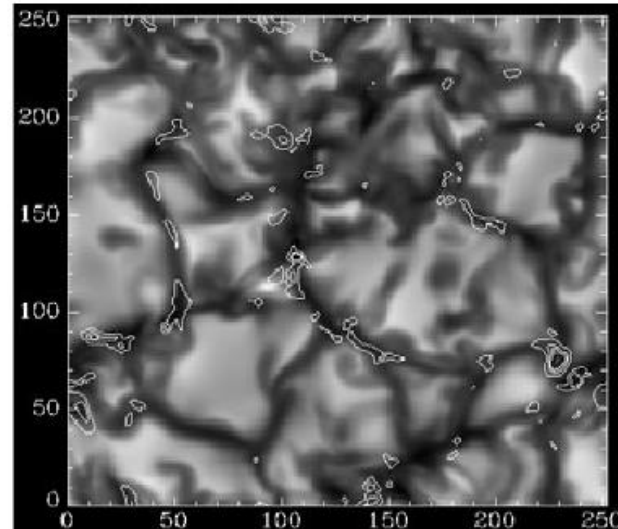
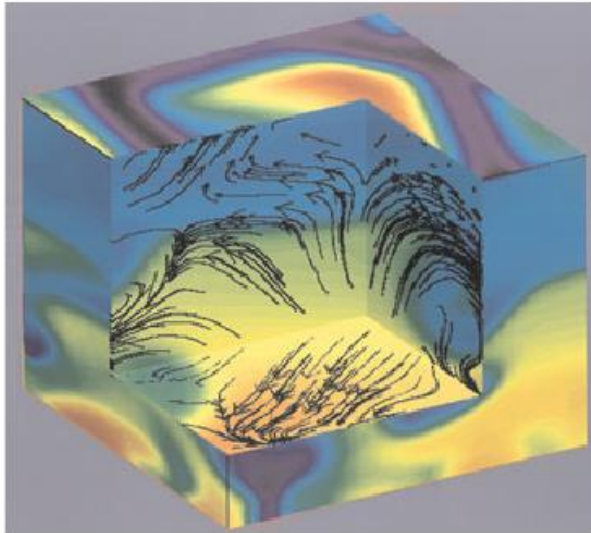


Lecture 15

- Talk about homework 3
- Convection, granulation (Stix pp. 237)



Homework 3

Choose a recent article (see list of sites and examples below) that interests you, then write a brief report that **describes the science upon which it is based**. Some key questions that you may like to consider include:

- Is the journalist leaving out any important information?
- Is the science reported faithfully or is it misrepresented?
- If the article includes "everyday-world" analogies or similes, are they misleading?
- If the science includes observations, does the article describe *how, when & where* the observations were made?
- Does the article convey a sense of *why* these results are important?

Your report should be about 1000 words in length, which is roughly 4 double-spaced pages. It can also include images or equations, but those don't count toward the 1000 word total. Please also include a **full copy of the news story** (with URL) that you chose to analyze. You can submit the whole thing -- your report and the story it's based on -- either electronically (PDF preferred; see main course page for my email address) or on paper.

Your grade will be based on how well you convey your understanding of the topic (i.e., expressing what you have learned in your own words) and how you link the material to the topics that we're covering in class. Spelling and proper grammar will also be taken into account, since the ability to communicate your thoughts clearly in writing is a key skill to develop.

Science media news sites:

On the following sites, it will be helpful to search for keywords like "Sun", "solar flare", "solar wind", "plasma", "magnetosphere", or "aurora":

- science.nasa.gov/science-news/
- space.com/news
- sciencemag.org/category/space

Check details

Mind boggling as that number is, this tremendous energy output cannot explain how material that is spit out by these explosions gets ramped up to [nearly the speed of light](#). It's like expecting a golf cart motor to power a Ferrari.

Bin Chen, a researcher at the Harvard-Smithsonian Center for Astrophysics is the lead author on a new research paper that provides the first solid observational evidence that ultraspeedy particles released during a solar eruption are accelerated by a kind of stationary shock wave called a "termination shock."

Chen and his coauthors saw evidence of this termination shock during a solar flare on March 3, 2012, using the [Karl G. Jansky Very Large Array](#) (VLA) in New Mexico. The recently upgraded telescope was beneficial for two reasons. First, it detects radio waves, which means it isn't overwhelmed by the brightest flashes of light emitted during a solar flare. But looking at a solar flare radio frequencies does reveal the particles accelerated by the termination shock.

Verify with ADS

[SAO/NASA ADS](#) Astronomy Query Form for Axel Brandenburg

[Sitemap](#) [What's New](#) [Feedback](#) [Basic Search](#) [Preferences](#) [FAQ](#) [HELP](#)

Looking for an easy on the eyes UI? Try [ADS Bumblebee](#) !

Databases to query: [Astronomy](#) [Physics](#) [arXiv e-prints](#)

[Authors](#): (Last, First M, one per line) [SIMBAD](#) [NED](#) [ADS Objects](#)

[Exact name matching](#)

[Object name/position search](#)

Require author for selection

Require object for selection

(OR AND [simple logic](#))

(Combine with: OR AND)

Publication Date between

(MM) (YYYY)

(MM) (YYYY)

(MM) (YYYY)

- [Full Refereed Journal Article \(PDF/Postscript\)](#)
- [arXiv e-print](#) (arXiv:1512.02237)
- [References in the article](#)

arXiv version easier?

| # | Bibcode Authors | Score Date Title | List of Links Access Control Help |
|---|--|---|---|
| 1 | <input type="checkbox"/> 2015Sci...350.1238C Chen, Bin; Bastian, Timothy S.; Shen, Chengcai; Gary, Dale E.; Krucker, Säm; Glesener, Lindsay | 1.000 12/2015 Particle acceleration by a solar flare termination shock | A E F X R U |
| 2 | <input type="checkbox"/> 2015PhRvD..92I6002C Chen, Bin; Wu, Jie-qiang | 1.000 12/2015 Large interval limit of Rényi entropy at high temperature | A E X R C U |
| 3 | <input type="checkbox"/> 2015JHEP...12..109C Chen, Bin; Wu, Jie-qiang | 1.000 12/2015 1-loop partition function in AdS ₃ /CFT ₂ | A E X R C U |
| 4 | <input type="checkbox"/> 2015arXiv151208400C Chen, Bin; Wu, Jie | 1.000 12/2015 Non-vanishing and sign changes of Hecke eigenvalues for half-integral weight cusp forms | A X R C U |

Try to understand
at least one
details from one
caption

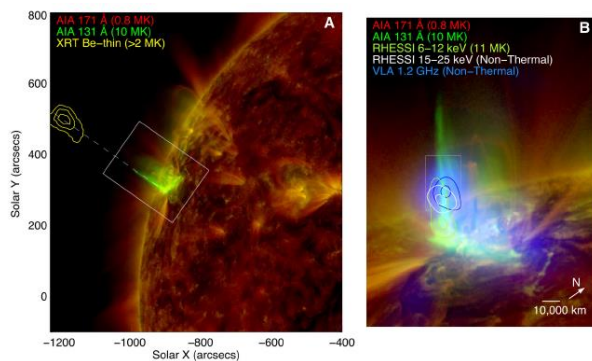


Fig. 1. Solar flare seen in multiple wavelengths (A) The eruptive flare observed in EUV and X-ray wavelengths by the Atmospheric Imaging Assembly 171 Å (red), X-Ray Telescope (XRT; aboard Hinode) Be-thin (yellow contours, showing the eruption), and AIA 131 Å (green, showing the newly-reconnected flare loops) passbands, which are respectively sensitive to plasma temperatures of 0.8 MK, >2 MK, and 10 MK. (B) Closer view of the flaring region (box in A, rotated clockwise to an upright orientation). A radio source (blue, at 1.2 GHz) is observed at the top of hot flaring loops (~10 MK), which is nearly copatial with a non-thermal HXR source (white contours, at 15–25 keV) seen by the Reuven Ramaty High Energy Solar Spectroscopic Imager (RHESSI).

...one detail that
relates to the title
of the paper

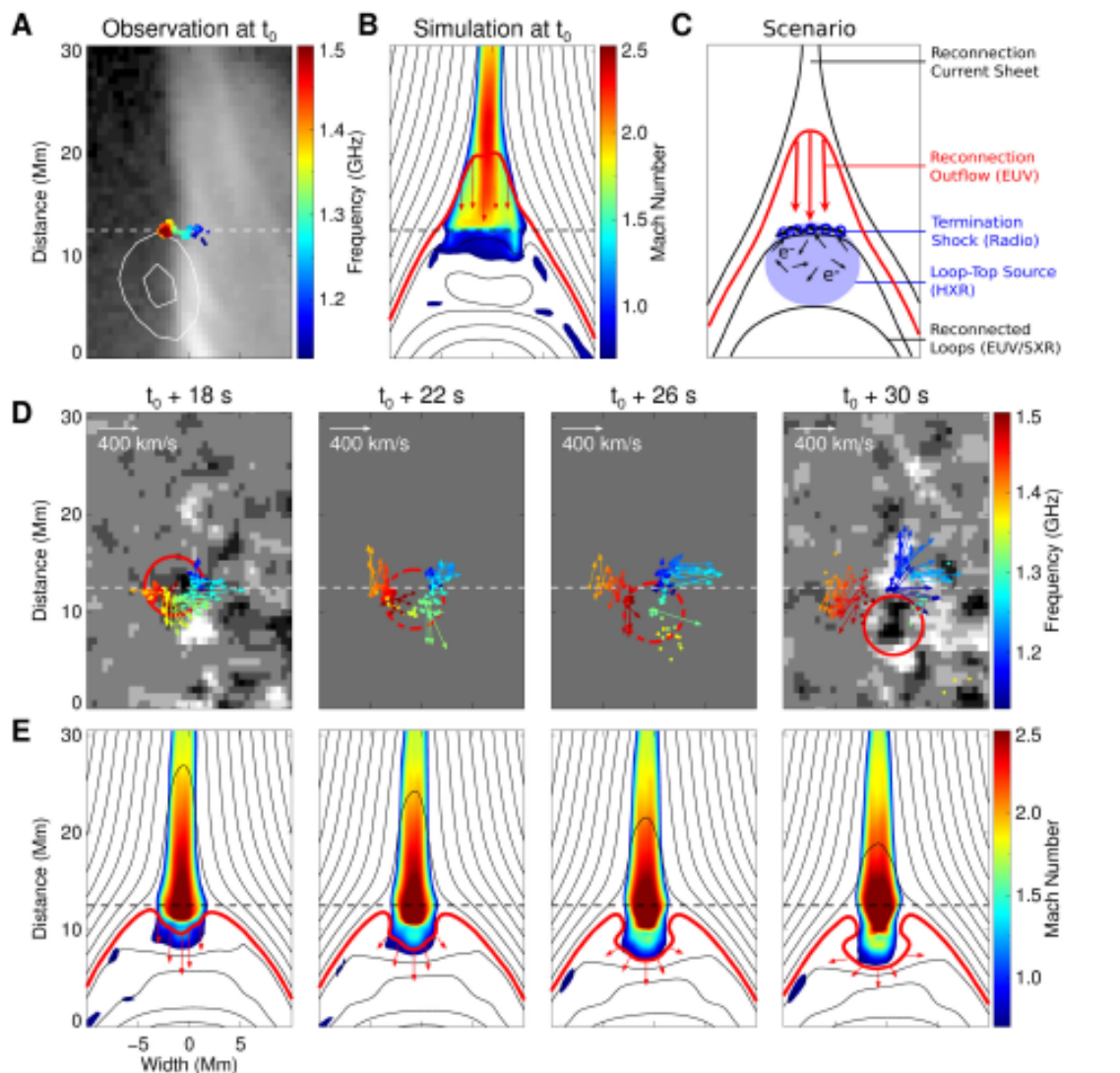


Fig. 3. Observation and simulation of the dynamic termination shock. (A) A closer view of the LT region (white box in Fig. 1B) at 18:30:57 UT (denoted as t_0 in Fig. 2E). The TS appears as a dynamic surface delineated by the many unresolved radio sources, each of which corresponds to a radio spike in the dynamic spectrum at a given time and frequency (colored dots indicate their centroid location). White contours show the coronal HXR source at 15–25 keV. The grayscale background is the AIA 94 Å intensity. (B) The TS is seen in the MHD simulation as a sharp layer of velocity discontinuity at the LT. The fast-mode magnetosonic Mach number is shown in color, overlaid with magnetic field lines. (C) Physical scenario of emission processes near the TS. Radio spikes are emitted as accelerated electrons impinge density fluctuations at the shock (blue circles). These electrons also produce a HXR source in the

Last time

- First law of thermodynamics
- Working with entropy
- Convection

When do we get convection?

- A. Temperature decreases upward
- B. Temperature increases upward
- C. Specific entropy decreases upward
- D. Specific entropy increases upward

Using entropy: pressure equilibrium

as: $ds = c_v d \ln P - c_p d \ln \rho$

$$ds / c_p = \frac{1}{\gamma} d \ln P - d \ln \rho$$

Small changes

$$\delta s / c_p = \frac{1}{\gamma} \delta \ln P - \delta \ln \rho$$

Pressure equilibrium
between blob and
surroundings

$$\delta \ln P = 0$$

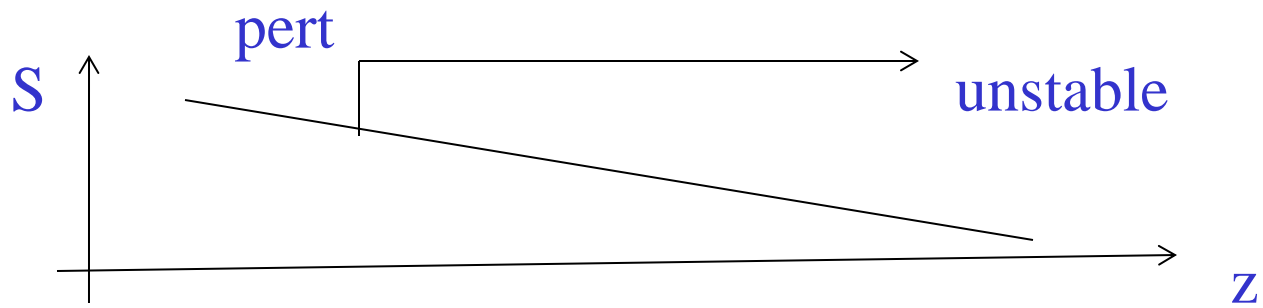
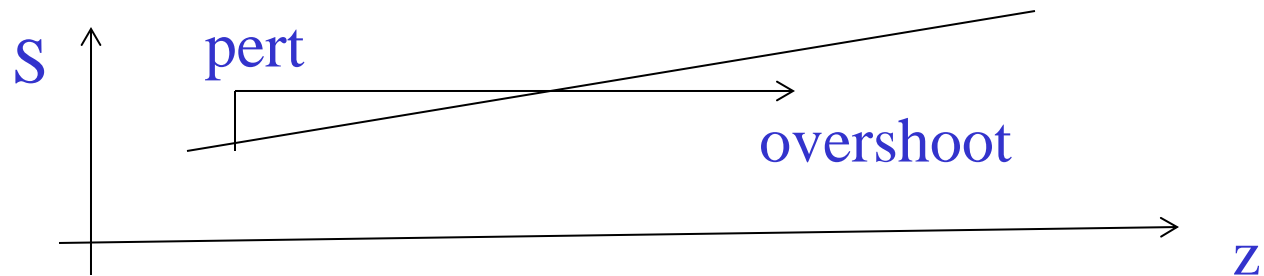
$$\Rightarrow \delta s / c_p = - \delta \ln \rho$$

$\delta s > 0 \rightarrow$ buoyant

Entropy & convection

$$s / c_p = \frac{1}{\gamma} \ln P - \ln \rho$$

Adiabatic changes: $S = \text{const}$
P equilibrium: $S+ \rightarrow$ buoyant



Changes in entropy?

discuss in groups

Changes in entropy?

$$\rho T \frac{Ds}{Dt} = \underbrace{\oint_{4\pi} (I - S) d\Omega}_{-\nabla \cdot \mathbf{F}_{\text{rad}}} + Q_{\text{visc}} + Q_{\text{Joule}} + Q_{\text{nuclear}}$$

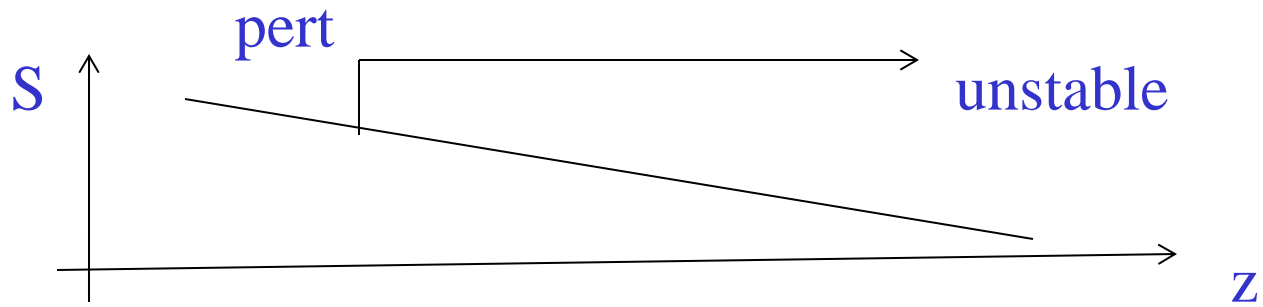
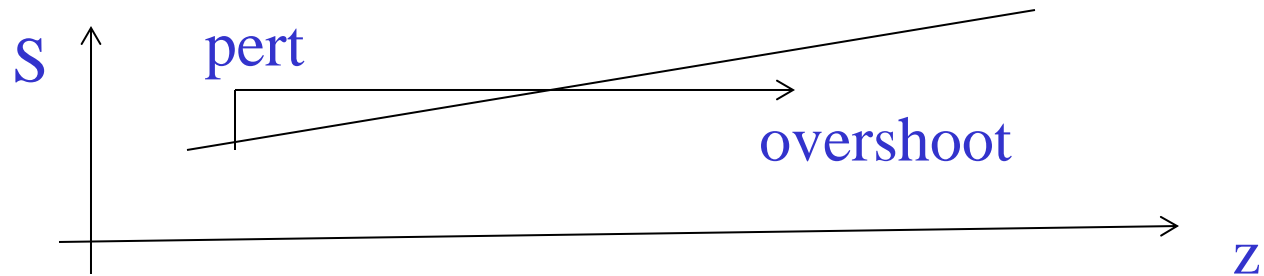
Here:

$$\frac{Ds}{Dt} = \frac{\partial s}{\partial t} + \mathbf{u} \cdot \nabla s$$

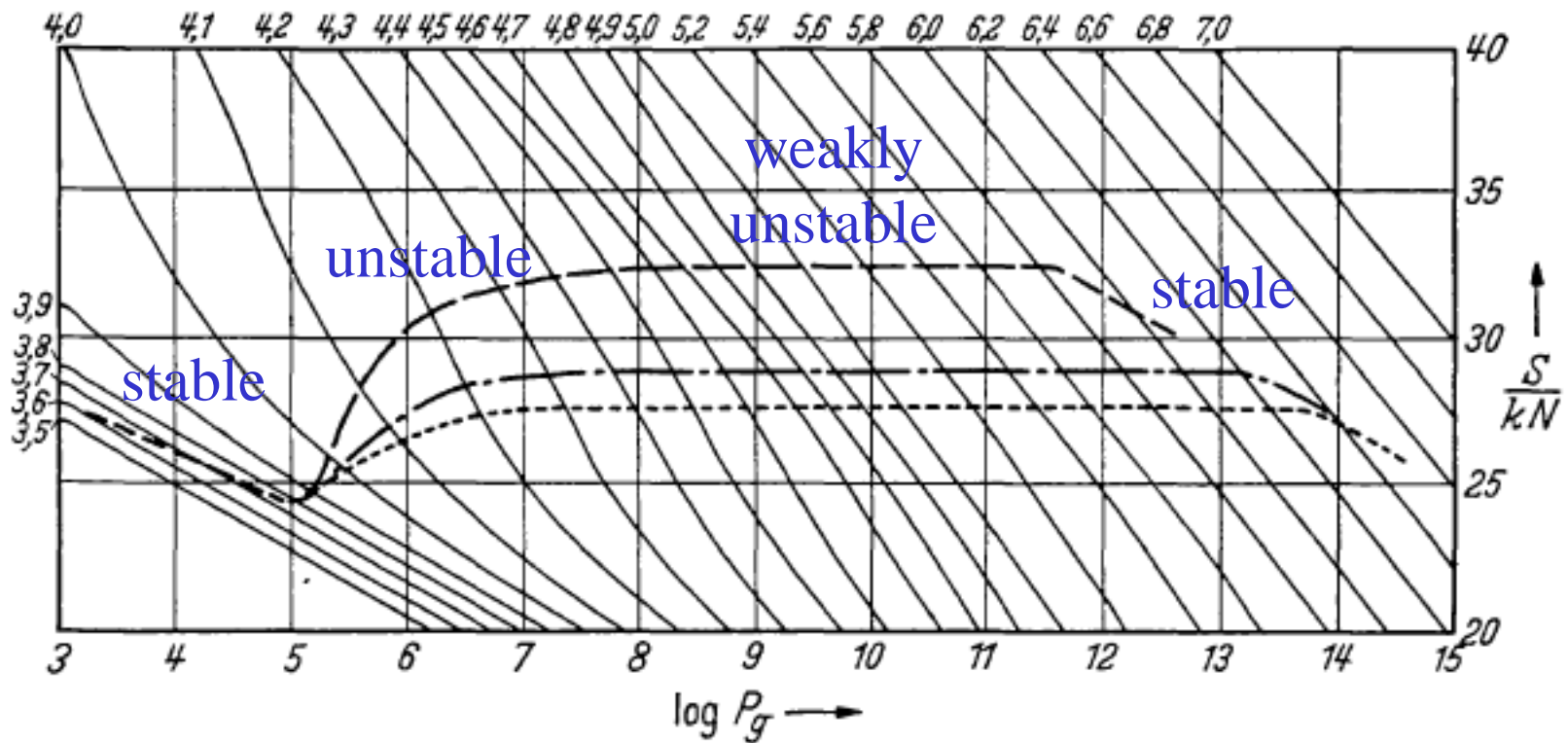
Entropy & convection

$$s / c_p = \frac{1}{\gamma} \ln P - \ln \rho$$

Adiabatic changes: $S = \text{const}$
P equilibrium: $S+ \rightarrow$ buoyant



Original mixing length model



surface

Von

interior

ERIKA VITENSE, Kiel.

Mit 11 Textabbildungen.

(Eingegangen am 15. November 1952.)

Buoyancy oscillations

Momentum eqn:

$$\rho_0 \frac{\partial \mathbf{u}_1}{\partial t} = -\nabla p_1 + \rho_1 \mathbf{g} \dots$$

$$\rho_1 / \rho_0$$

Entropy equation:

$$\frac{\partial s_1}{\partial t} = -\mathbf{u}_1 \cdot \nabla s_0$$

$$= \delta \rho / \rho$$

$$= \delta \ln \rho$$

$$= -\delta s / c_p$$

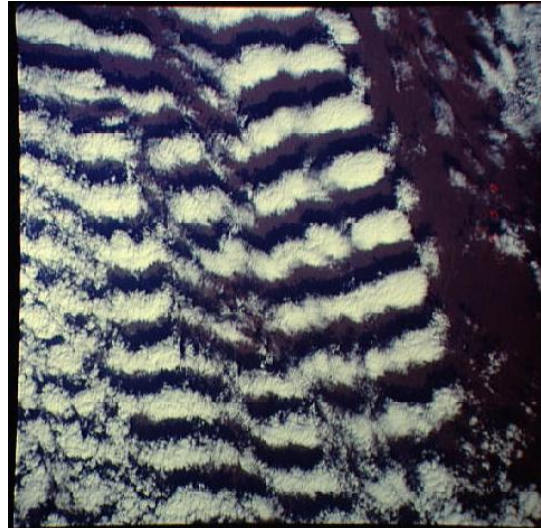
$$= -s_1 / c_p$$

Ignore pressure for now,
so as to understand
buoyancy effect

$$\begin{pmatrix} i\omega & -g/c_p \\ -ds_0/dz & i\omega\rho_0 \end{pmatrix} \begin{pmatrix} \hat{u}_{1z} \\ \hat{s}_1 \end{pmatrix} = 0$$

g-modes

- Would probe the center
- Are evanescent in the convection zone



Internal energy & specific heat

$$c_v dT = \frac{P}{\rho^2} d\rho + T ds$$

Internal energy equation

$$\rho c_v \frac{DT}{Dt} = P \frac{D \ln \rho}{Dt} + \rho T \frac{Ds}{Dt}$$

Use continuity equation

$$\rho c_v \frac{DT}{Dt} = -P \nabla \cdot \mathbf{u} + \rho T \frac{Ds}{Dt}$$

What we learned

- Use ADS
- Entropy: what makes it change
- Buoyancy oscillations