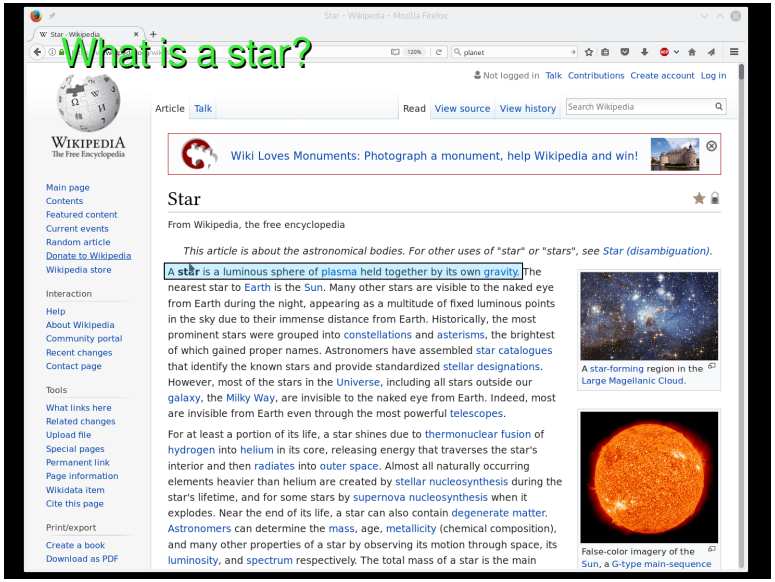
AST 221 - Stars and Planets

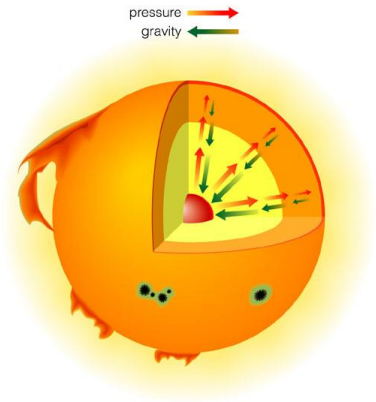
Fall 2017 - Marten van Kerkwijk

www.astro.utoronto.ca/~mhvk/AST221/

What is a star?



Star's life: Protracted battle with gravity



ALWAYS

To support weight:

⇒ need high pressure

MOSTLY

⇒ need high temperature

⇒ will loose energy

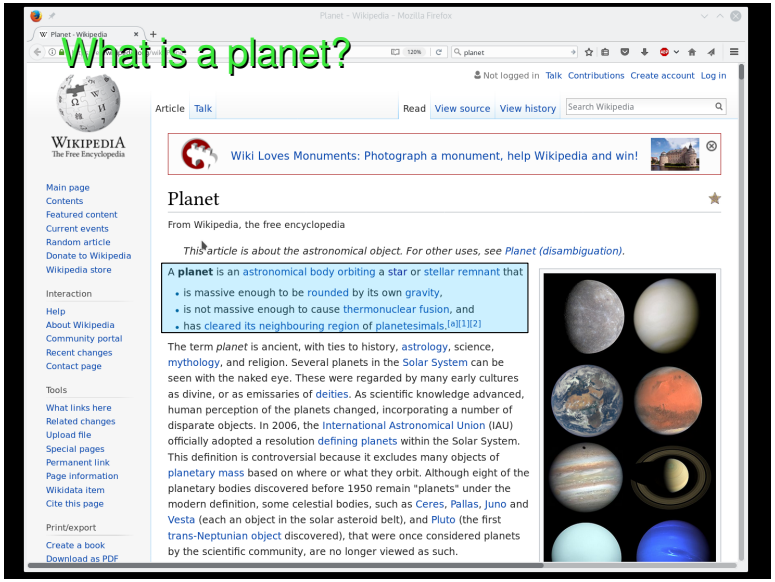
⇒ need energy source:

- Gravitational contraction
- Nuclear fusion

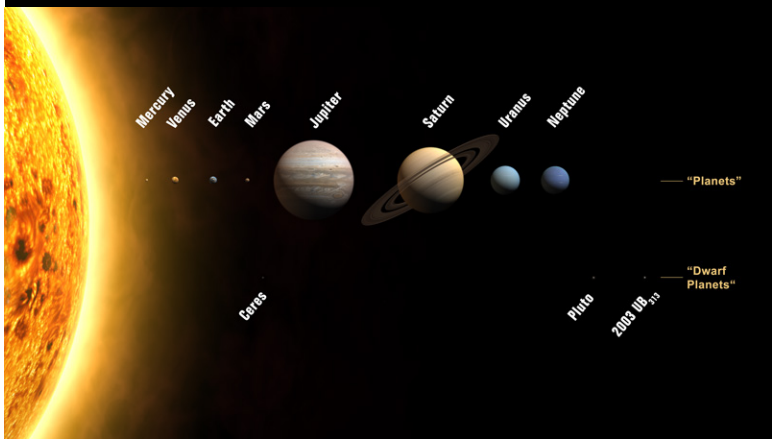
Ultimately,

Can something else than thermal pressure balance gravity?

What is a planet?



What is a planet?



AST 221 - Stars and Planets

1) Introduction to astronomy concepts & phenomena
2) Solidify 1st year physics & math application & understanding
3) Problem solving skills intuition & estimation

This is a quantitative course.

Applied physics!
laws of gravity, Kepler's laws
hydrodynamics, hydrostatic equilibrium
radiation, interaction of light and matter
nuclear physics, quantum physics
matter-matter interaction, equation of state
optics, duality of photons

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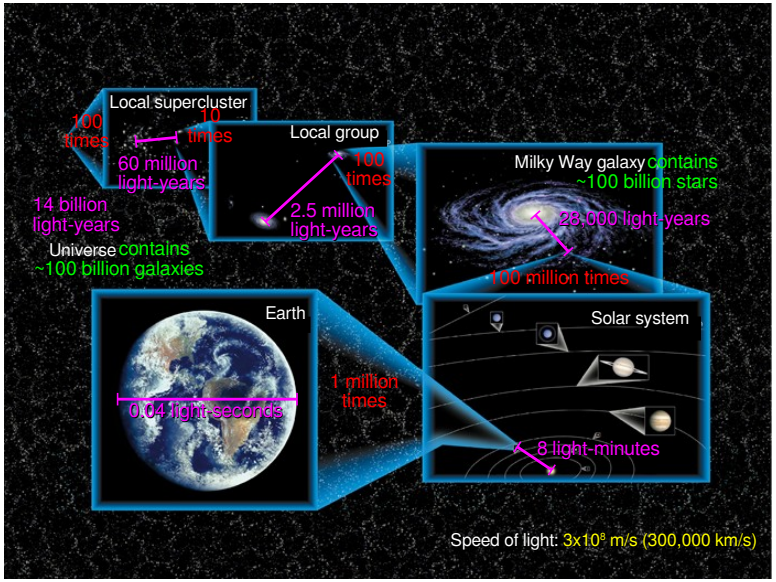
Book:	Introduction to Modern Astrophysics, 2nd edition, Carroll & Ostlie, Addison-Wesley
Lectures:	MWF12, Cody Hall (AB 107) (MW lectures and F tutorial, typically)
Lecturer:	Marten van Kerkwijk
Office hours:	MF, after class, or by appointment
TAs:	Ryan Cloutier Sasha Kostenko

Be there

AST 221 - Stars and Planets

first one posted!

Problem sets (35%)	five sets, due every other Friday; discussion OK, but write up yourself!
Presentation (10%)	~10 minutes, half talk, half discussion; joint with another student; see web site
Midterm (20%)	In-class, 50-minute, open-book exam
Final (35%)	3-hour, calculator-only exam (will get list of constants)



Distance measures

AU: astronomical unit, mean Earth-Sun distance (1.496×10^{11} m)
Mercury 0.4 AU ; Mars 1.5 AU; Pluto 39.5 AU

pc: parsec, *defined* as the distance at which 1 AU is 1"
1 parsec = 1 AU * 180*60*60/π ~ 200,000 AU ~ 3×10^{16} m
closest star – α Cen system, Proxima Centauri: 1.3 pc (4.3 light-yr)
galactic center: ~8 kpc
nearest small galaxy – Large Magellanic Cloud: ~50 kpc
nearest normal galaxy – Andromeda: ~780 kpc
observable universe: ~4 Gpc (speed of light x age of universe of 13 Gyr)

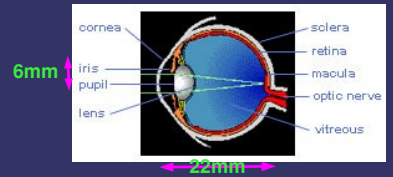
arcsecond ("): a circle 360 deg(°); each deg (°) has 60 arcminutes ('), each arcminute (') has 60 arcseconds (")
1 radian = 180/π deg;
whole sky: 4π ster-radian = $4\pi (180/\pi)(180/\pi) = 360^2/\pi \sim 4 \times 10^4$ square degrees
angular resolution of human eye ~ 1 arcminute
(diffraction limit of 6 mm pupil & matched cone size in retina)
⇒ precision of pre-telescope astronomy
best current day angular resolution ~ milli-arcsecond

Brightness measure

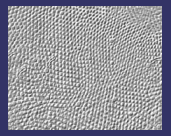
magnitude: a logarithmic brightness scale
difference of 5 mag. = factor 100 in brightness
larger values are *dimmer*

apparent magnitude (m): brightness as observed
Sun $m_V = -26.74$, Sirius (brightest star on sky) $m_V = -1.46$
human eyes see down to $m_V = +6$ (telescope down to m=+30)

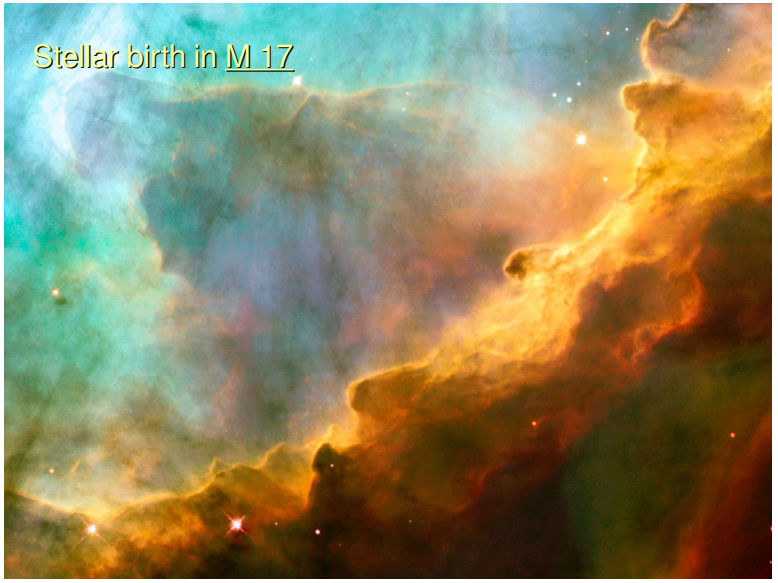
absolute magnitude (M): m at 10pc, intrinsic brightness
Sun $M_V = +4.83$, Sirius $M_V = +1.43$
$m - M = 5 \log_{10} (d/10pc)$



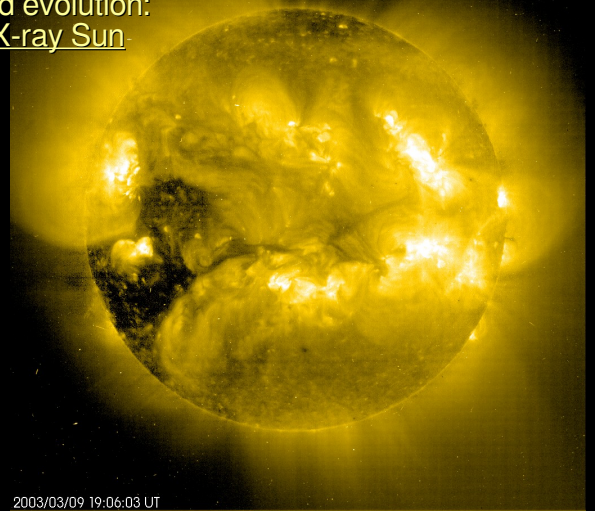
Cones on retina



5 μm = 0.005 mm

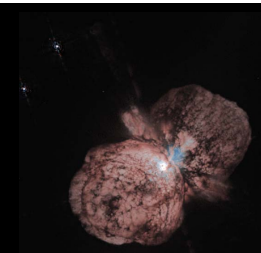


Stellar structure and evolution: X-ray Sun



Stellar death

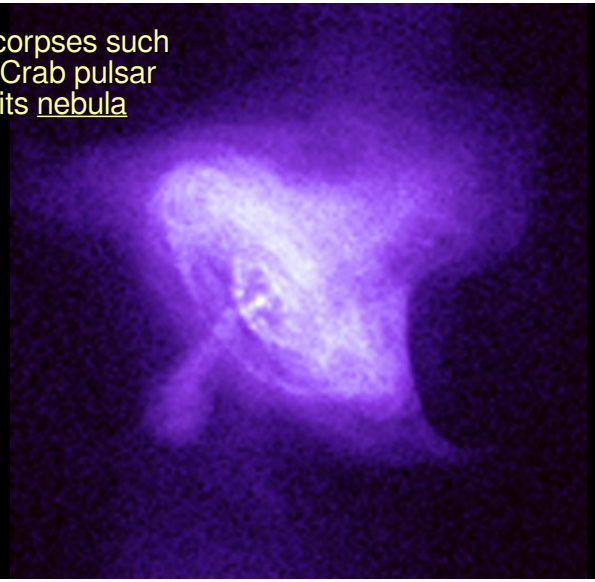
Lost envelope in the Helix nebula



Death throws of Eta Carinae

Mysterious rings in SN 1987A

Stellar corpses such as the Crab pulsar and its nebula



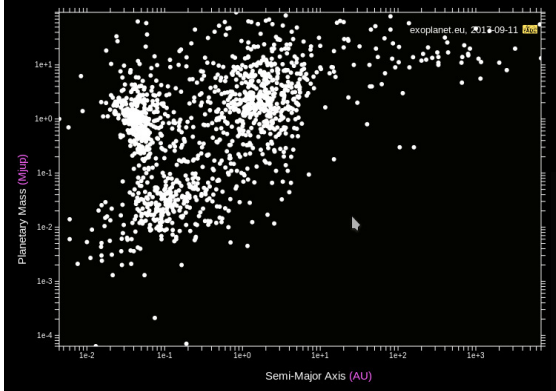
Planets and their formation

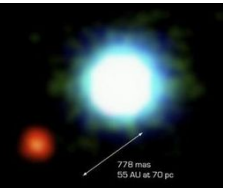
"Hamburger," a proto-planetary nebula

Earth from the Moon

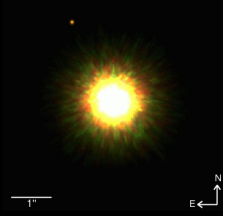
Saturn and its rings

Extra-solar planets





2M J1207B, first directly imaged one



1RXS J1609B, first one around a solar-mass star

History of the Universe in 200 words or less

Quantum fluctuation. Inflation. Expansion. Strong nuclear interaction. Particle-antiparticle annihilation. Deuterium and helium production. Density perturbations. Recombination. Blackbody radiation. Local contraction. Cluster formation. Reionization? Violent relaxation. Virialization. Biased galaxy formation? Turbulent fragmentation. Contraction. Ionization. Compression. Opaque hydrogen. Massive star formation. Deuterium ignition. Hydrogen fusion. Hydrogen depletion. Core contraction. Envelope expansion. Helium fusion. Carbon, oxygen, and silicon fusion. Iron production. Implosion. Supernova explosion. Metals injection. Star formation. Supernova explosions. Star formation. Condensation. Planetesimal accretion. Planetary differentiation. Crust solidification. Volatile gas expulsion. Water condensation. Water dissociation. Ozone production. Ultraviolet absorption. Photosynthetic unicellular organisms. Oxidation. Mutation. Natural selection and evolution. Respiration. Cell differentiation. Sexual reproduction. Fossilization. Land exploration. Dinosaur extinction. Mammal expansion. Glaciation. Homo sapiens manifestation. Animal domestication. Food surplus production. Civilization! Innovation. Exploration. Religion. Warring nations. Empire creation and destruction. Exploration. Colonization. Taxation without representation. Revolution. Constitution. Election. Expansion. Industrialization. Rebellion. Emancipation Proclamation. Invention. Mass production. Urbanization. Immigration. World conflagration. League of Nations. Suffrage extension. Depression. World conflagration. Fission explosions. United Nations. Space exploration. Assassinations. Lunar excursions. Resignation. Computerization. World Trade Organization. Terrorism. Internet expansion. Reunification. Dissolution. World-Wide Web creation. Composition. Extrapolation?