

Astrophysical Hydrodynamics

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 - b Office hours: You are always welcome to come to my office for short questions. You can also make an appointment via email.
- ii Teaching assistant: Stefano Antonellini
 - a Office: 192, phone: 8689, email: S.Antonellini@astro.rug.nl
- iii. Website course:
www.astro.rug.nl/~weygaert/astrohydro2015.html
- iv The purpose of the course is to complete the fluid mechanics background needed in astrophysics.
- v Attendance of a substantial fraction of course lectures is obligatory.
- vi Problem sets are mandatory and constitute 25% of the final grade

Astrophysical Hydrodynamics

vi Lectures:

Monday	9:00-11:00	ZG161	lecture
Wednesday	15:00-17:00	Kapteynborgh 103	tutorial
Friday	11:00-15:00	ZG161	lecture

1st lecture: Monday Feb. 2, 2015

last lecture: Friday March 27, 2015

vii Written exam at the end of the term:

Friday April 10, 2015	09:00-12:00 (exam)
Tuesday May 12, 2015	18:30-21:30 (re-exam)

Bibliography

I. The lecture notes and handouts are the main source of material. However, there are a number of good books that the student can use to clarify some of the topics or for extra material.

II. Interesting Books:

- **Fluid Mechanics**, Landau and Lifshitz
exceptional book but of somewhat higher level.
- **Gas Dynamics**; Vol. II, Physics of Astrophysics, F. Shu
Univ. Science Books, very good for astrophysical perspective.
- **An Introduction to Fluid Dynamics**, G. K. Batchelor
historic classic, widely regarded as a "bible" for the subject.
Daunting at first sight, but lucid, thorough and reliable.
- **Astrofysica: Inleiding Gasdynamica**, Bram Achterberg (UU)
Very clear and complete treatment of astrophysical hydrodynamics
- **Album of Fluid Motion**, van Dyke
Beautiful photographs showing fluid in motion

Astrophysical Fluid Mechanics

Topics

- I Fluid Picture Book
- II Basic fluid equations of ideal fluids
- III Inviscid Barotropic Flows: Kelvin Circulation Theorem Bernoulli Theorem
- IV Incompressible Fluids Compressible fluids:
- V Waves
- VI Hydrodynamic Instabilities

- VII. Shock Waves
- VIII. Viscous flows: Navier-Stokes Eqns.
- IX. Turbulence
- X. Numerical (astro)hydrodynamics

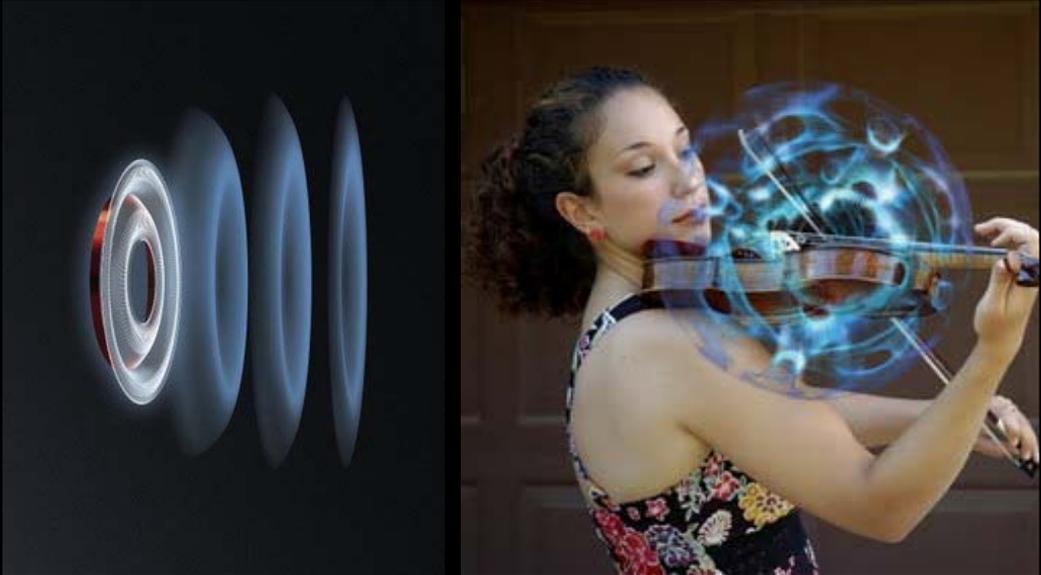
Fluid Picture Book

Waves: sea & ocean waves

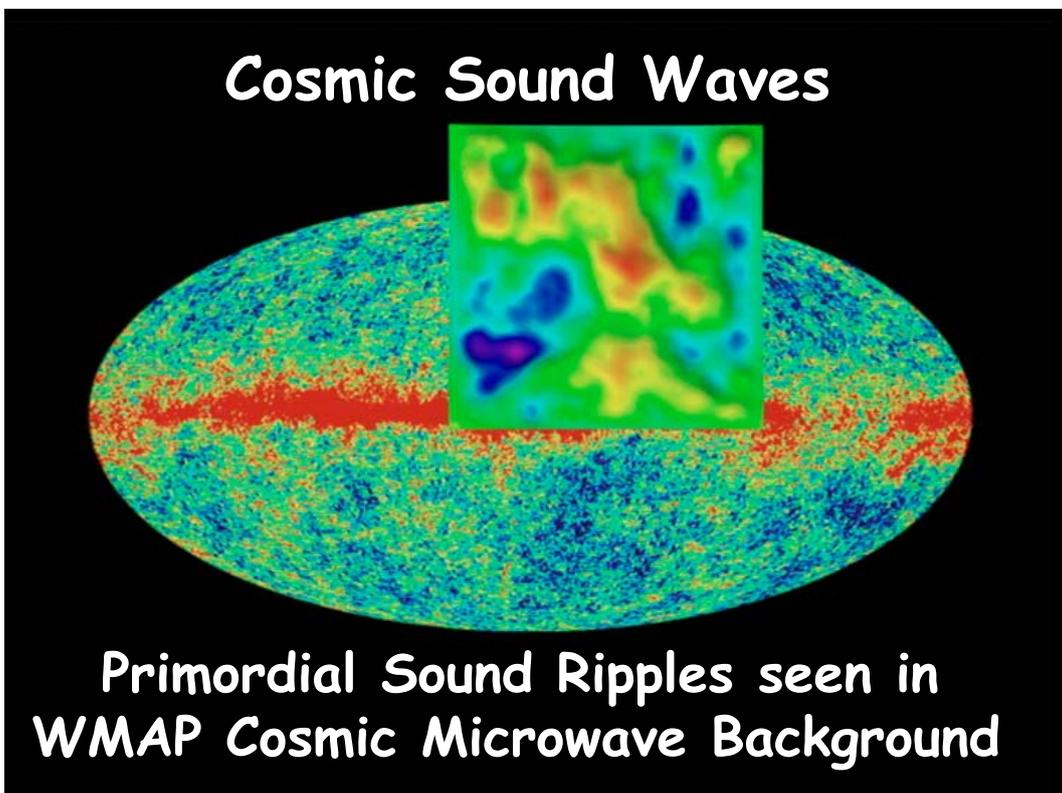
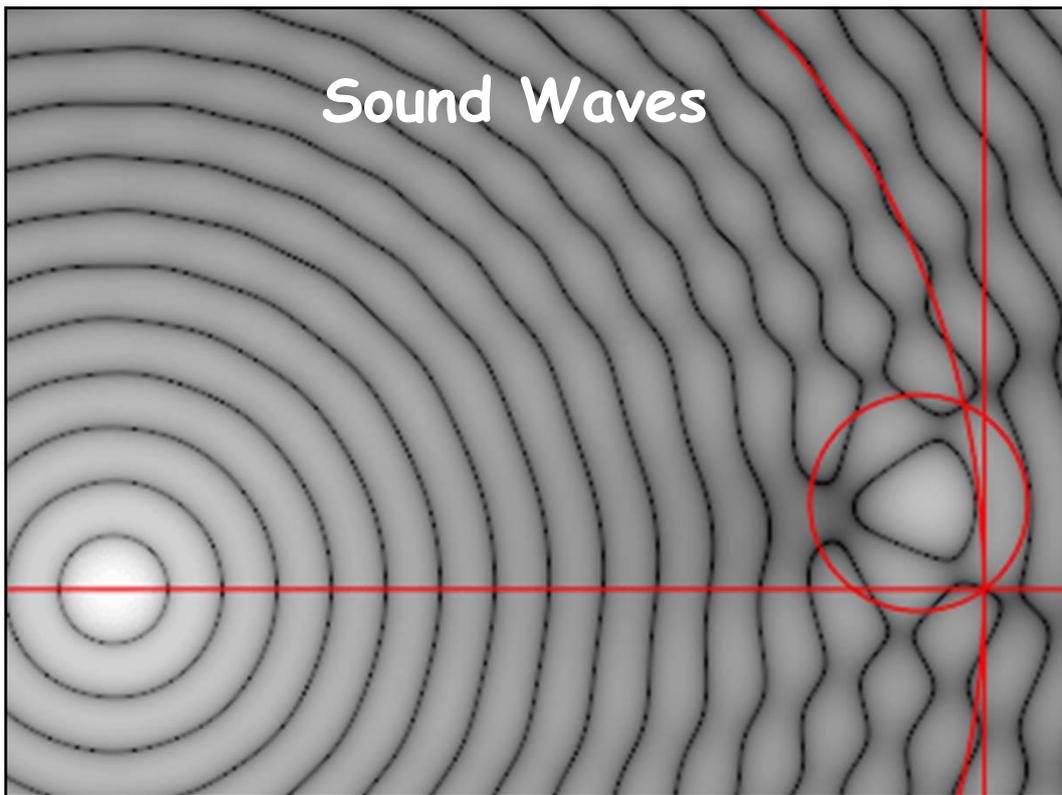


This section features three distinct images of water waves. The top-left image shows close-up ripples on a blue water surface. The middle image depicts a line of white-capped waves breaking on a beach. The bottom-right image shows a large, powerful wave curling over, with a deep blue tunnel visible in its base.

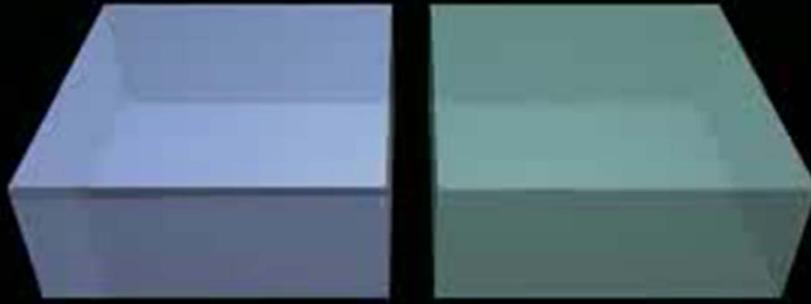
Sound Waves:



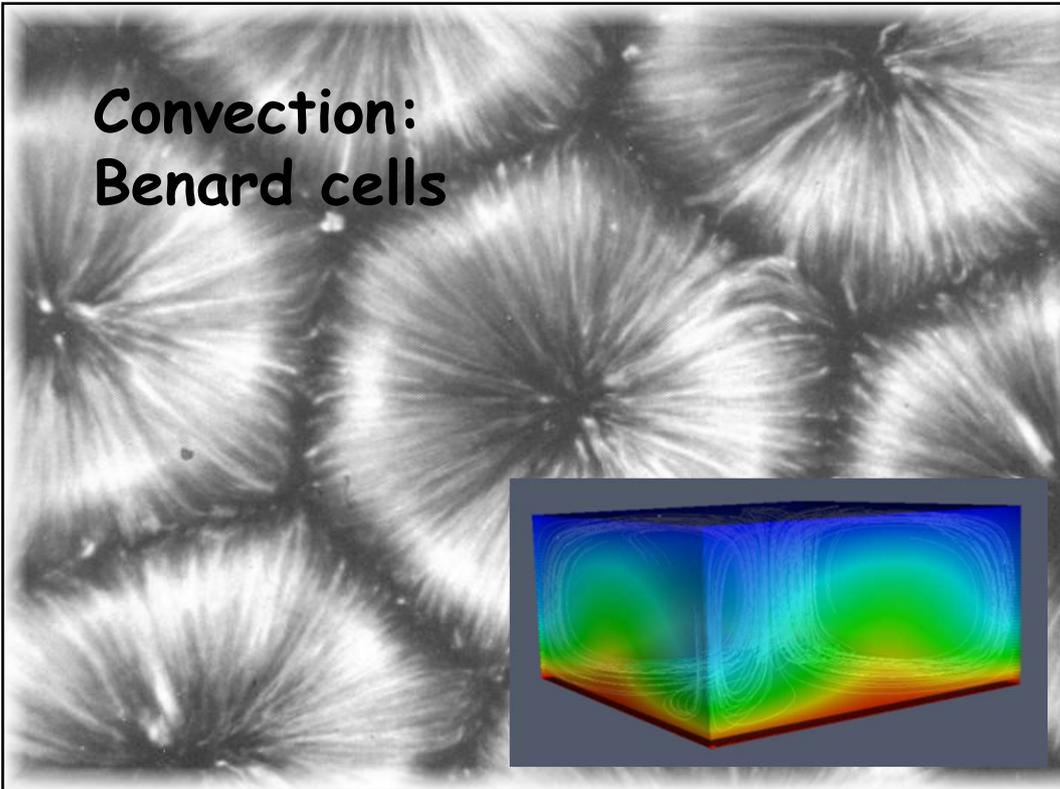
This section contains two images related to sound. On the left is a 3D diagram showing a speaker on the left emitting concentric circular waves that propagate to the right, passing through a series of vertical panels. On the right is a photograph of a violinist playing, with a glowing blue digital sound wave visualization overlaid on the violin and her face.



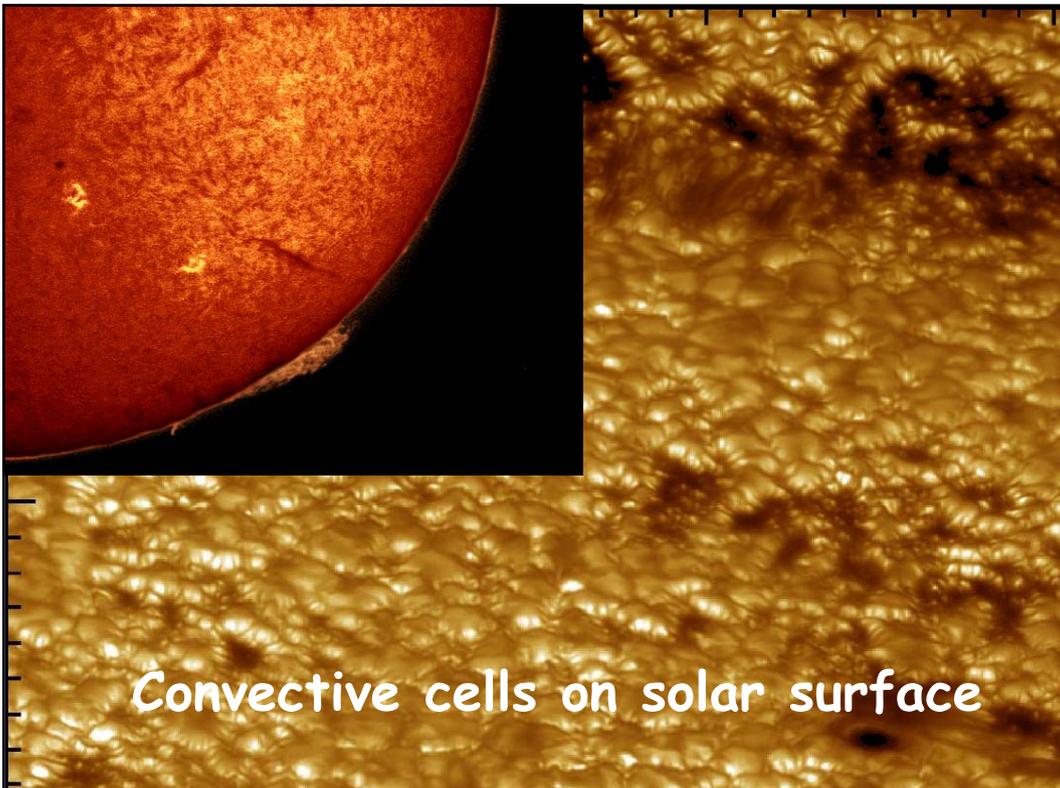
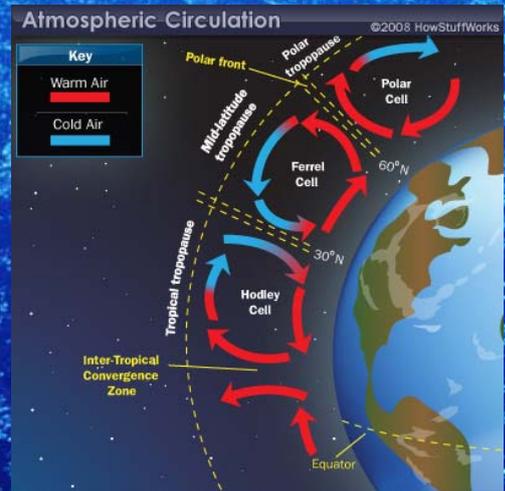
Cosmic Sound Waves

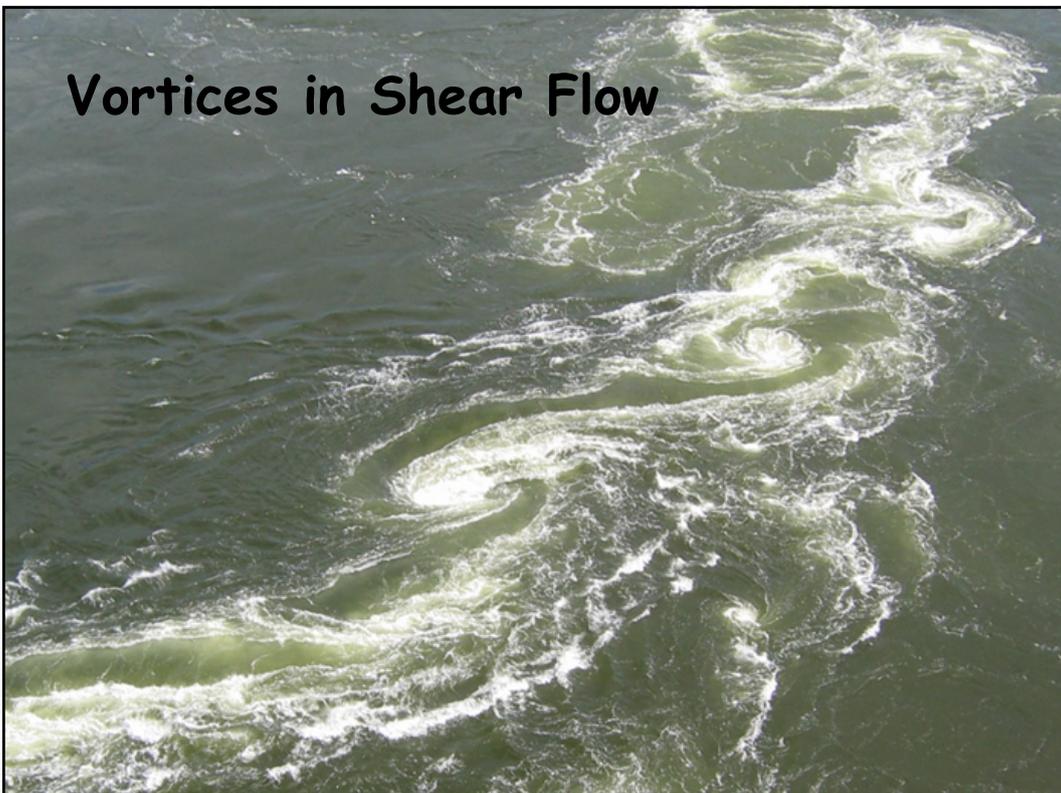
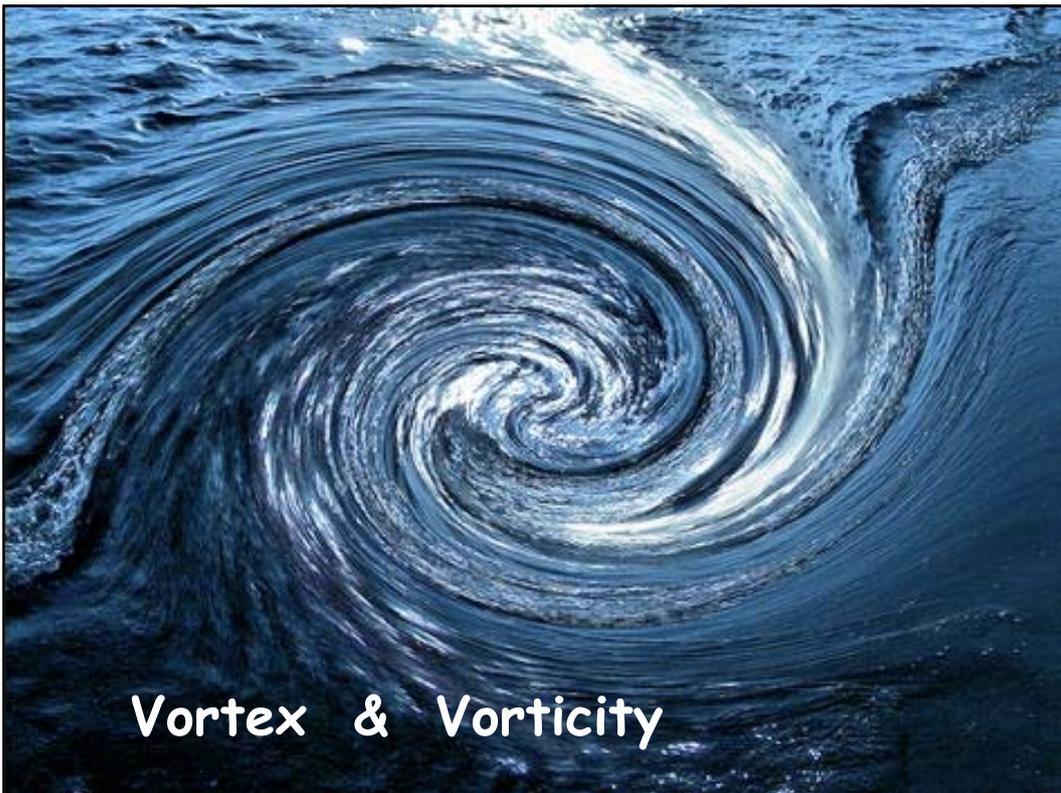


Convection: Benard cells

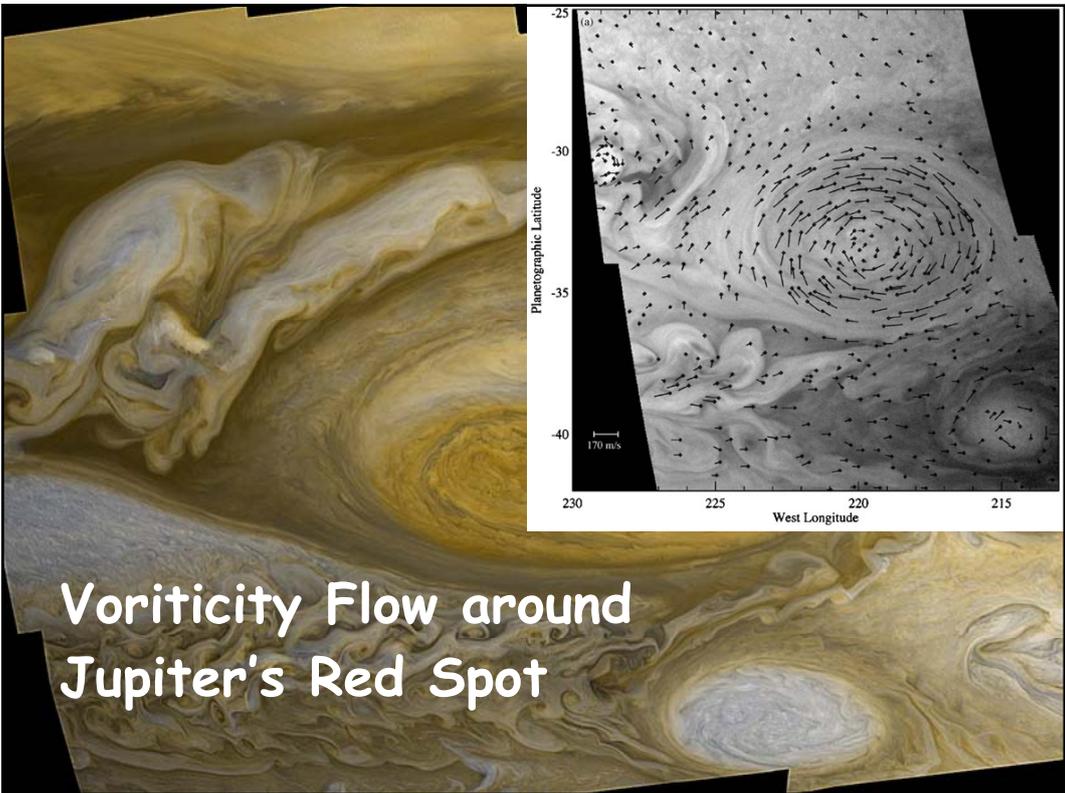
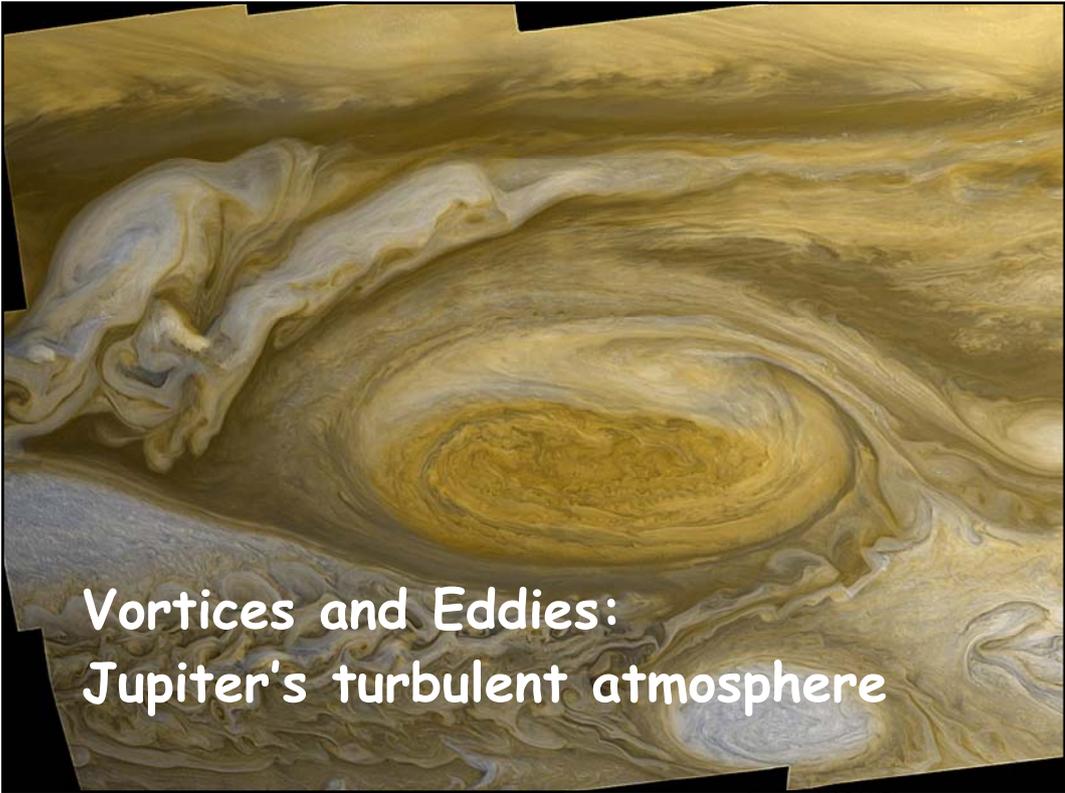


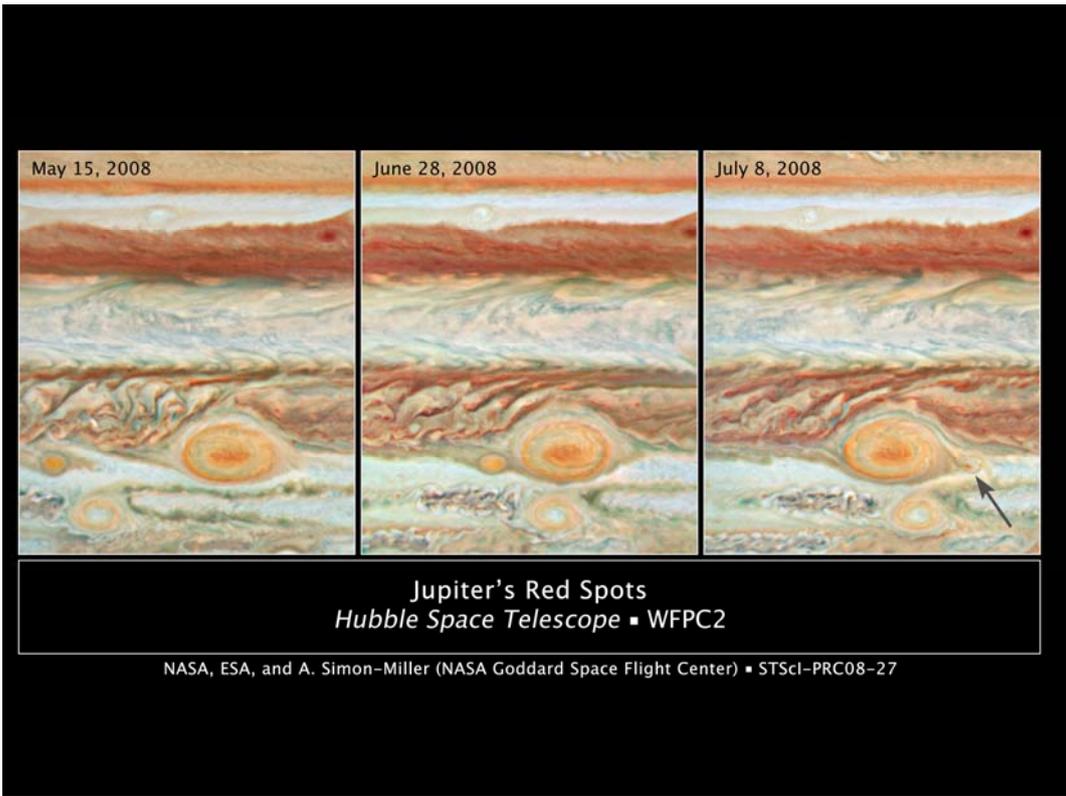
Convection: Earth Atmosphere











Jupiter's Great Red Spot

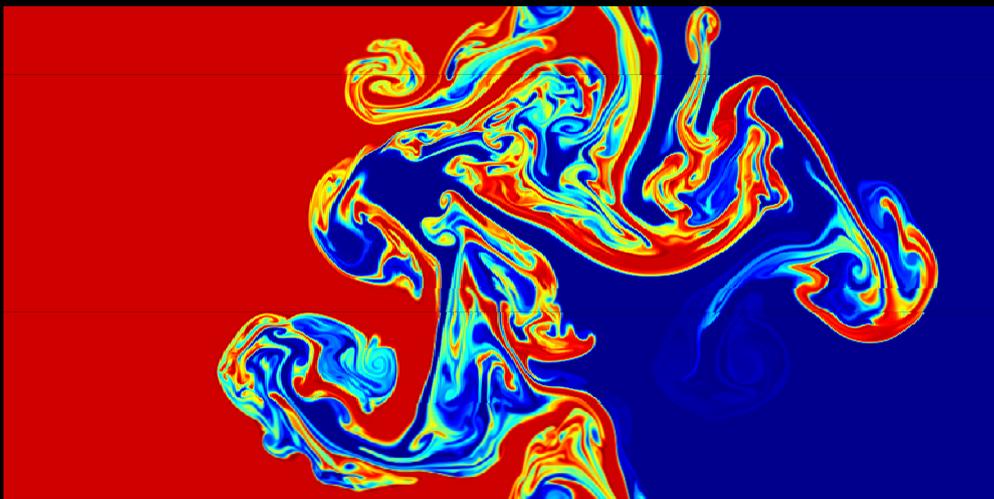


Rayleigh-Taylor Instability

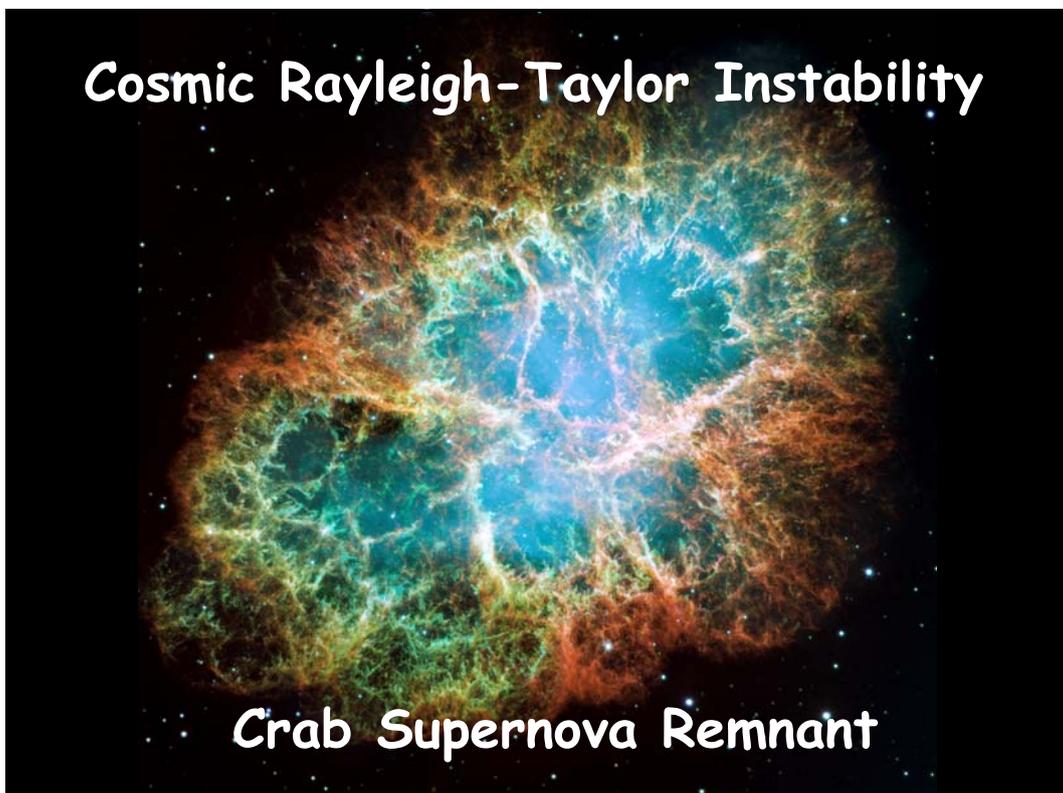
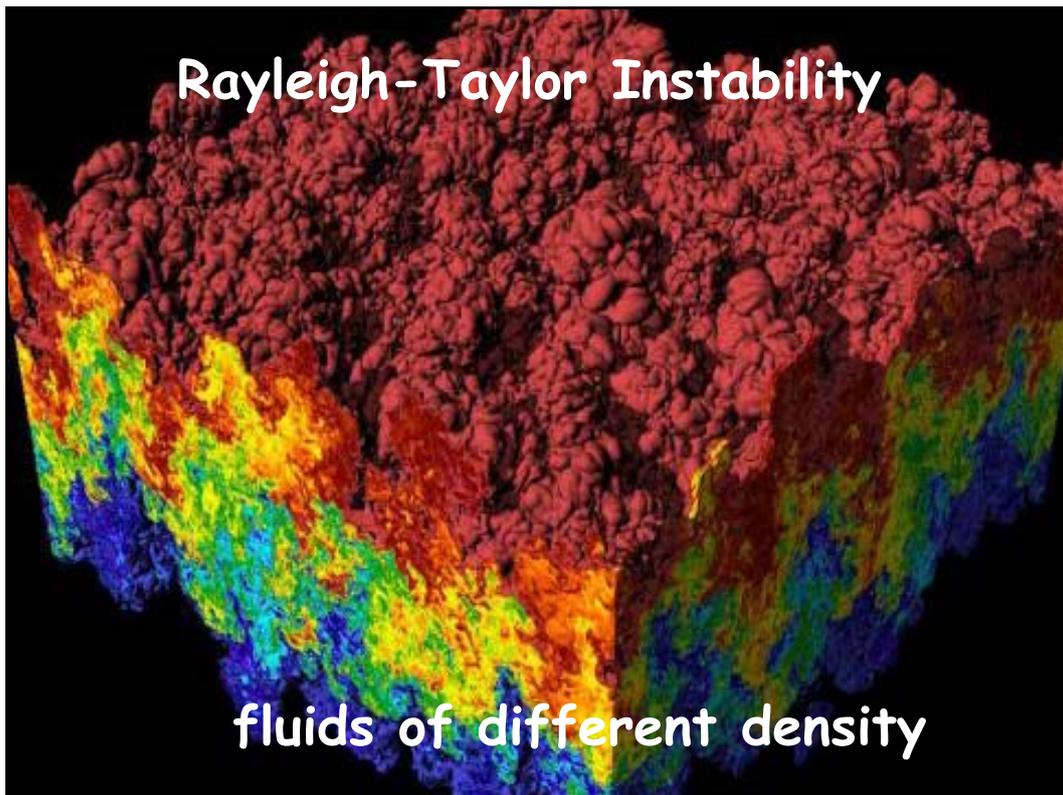


2 fluids of different density

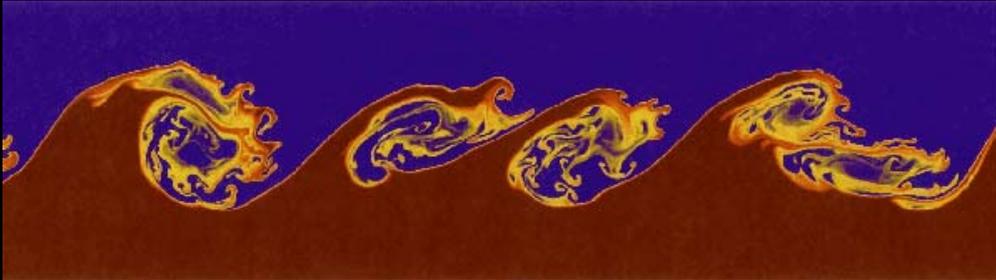
Rayleigh-Taylor Instability



2 fluids of different density



Kelvin-Helmholtz Instability



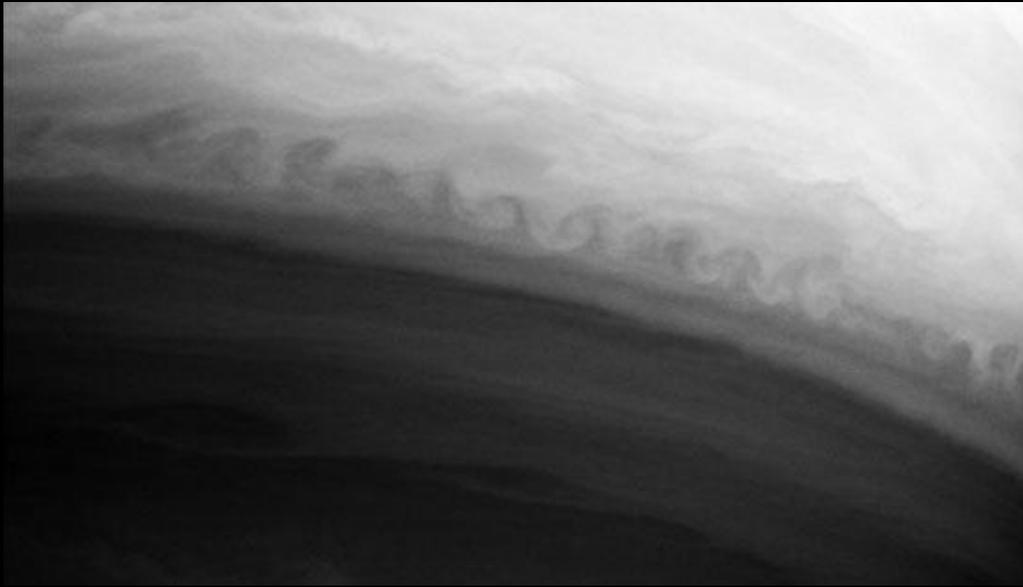
at the boundary of 2 shearing fluids

Kelvin-Helmholtz Instability



KH instability in cloud cover

Kelvin-Helmholtz Instability



KH instability in Saturn's atmosphere

Supersonic Motion & Shockwaves

