Seminar 1
Session 09: Reading a textbook

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first semester, academic year 2022
28 November 2022

Did you think about the question about asteroseismology?

About asteroseismology

- Why we tap a watermelon before buying it?
- How do we know the internal structure of the Earth?
- What is asteroseismology?
- Has anyone studied about asteroseismology?

Some notes for reading a textbook

Some notes for reading a textbook

- Each of you have given two oral presentations this semester.
- Some of you have not checked the meaning of English words that you do not know.
  - Now, dictionaries are available via your favourite web browser.
  - You can check the meaning of an English word that you do not know in a few seconds.
  - Don't be lazy.
- Some of you have not studied the meaning of technical terms that you do now know.
  - Use "樂詞網" of 國家教育研究院
    - `https://terms.naer.edu.tw/`
  - Use an encyclopedia.
    - e.g. Encyclopaedia Britannica

Some notes for reading a textbook

- Some of you may need to study basic physics and mathematics.
    - If you think you need to study basic physics and mathematics, upcoming winter vacation is a good opportunity for your follow-up study for basic physics and mathematics.
- Some of you may need to study basic astronomy.
    - If you think you need to study basic astronomy, upcoming winter vacation is a good opportunity for your follow-up study for undergraduate level astronomy.
    - Suggested textbooks:
        - Openstax "Astronomy 2e": `https://openstax.org/details/books/astronomy-2e`
        - "Universe" by Freedman, Geller, and Kaufmann

Some more additional notes

- Asking question is important for your research work.
  - The prize “天問獎” was awarded to Frank Shu (徐遐生) by ASROC (天文學會) in 2016.
  - At the annual meeting, a student asked Frank Shu a question.
  - “How to do a good research?”
  - Frank Shu answered “Ask questions!”.
- If you do not know who is Frank Shu, go to Google website, type “Frank Shu”, and push the button.
  - `https://www.asiaa.sinica.edu.tw/people/cv.php?i=fshu`
- Ask questions if you find anything you do not know.

Some more additional notes

- Be active!
  - Study actively when you find anything you have not studied yet.
  - Study actively when you find anything you have studied before, but you have forgotten about it.

Today's activity

Exercise 01

A *star* can be defined as a body that satisfies two conditions: (a) it is bound by self-gravity; (b) it radiates energy supplied by an internal source. From the first condition it follows that the shape of such a body must be spherical, for gravity is a spherically symmetric force field. Or, it might be spheroidal, if axisymmetric forces are also present. The source of radiation is usually nuclear energy released by fusion reactions that take place in stellar interiors, and sometimes gravitational potential energy released in contraction or collapse. By this definition, a *planet*, for example, is not a star, in spite of its stellar appearance, because it shines (mostly) by reflection of solar radiation. Nor can a *comet* be considered a star, although in early Chinese and Japanese records comets belonged with the 'guest *stars*' – those stars that appeared suddenly in the sky where none had previously been observed. Comets, like planets, shine by reflection of solar radiation and, moreover, their masses are too small for self-gravity to be of importance.

Exercise 01

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 02

We shall therefore start pursuing the evolution of a star from the earliest time when both conditions of the definition have been fulfilled, and we shall stop when at least one condition has ceased to be satisfied, completely and irreversibly. Finally, we shall consider the life cycle of stellar populations and the effect of stellar evolution on the evolution of galaxies within which stars reside. Galaxies are large systems of stars (up to 10^{11} or so), which also contain interstellar clouds of gas and dust. Many of the stars in a galaxy are aggregated in clusters, the largest among them containing more than 10^5 stars. The object of reference in stellar physics is, naturally, the Sun, and in galactic physics, the Galaxy to which it belongs, also known as the Milky Way galaxy.

Exercise 02

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 03

Astrophysics (the physics of stars) does not lend itself to experimental study, as do the other fields of physical science. We cannot devise and conduct experiments in order to test and validate theories or hypotheses. Validation of a theory is achieved by accumulating observational evidence that supports it and its predictions or inferences. The evidence is derived from events that have occurred in the past and are completely beyond our control. The task is rather similar to that of a detective. As a rule of thumb, a theory is accepted as valid (or at least highly probable) if it withstands two radically different and independent observational tests, and of course, so long as no contradictory evidence has been found.

Exercise 03

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 04

The surface temperatures of stars range between a few thousand to a few hundred thousand degrees Kelvin (K), the wavelength of maximum radiation $\lambda_{\max}$ shifting, according to Wien's law

$$\lambda_{\max} T = \text{constant}, \tag{1.4}$$

from infra-red to soft X-rays. The effective temperature of the Sun is 5780 K. We should bear in mind, however, that conclusions regarding internal temperatures cannot be drawn from surface temperatures without a theory.

Exercise 04

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 05

The chemical composition, too, can be inferred from the spectrum. Each chemical element has its characteristic set of spectral lines. These lines can be observed in the light received from stars, superimposed upon the continuous spectrum, either as emission lines, when the intensity is enhanced, or as absorption lines, when it is diminished. The elements that make up the photosphere of a star, which emits the observed radiation, may thus be identified in the stellar spectrum. But since the photosphere is very thin, the deduced composition is not representative of the bulk, opaque interior of the star. Most of the chemical elements were found to be present in the solar spectrum. In fact the existence of the element *helium* was first suggested by spectral lines from the Sun (in the 1860s); its name is derived from 'helios', the Greek word for Sun.

Exercise 05

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 06

Under certain conditions, the mass of a star that is a member of a binary system can be calculated, based on spectral line shifts, as we shall show in Chapter 11. Very seldom, in eclipsing binary systems, may the radius of a star be directly derived; it can, however, be estimated from the independently derived luminosity (when possible) and effective temperature using Equation (1.3). Stellar masses and radii are measured in units of the *solar mass*, $M_\odot = 1.99 \times 10^{30}$ kg, and the *solar radius*, $R_\odot = 6.96 \times 10^8$ m. The mass range is quite narrow – between $\sim 0.1 M_\odot$ and a few tens $M_\odot$; stellar radii vary typically between less than $0.01 R_\odot$ to more than $1000 R_\odot$. Much more compact stars exist, though, with radii of a few tens of kilometres.

Exercise 06

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 07

In a similar manner, if we find that a certain property is common to a great number of stars, we may infer – on the basis of the evolution hypothesis – that such a property prevails in stars for long periods of time. By the same token, rarely observed phenomena might not be rare events, but simply short-lived ones. At the same time, the possibility of actually rare phenomena cannot be entirely ruled out. This is a sample of the problems one would have to face if the understanding of stars and their evolution were to rest entirely on observation.

Exercise 07

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 08

With very few exceptions, the abundances of the chemical elements, as derived from stellar spectra, are remarkably similar. Moreover, they are very similar to those prevailing in the interstellar medium. As stars are born in interstellar clouds, and the composition of their surface layers is expected to be the least affected by evolutionary processes, it may be concluded that there is little difference in the *initial* composition of stars. The largest differences occur for the abundances of the heavy elements, which vary among different stars between less than 0.001 to a few per cent of the entire stellar mass. But differences in the initial abundances of these elements are of secondary importance to stellar evolution. For simplicity, we shall ignore differences in the initial composition of stars. In numerical examples we shall generally adopt the solar composition. The fate of a star will then be solely dependent upon its initial mass M.

Exercise 08

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 09

Departure from spherical symmetry may be caused by rotation or by the star's own magnetic field (since by assuming isolation, we have excluded all possible external force fields). In the overwhelming majority of cases, the energy associated with these factors is much smaller than the gravitational binding energy. We know, for example, that the period of revolution of the Sun around its axis is about 27 days, so that its angular velocity is $\omega \simeq 2.5 \times 10^{-6}\ \mathrm{s}^{-1}$. The spin velocity of more distant stars can be deduced from the broadening of spectral lines caused by the Doppler effect. The kinetic energy of rotation relative to the gravitational binding energy is of the order:

$$\frac{M\omega^2 R^2}{GM^2/R} = \frac{\omega^2 R^3}{GM} \sim 2 \times 10^{-5},$$

where G is the constant of gravitation. (This is also the ratio of the centrifugal acceleration to the gravitational acceleration at the equator.)

Exercise 09

- Read the paragraph.
- Translate the highlighted part into Chinese.
- Write down your translation.

Exercise 10

Another region of the ($\log T_{\mathrm{eff}}$, $\log L$) plane that is relatively rich in points is located at the lower left corner: low luminosities and high effective temperatures. Stars that fall in this region have a small radius and a bluish-white colour; accordingly, they are named *white dwarfs*. White dwarf radii are of the order of the Earth's, although their masses are close to the Sun's. The typical densities of such stars are therefore tremendous; one cubic centimetre of white dwarf material would weigh more than a ton on Earth.

Exercise 10

- Read the paragraph.
- Calculate typical mean density of a white dwarf.
- Is the result of your calculation roughly equal to $\sim$ a ton per cubic centimetre?

Need to improve your English reading skill?

- If you think you need to improve your English reading skill, do not miss the winter vacation time.
  - Think about what to do in winter vacation now, if you think you need to improve your English reading skill.
  - And, start your action next week.

Need any help?

- If you think you need to study astronomy (or mathematics, physics, English, or computer programming), but you have no idea what to do, come and talk to me. I may be able to give you some suggestion.