Lecture 0

PC3246 Astrophysics I

Dr. Cindy Ng

- Senior lecturer
- Research areas:
  - Cosmology
  - Dark energy
  - Testing models using observational data
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Course Description

- Introduction to astrophysics
- Coverage:
  - Observational astronomy
  - Celestial mechanics
  - Stars

(a)

Learning Outcomes

- Understand the astrophysical concepts presented in journal articles
- Design and conduct astronomical observations
- Analyze and interpret astronomical data

List of topics

Observational astronomy

1. Celestial sphere
2. Telescopes

Celestial mechanics

3. Celestial mechanics
4. Second-order effects of gravity

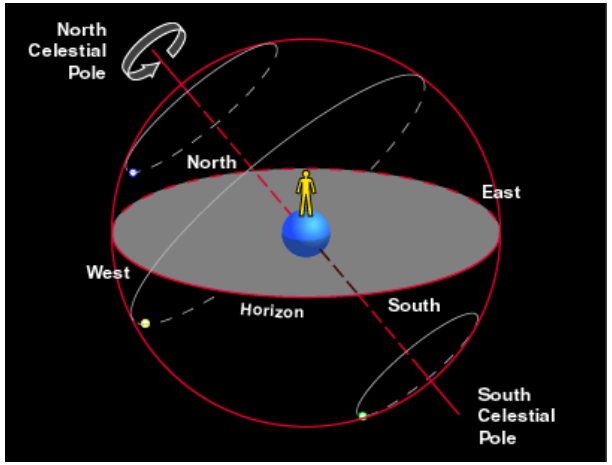
Stars

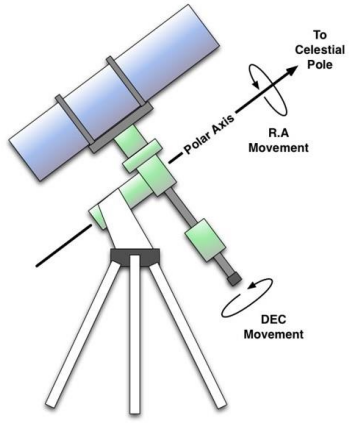
5. Properties of stars
6. Binary systems
7. Stellar spectra
8. Stellar atmospheres
9. Stellar interiors
10. Interstellar medium & star formation

Observational astronomy

1. Celestial sphere
   - Celestial motions
   - Celestial coordinate systems
2. Telescopes
   - Optical telescope
   - Radio telescope
   - Other telescopes

http://lifeng.lamost.org/courses/Hongkong/Hongkong_En/lecture/ch02/ch02.html

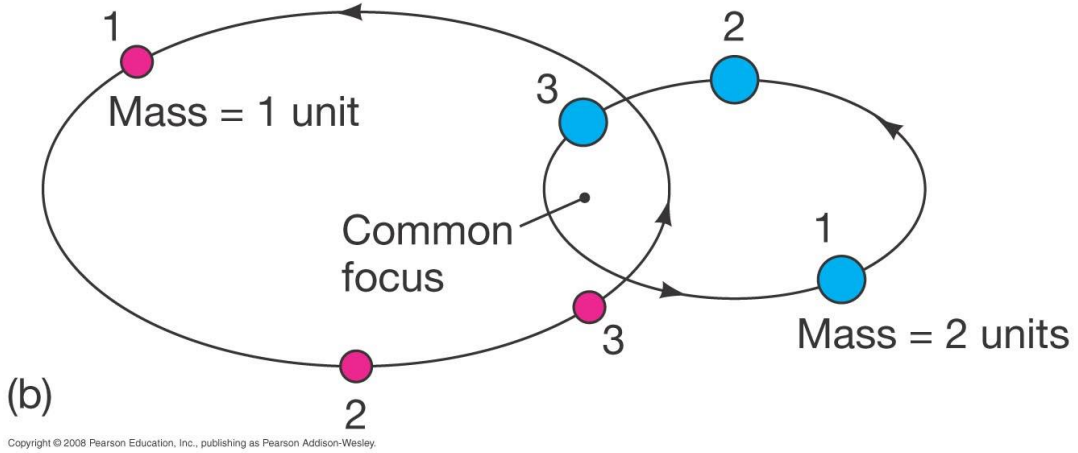




https://scienceatyourdoorstep.com/2017/10/05/improved-telescope-mounting/

Celestial mechanics

3. Celestial mechanics
   - Kepler's laws of planetary motion
   - Derivation
4. Second-order effects of gravity
   - Axial precession
   - Tidal force



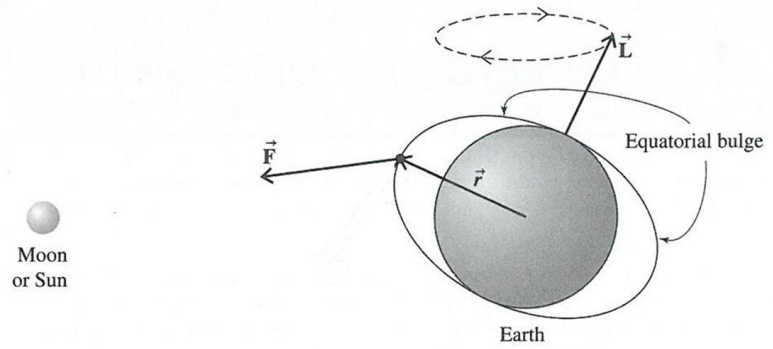
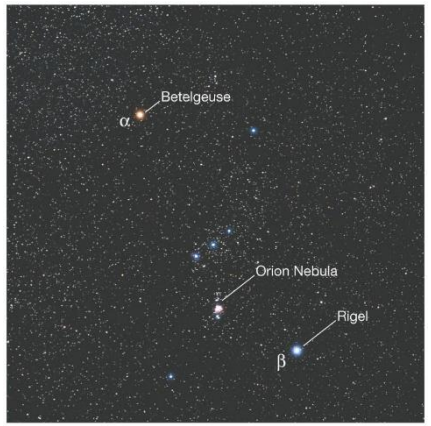


FIGURE 4.1 Gravitational torque on the Earth's equatorial bulge results in precession of the rotation axis. The torque vector is pointing out of the page.

Stars

5. Properties of stars
   - Stellar parallax
   - Apparent magnitude
   - Color index



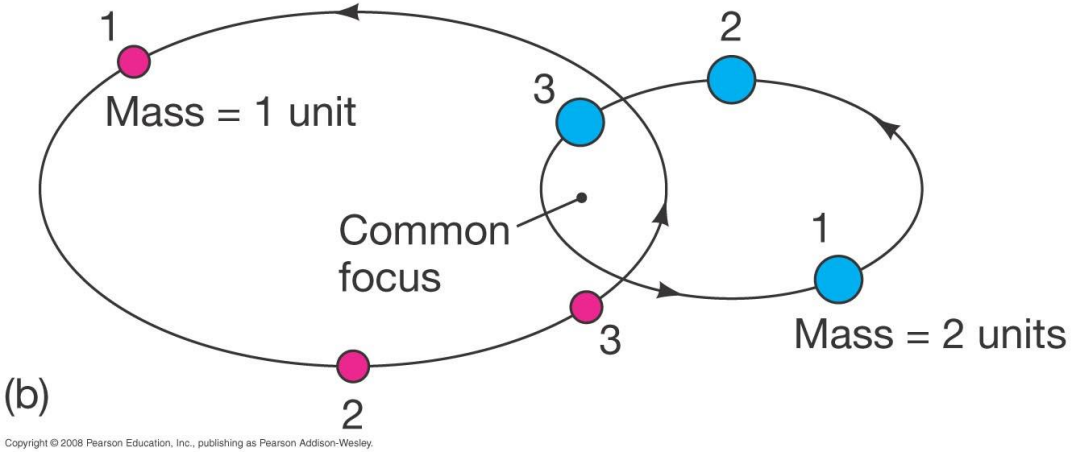
(a)

Betelgeuse

Observation data	
Epoch J2000.0	Equinox J2000.0
Constellation	Orion
Pronunciation	/ˈbɛtəldʒuːz, ˈbiːt-, -dʒuːs/ *BE(E)T-əl-jooz, -jooss*[1][2] (*see below*)
Right ascension	$05^h\ 55^m\ 10.30536^s$[3]
Declination	+07° 24′ 25.4304″[3]
Apparent magnitude (V)	+0.50[4] (0.0–1.6[5])
Characteristics	
Evolutionary stage	Red supergiant
Spectral type	M1–M2 Ia–ab[6]
Apparent magnitude (J)	−3.00[7]
Apparent magnitude (K)	−4.05[7]
U−B color index	+2.06[4]
B−V color index	+1.85[4]
Variable type	SRc[8]
Astrometry	
Radial velocity (R_v)	+21.91[9] km/s
Proper motion (μ)	RA: 26.42 ±0.25[10] mas/yr Dec.: 9.60 ±0.12[10] mas/yr
Parallax (π)	$5.95\ ^{+0.58}_{-0.85}$ mas[11]
Distance	$408 – 548\ ^{+90}_{-49}$ ly (125[12] – $168.1\ ^{+27.5}_{-14.9}$[11] pc)
Absolute magnitude (M_V)	−5.85[13]

6. Binary systems

- Visual binary
- Spectroscopic binary
- Eclipsing binary



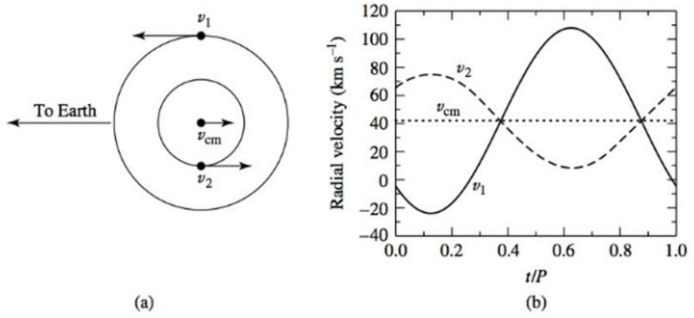


FIGURE 5 The orbital paths and radial velocities of two stars in circular orbits ($e = 0$). In this example, $M_1 = 1\ M_\odot$, $M_2 = 2\ M_\odot$, the orbital period is $P = 30$ d, and the radial velocity of the center of mass is $v_{cm} = 42$ km s^{-1}. v_1, v_2, and v_{cm} are the velocities of Star 1, Star 2, and the center of mass, respectively. (a) The plane of the circular orbits lies along the line of sight of the observer. (b) The observed radial velocity curves.

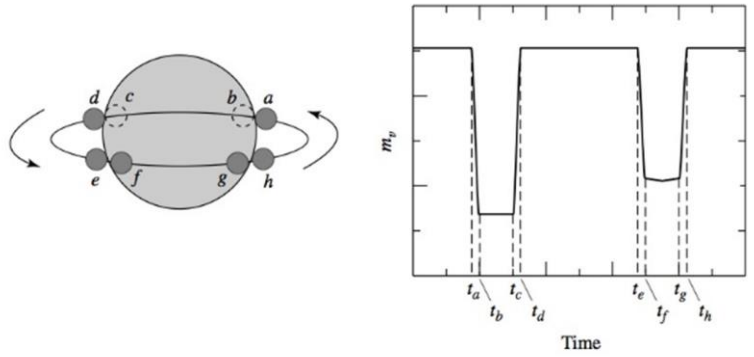


FIGURE 9 The light curve of an eclipsing binary for which $i = 90°$. The times indicated on the light curve correspond to the positions of the smaller star relative to its larger companion. It is assumed in this example that the smaller star is hotter than the larger one.

7. Stellar spectra

- Hertzsprung-Russell diagram

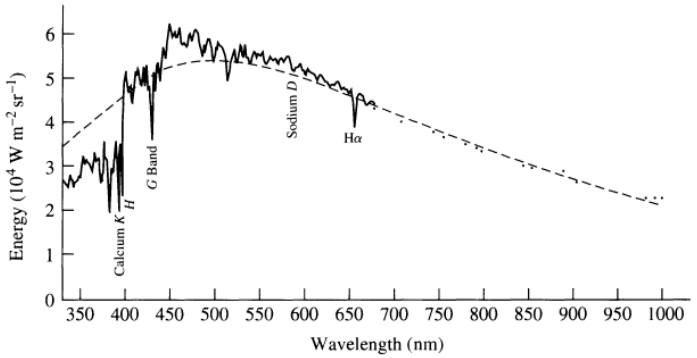


FIGURE 9.5 The spectrum of the Sun in 2 nm wavelength intervals. The dashed line is the curve of an ideal blackbody having the Sun's effective temperature. (Figure adapted from Aller, *Atoms, Stars, and Nebulae*, Third Edition, Cambridge University Press, New York, 1991.)

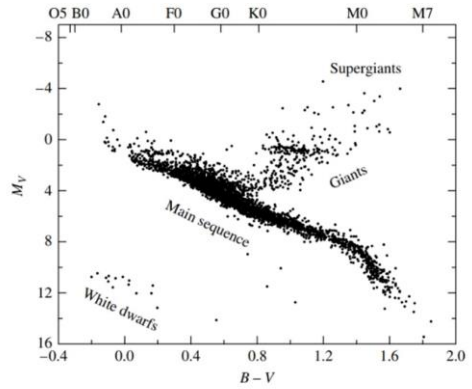
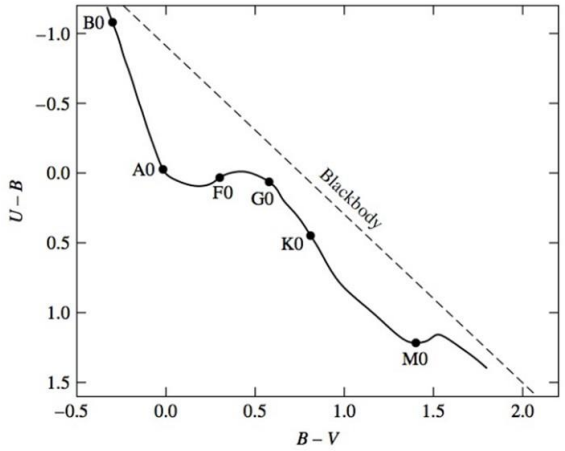


FIGURE 13 An observer's H–R diagram. The data are from the Hipparcos catalog. More than 3700 stars are included here with parallax measurements determined to better than 20%. (Data courtesy of the European Space Agency.)

8. Stellar atmospheres

- Color-color diagram
- Profile of a spectral line



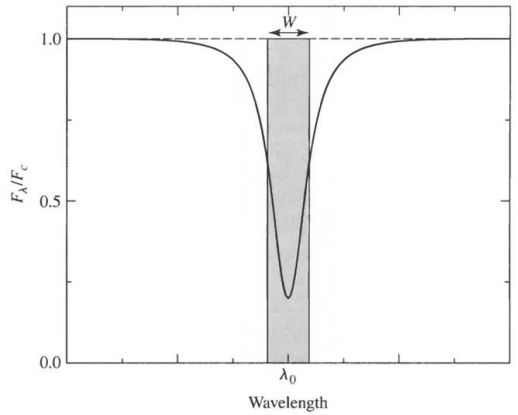


FIGURE 9.18 The profile of a typical spectral line.

9. Stellar interiors

- Equations of stellar structure

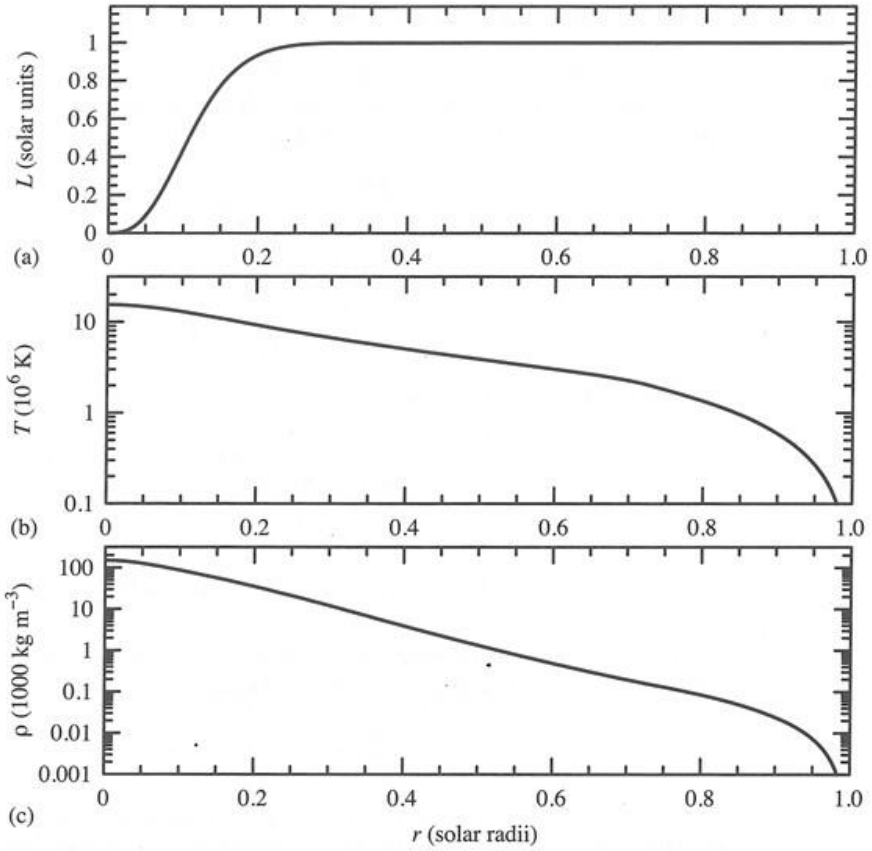
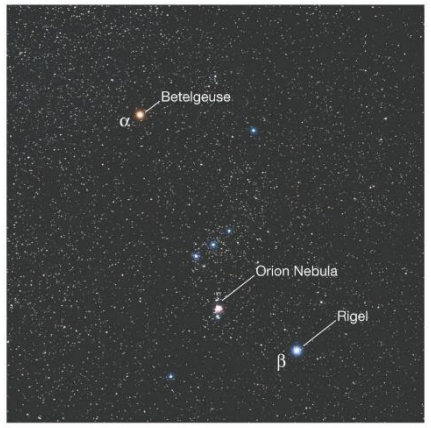


FIGURE 15.7 (a)–(c) Enclosed luminosity, temperature, and mass density as a function of radius within the Sun.

10. Interstellar medium & star formation

- Jeans mass



(a)

Textbooks

- Carroll & Ostlie, “An Introduction to Modern Astrophysics”, Cambridge
  I. The tools of astronomy (Astrophysics I)
  II. The nature of stars (Astrophysics I & II)
  III. The Solar System
  IV. Galaxies and the Universe (Astrophysics II)
- Ryden & Peterson, “Foundations of Astrophysics”, Pearson

PC4249 – Astrophysics II

- Stellar evolution
  - Nuclear Astrophysics
  - Lecturer: Associate Prof. Thomas Osipowicz
- Galaxies
  - Lecturer: Dr. Abel Yang

Teaching modes

- Lecture
  - Monday & Wednesday, 10 – 11:30am
- Consultation
  - Wednesday, 9 – 10 am
    - Venue: S16-0307
  - Other timeslots: By appointment

Assessment

- Participation – 5%
- Assignments – 10%
- Term tests – 25%
- Final exam – 45%
- Project – 15%

Participation (5%)

- Attend lectures regularly
- Answer questions & ask good questions during the lectures

Assignments (10%)

- Weekly assignments
  - Published on Thursday
  - Due on the following Wednesday

Term tests & final exam

- Term test 1 – 10%
  - Coverage: Lecture 1 – 3
- Term test 2 – 15%
  - Coverage: Lecture 4 – 6
- Final exam – 45%
  - Coverage: Lecture 1 - 10

Project (15%)

- Three options
  1. Conduct an astronomical observation
  2. Study a journal article
  3. Design your own project
- Submit a report and give a presentation
  - Individual report
  - Group presentation (for group project)

Conduct an astronomical observation

- Suggested topics (related to the course)
  - Observe bright stars and measure their color indices
  - Observe Jupiter's moons, measure their orbits, and calculate Jupiter's mass
  - Measure stellar spectra
  - Capture an image of a nebula to reveal its star-forming region

Telescope equipment request

- Approach Dr. Abel Yang
- Group project: $\sim$ 4 (or fewer) members

Stargazing sessions

- Fridays:
  - 31 January (Week 3)
  - 14 February (Week 5)
  - 21 March (Week 9)
  - 4 April (Week 11)
- Venue: Multi-Purpose Fields

Stargazing field trip

- Date: 21 – 23 February (Weekend of Week 6)
- Cost: $250 (triple sharing), $280 (twin sharing)
  - Includes all accommodations, meals and transport
- Destination: Teluk Penyabung Resort Mersing, Johor, Malaysia
- Signup due date: 31 January

Report/presentation format

- Introduction
- Equipment & methods
- Observations/Data
- Analysis
- Discussion
- Conclusion

Study a journal article

- A journal article that was published recently
- Suggested topic: Extrasolar planet (related to binary systems)
  - An extrasolar planet detected by one of the following methods:
    - Astrometry
    - Radial velocity
    - Transit method
- Explain the astrophysical concepts
- Replicate the data analysis
- Individual or group (2 members) project

Design your own project

- Topic: Related to the course
  - Refer to the course's list of topics
- Subject to approval

Due dates

- Report
  - Due date: 15 April (Tuesday of Week 13)
- Presentation
  - Date: 16 April (Wednesday of Week 13)

Evaluation criteria (15%)

1. Difficulty of project
2. Substantiality of student's contribution
3. Mastery of subject
4. Originality of project
5. Quality of report
6. Quality of presentation