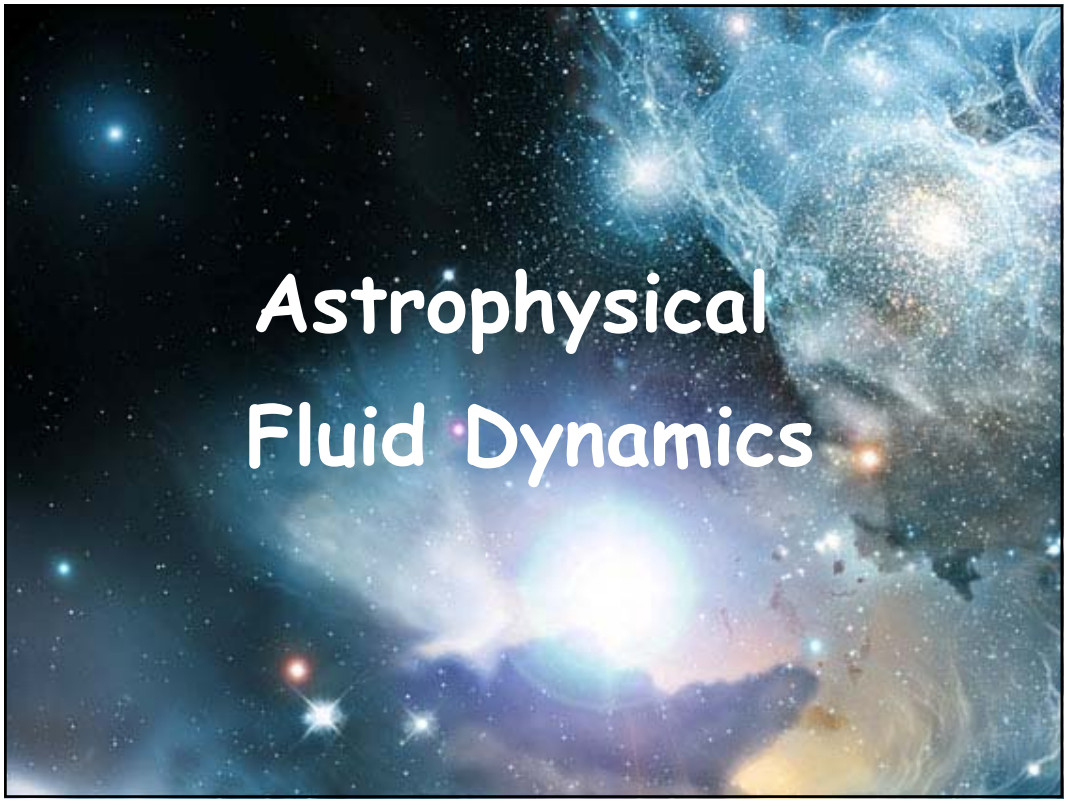


Astrophysical Hydrodynamics

i Lecturer: Rien van de Weijgaert

  a Room 186, phone 4086, email: weygaert@astro.rug.nl

  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 The purpose of the course is to complete the fluid mechanics background needed in astrophysics.

iv Attendance of a substantional fraction of course lectures is obligatory.

v Problem sets are mandatory and constitute about 25% of the final grade

vi Written exam at the end of the term: April 10, 2014 (exam)
May 8, 2014 (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

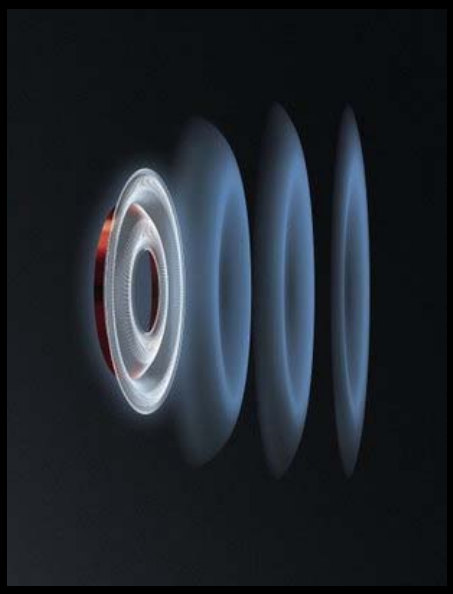
Topics

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. Similarity solutions
X. Turbulence
XI. Numerical (astro)hydrodynamics

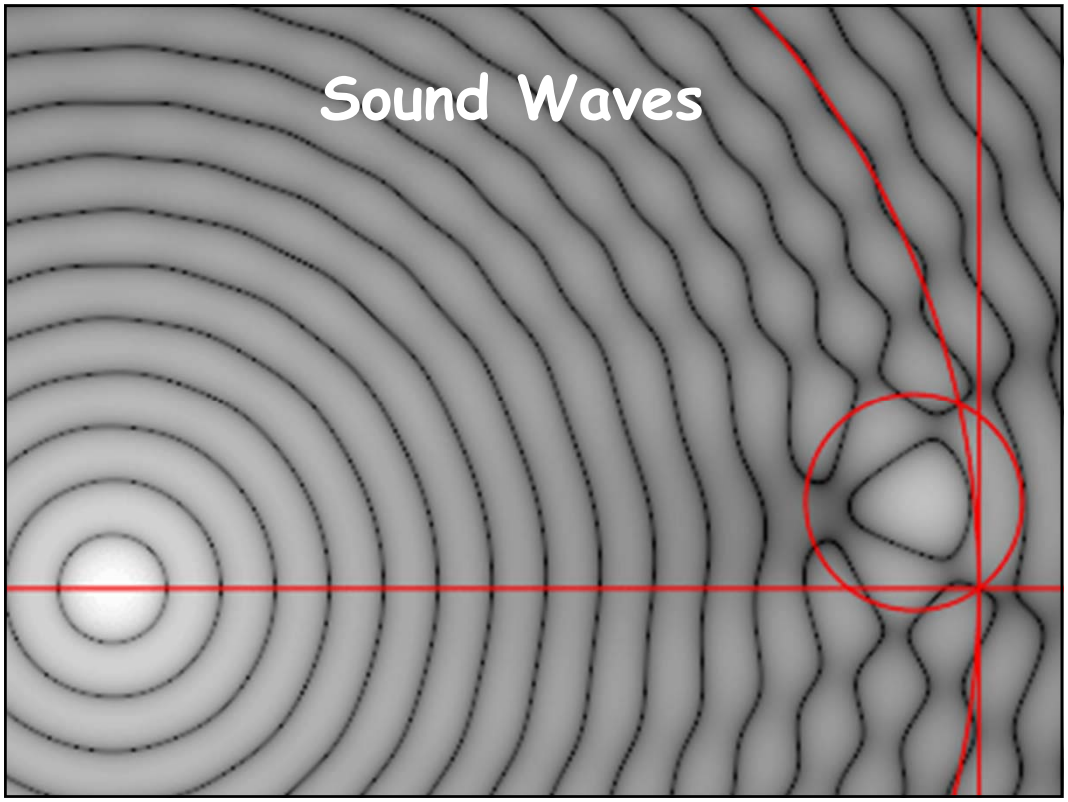
Fluid Picture Book

Waves:
sea & ocean waves

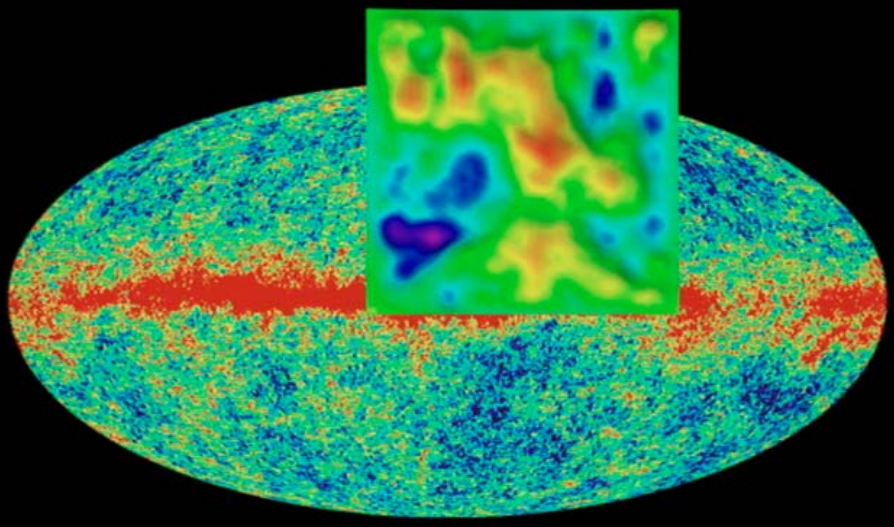
Sound Waves:



Sound Waves

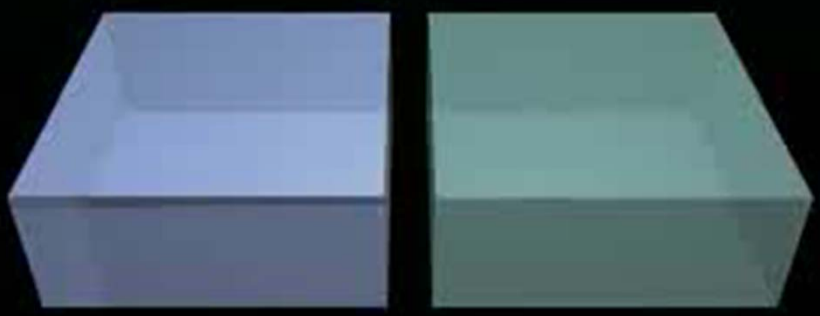


Cosmic Sound Waves

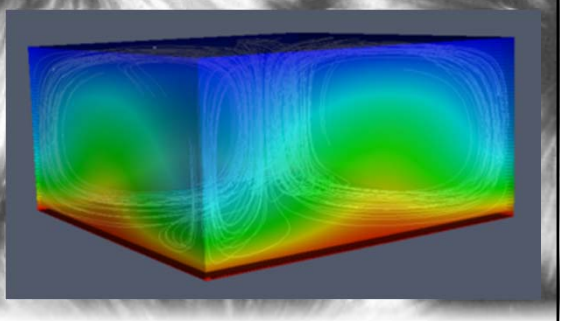


Primordial Sound Ripples seen in WMAP Cosmic Microwave Background

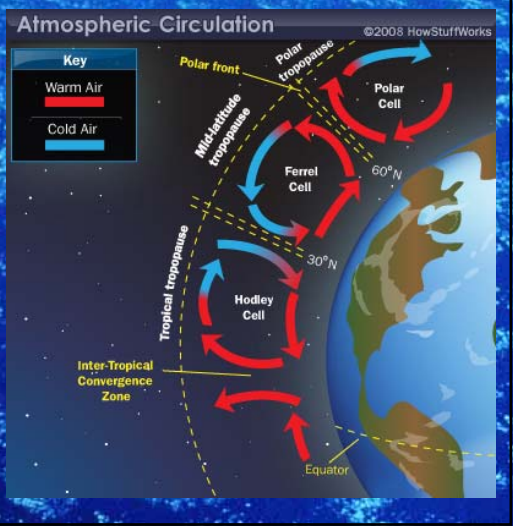
Cosmic Sound Waves

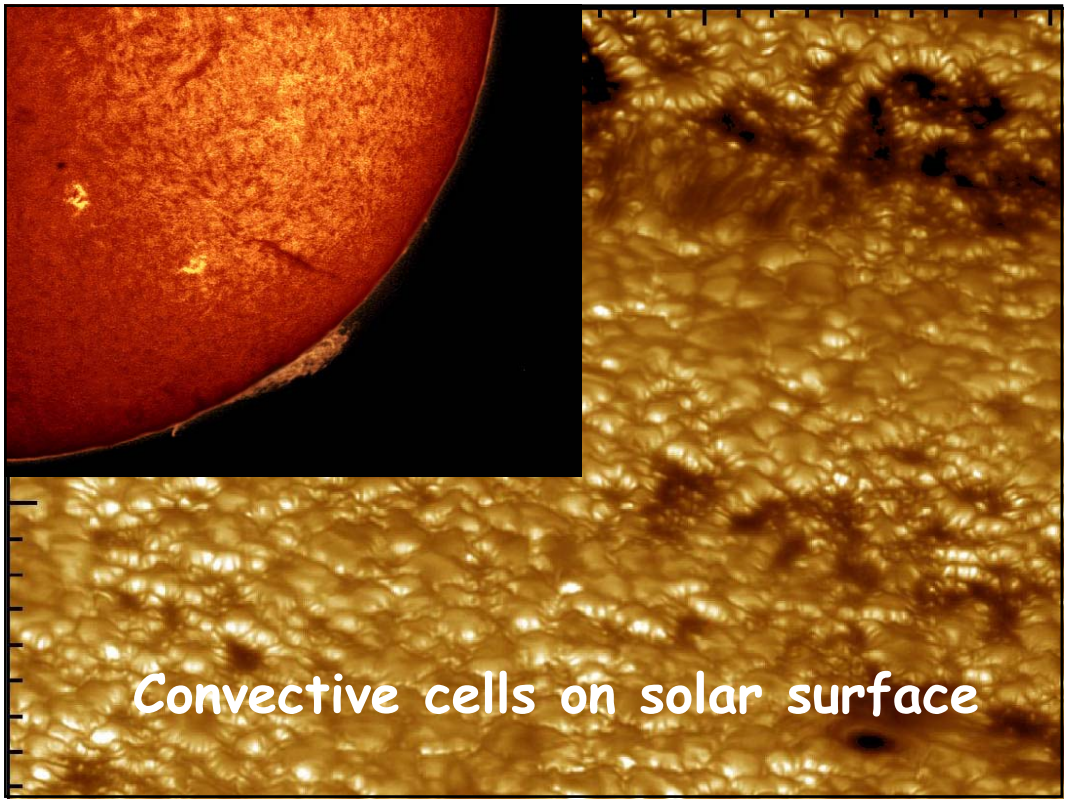


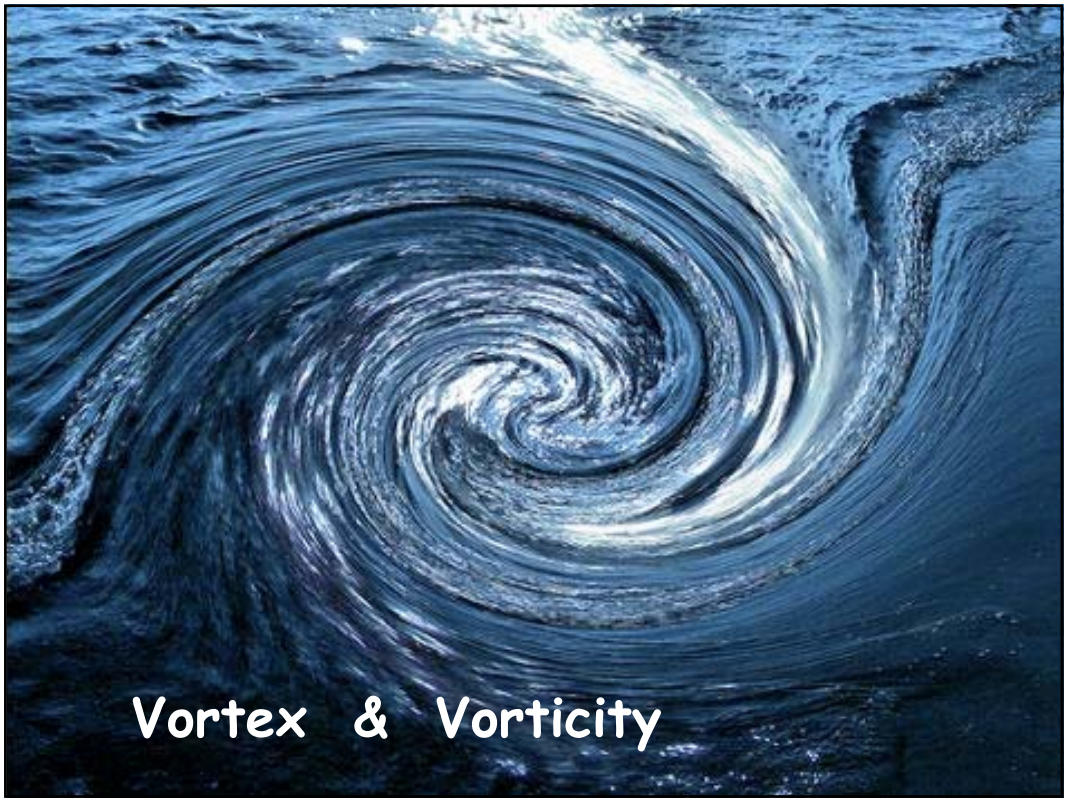
Convection: Benard cells



Convection: Earth Atmosphere

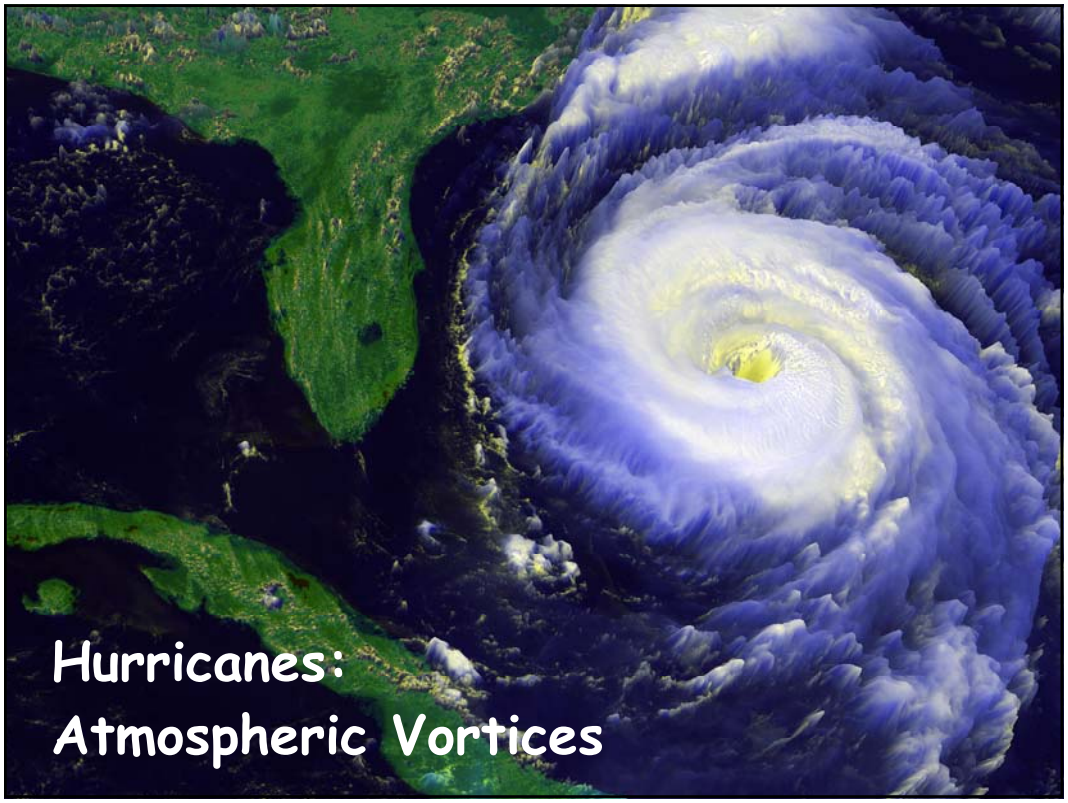


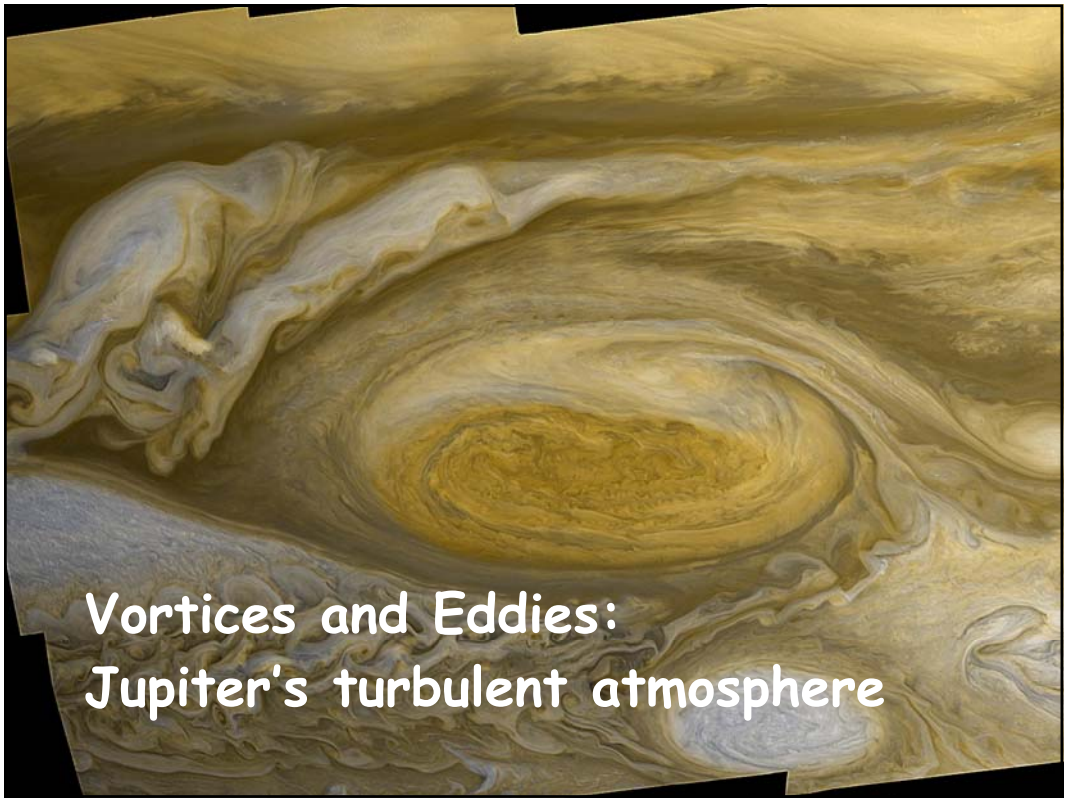

Convective cells on solar surface

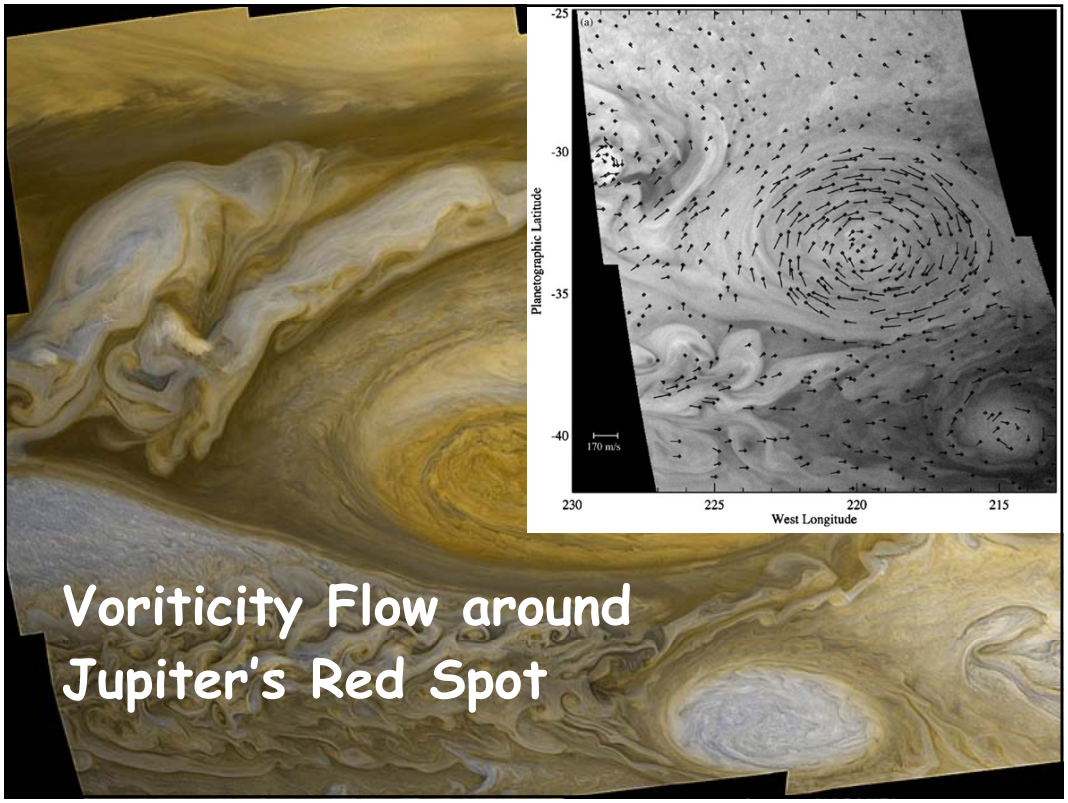

Vortex & Vorticity


Vortices in Shear Flow

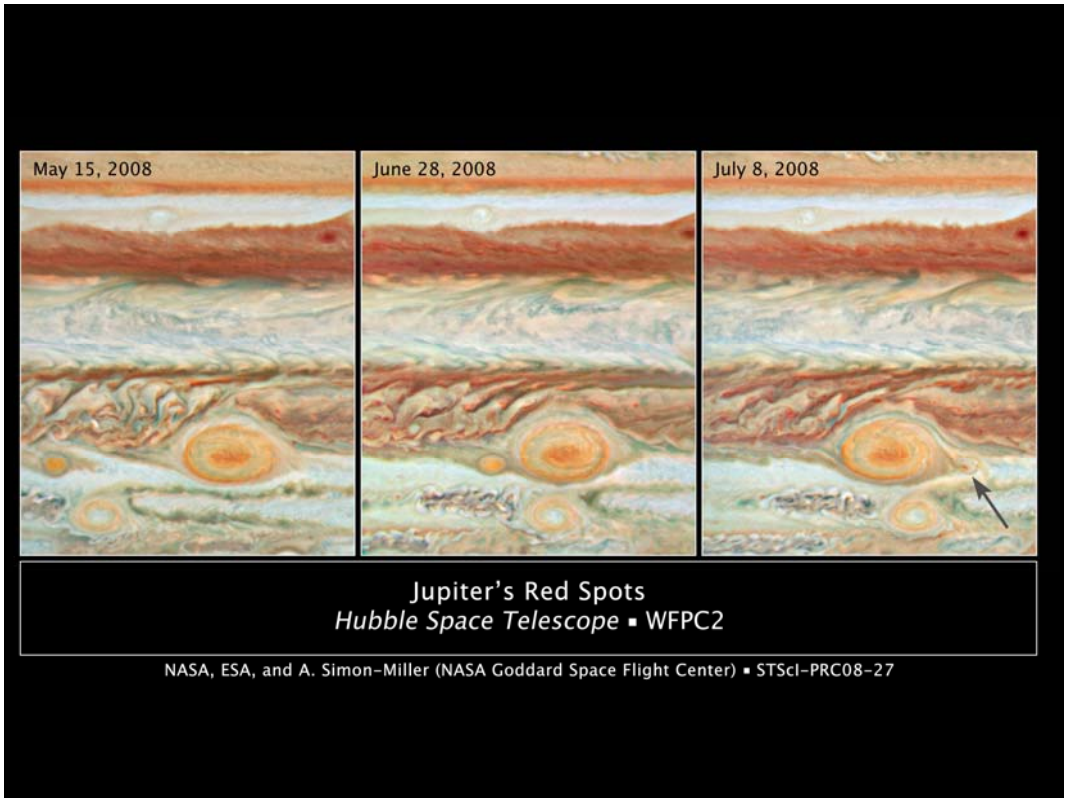

Tornados:
Atmospheric Vortices


Hurricanes:
Atmospheric Vortices


Vortices and Eddies:
Jupiter's turbulent atmosphere



Voriticity Flow around Jupiter's Red Spot

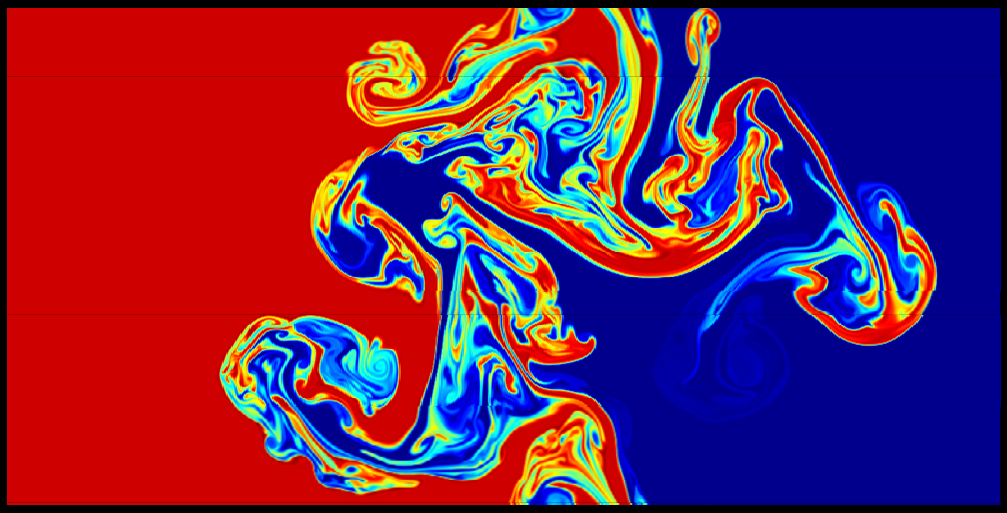


Jupiter's Great Red Spot

Rayleigh-Taylor Instability

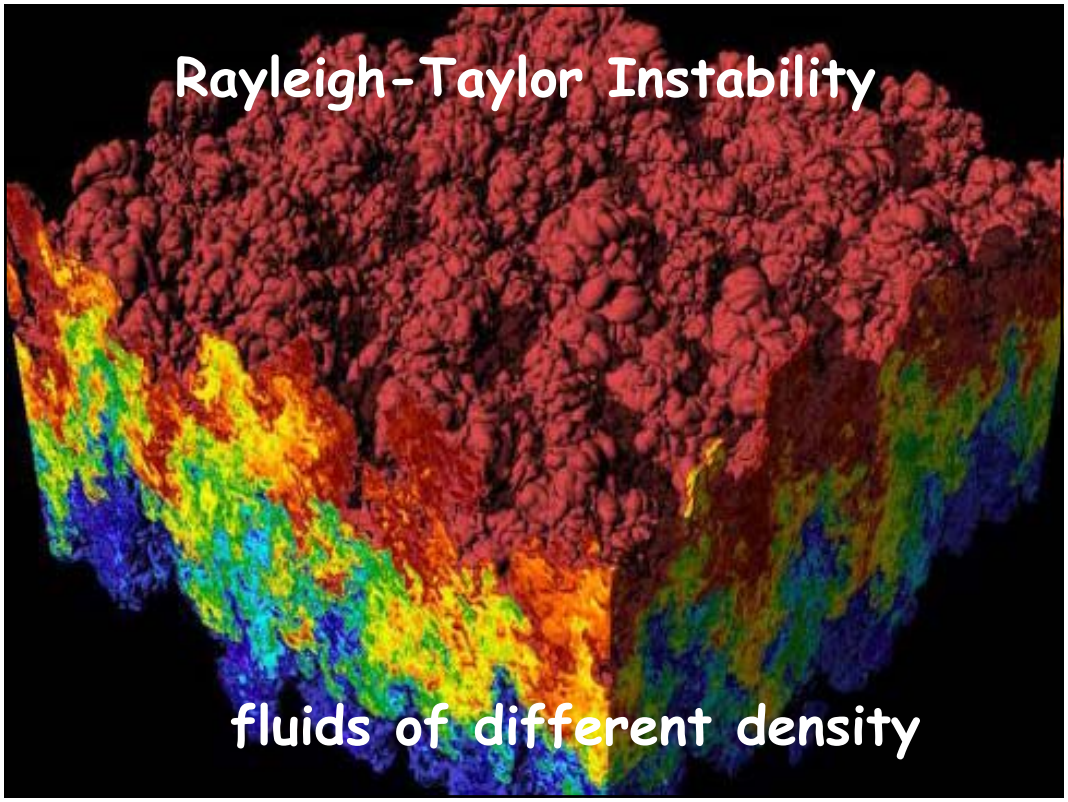
2 fluids of different density

Rayleigh-Taylor Instability



2 fluids of different density

Rayleigh-Taylor Instability

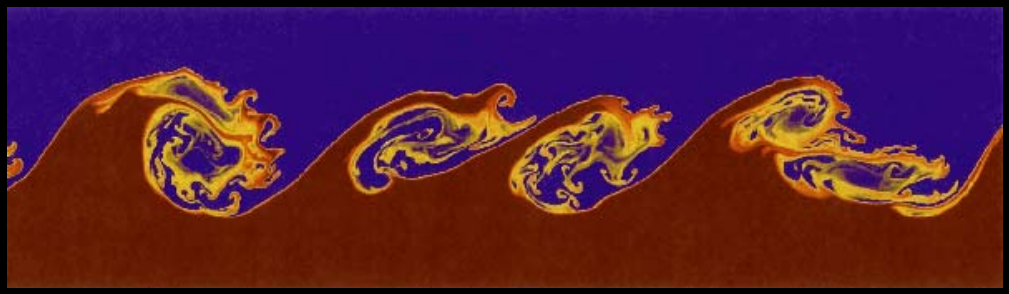


fluids of different density

Cosmic Rayleigh-Taylor Instability

Crab Supernova Remnant

Kelvin-Helmholtz Instability

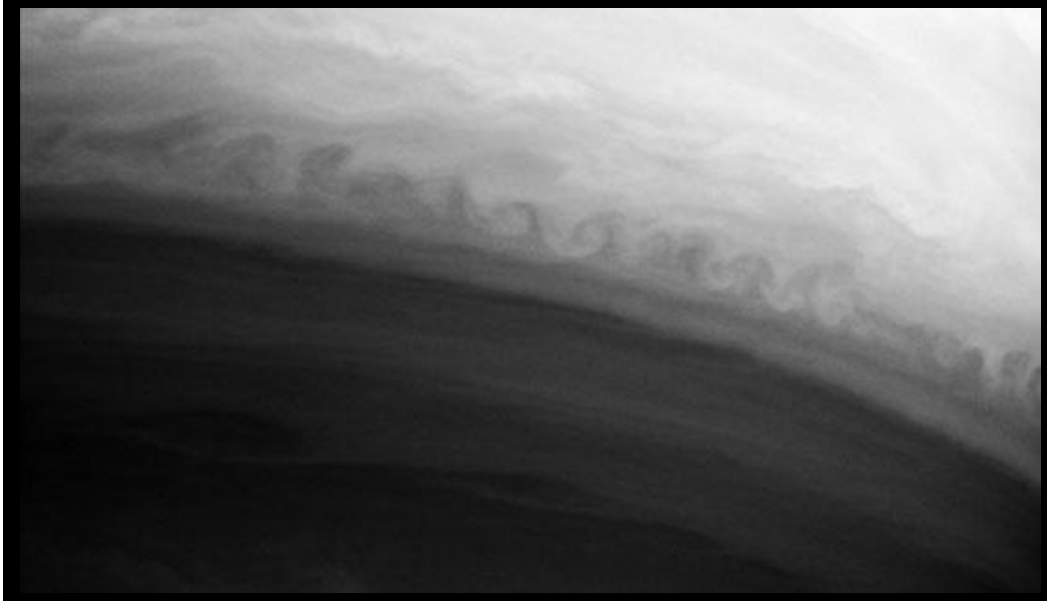


at the boundary of 2 shearing fluids

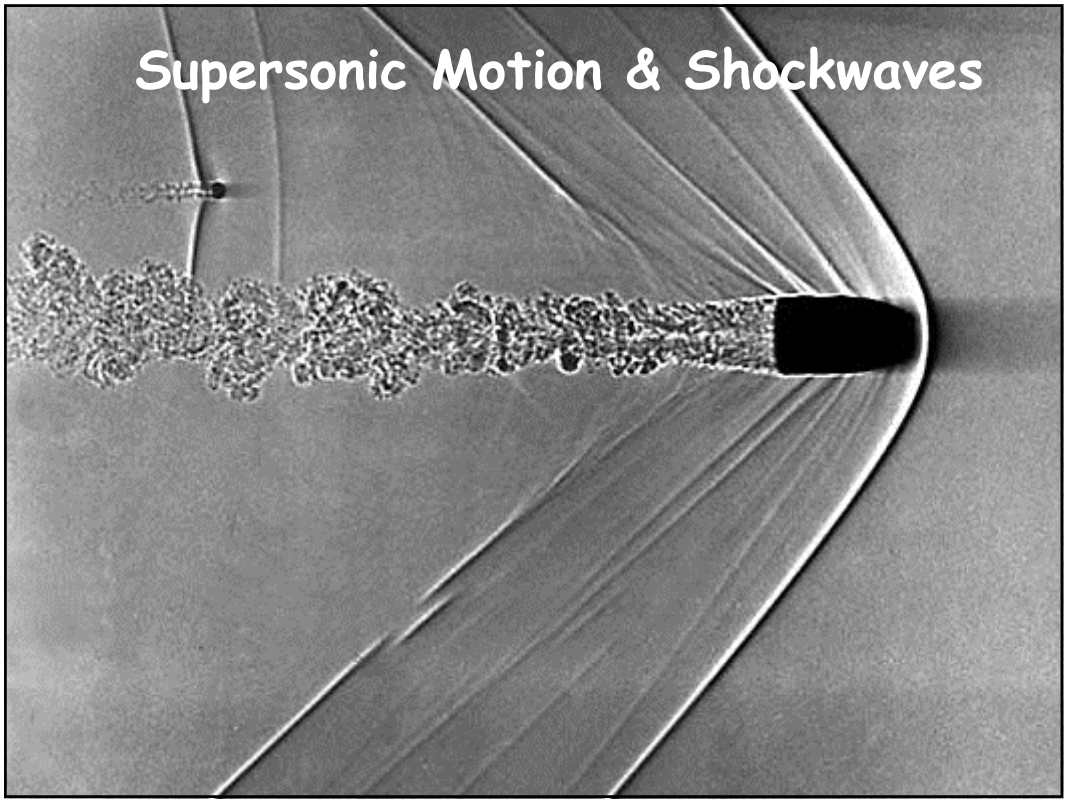
Kelvin-Helmholtz Instability

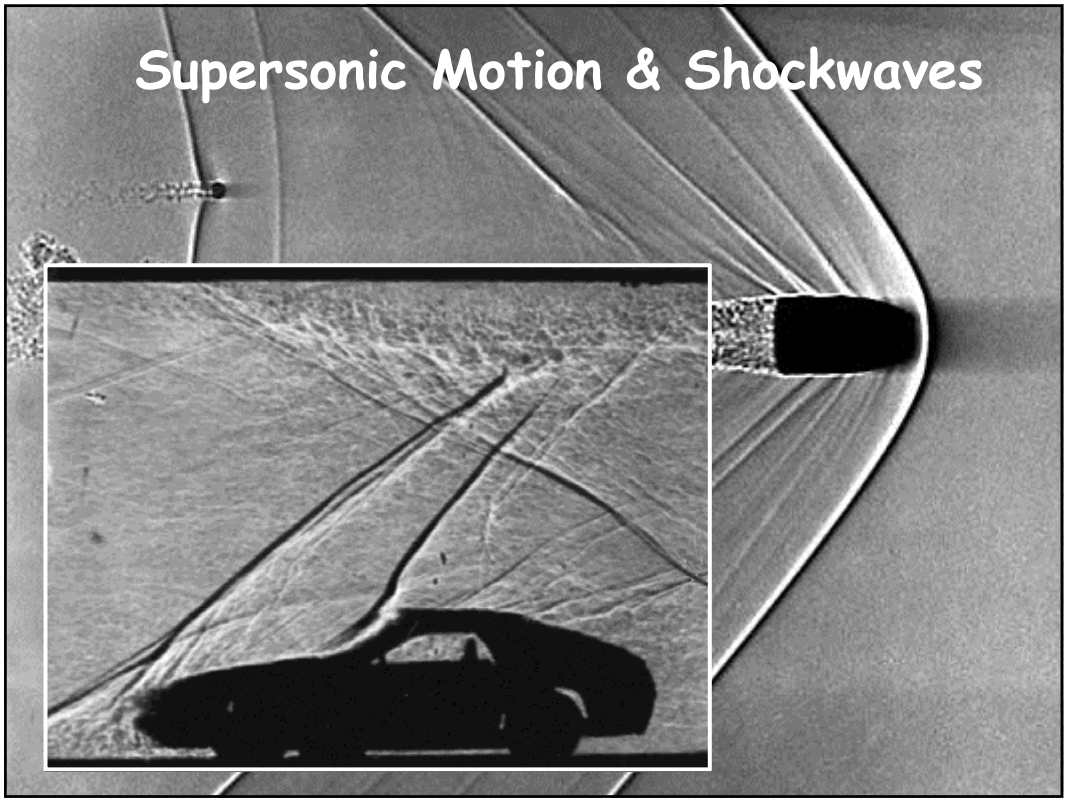
KH instability in cloud cover

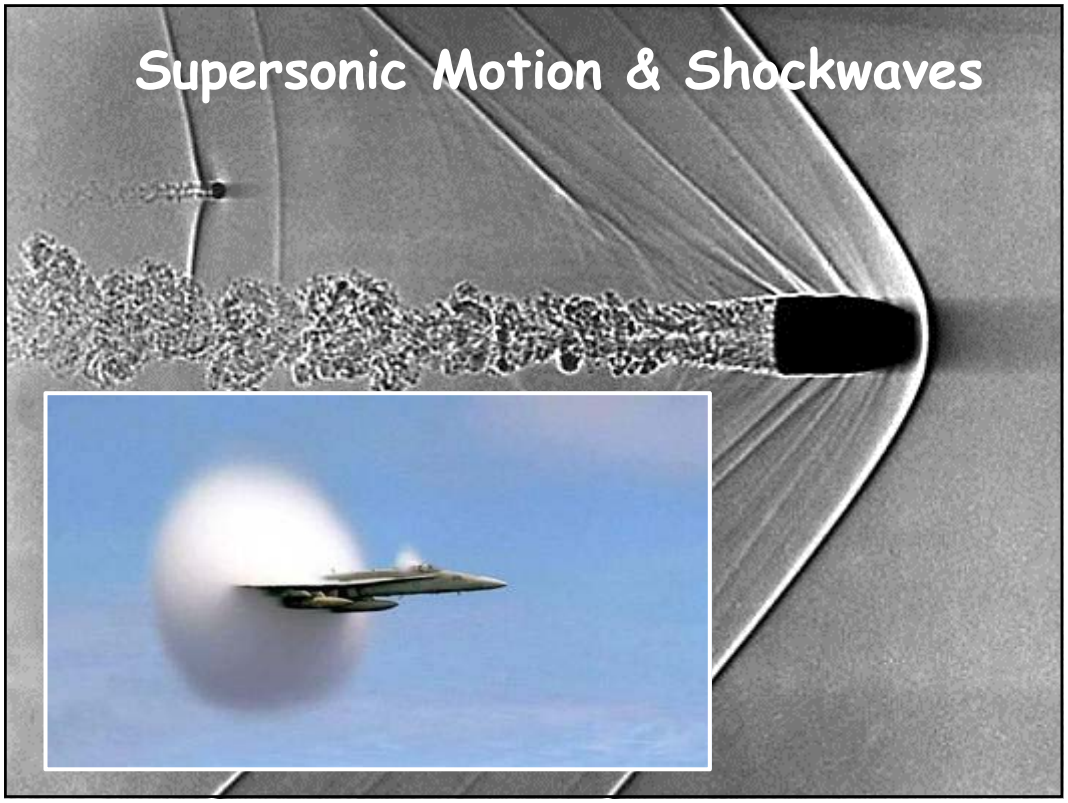
Kelvin-Helmholtz Instability



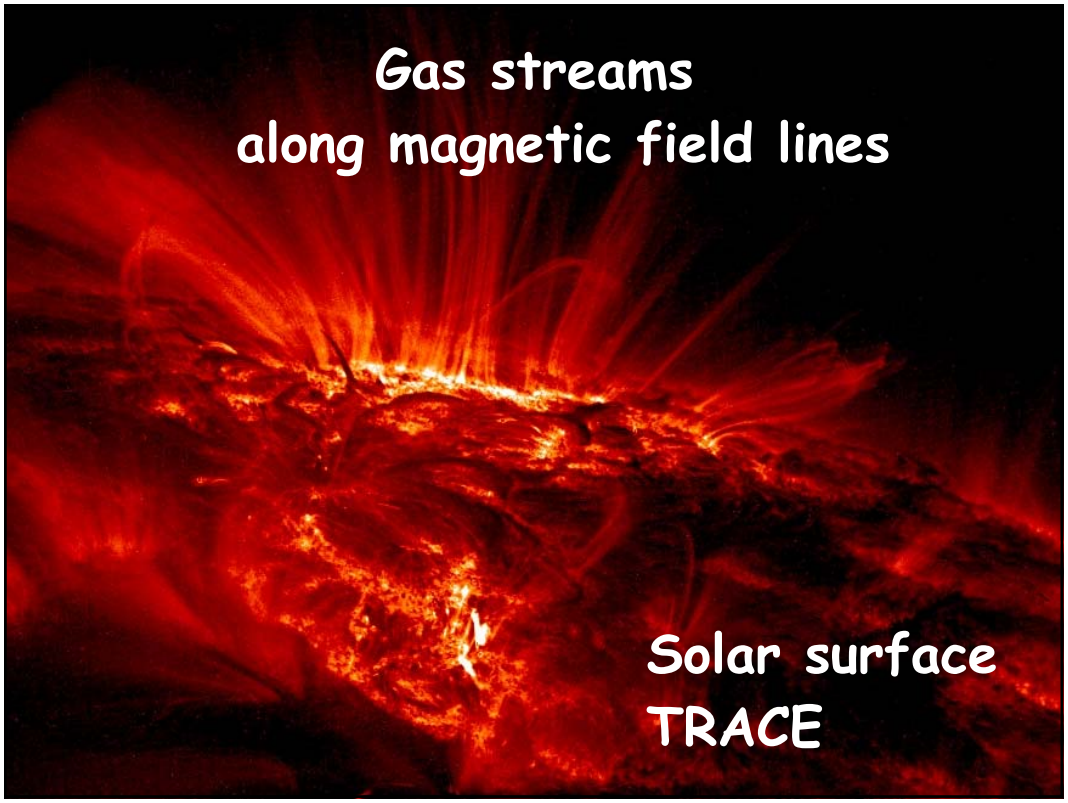
KH instability in Saturn's atmosphere


Supersonic Motion & Shockwaves


Supersonic Motion & Shockwaves


Supersonic Motion & Shockwaves


Cosmic Shockwave:
Supernova remnant CasA


Gas streams
along magnetic field lines
Solar surface
TRACE