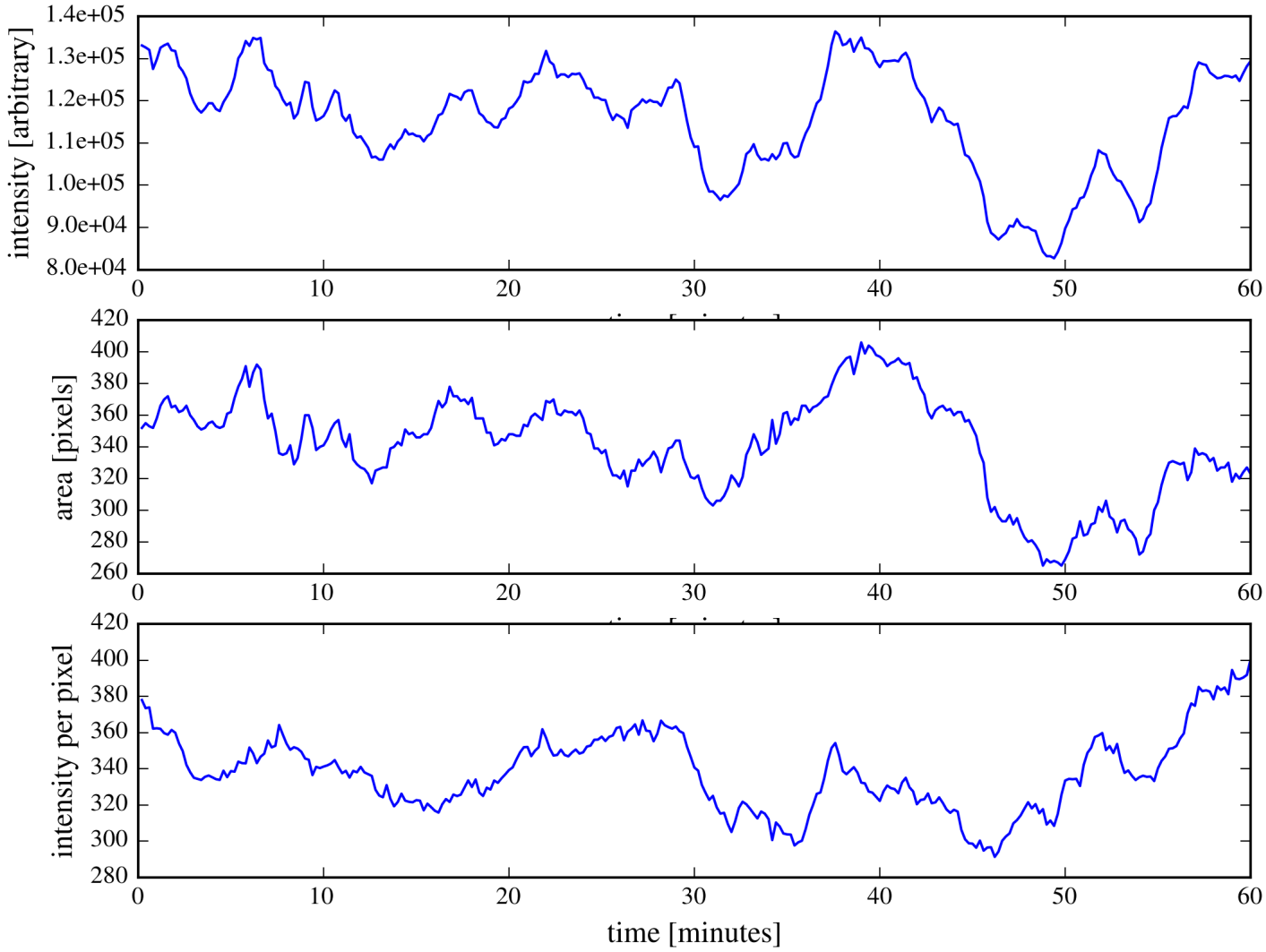
correlation
distance [pixels]
Central pixel: (240,1730)
correlation
timelag [cadence units]
Central pixel: (240,1730)
timelag [cadence units]
distance [pixels]

Research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1.3e+05
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1.1e+05
1.0e+05
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8.0e+04
area [pixels]
420
400
380
360
340
320
300
280
intensity per pixel
420
400
380
360
340
320
300
280
0
10
20
30
40
50
60
time [minutes]

Acknowledgements