

25.2 Stellar radii

Name: _____ Class: _____ Date: _____

Total: 26 marks

KEY WORDS stefan-boltzmann law 斯特藩-玻尔兹曼定律 • wien's displacement law 维恩位移定律
• temperature 温度 • wavelength 波长 • blackbody 黑体

Objective

Build the skills to answer exam questions on **stellar temperature and radius**.

You must be able to:

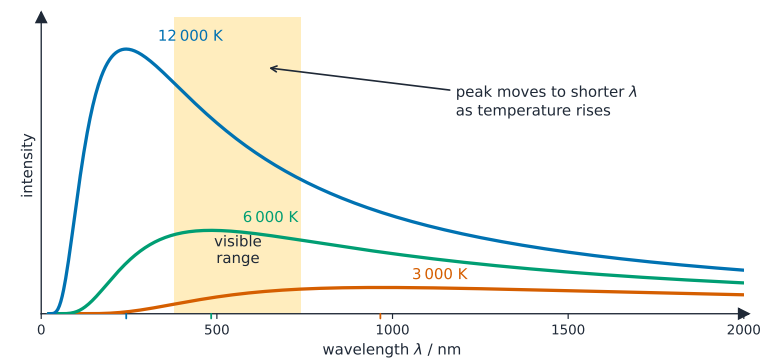
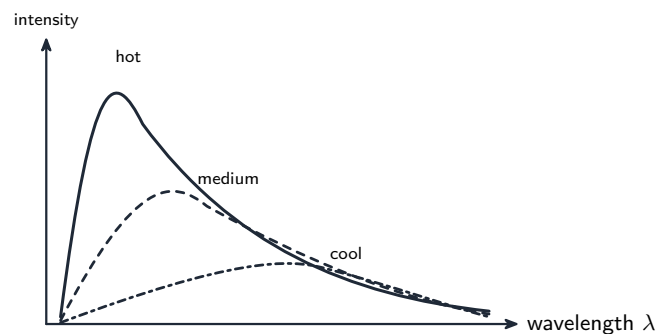
- use **Wien's law** $\lambda_{\max}T = \text{constant}$
- use the **Stefan-Boltzmann law** $L = 4\pi\sigma r^2T^4$
- combine them to estimate a star's **radius**

1 Worked examples

Study these first. Each one shows the method for a question type used later — follow the steps and you can do the Practice and Exam-style questions yourself.

■ Wien's law

A star radiates a **black-body** spectrum; a **hotter** star radiates more and peaks at a **shorter** wavelength:



Wien: $\lambda_{\max}T = \text{const}$ • hotter $\Rightarrow$ peak shifts left

A blackbody curve and Wien law

$$\lambda_{\max}T = b, \quad b = 2.90 \times 10^{-3} \text{ m K}.$$

■ Stefan-Boltzmann law and radius

$$L = 4\pi\sigma r^2T^4, \quad \sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}.$$

Find T from Wien's law, then $r = \sqrt{\frac{L}{4\pi\sigma T^4}}$.

Worked example. $\lambda_{\max} = 500 \text{ nm}$: $T = \frac{2.90 \times 10^{-3}}{500 \times 10^{-9}} = 5800 \text{ K}.$

2 Practice

Now apply the methods above.

2.1 Write Wien's displacement law.

[1]

2.2 A star's spectrum peaks at 500 nm. Find its surface temperature.

[2]

2.3 Write the **Stefan–Boltzmann law**. [1]

2.4 State how λ_{max} changes for a **hotter** star. [1]

3 Exam-style questions

3.1 A **hotter** star has its peak emission at a: [1]

- | | |
|---|---|
| A | B |
| C | D |
- A longer wavelength
B shorter wavelength
C the same wavelength
D no peak

3.2 A star's black-body spectrum peaks at 290 nm. Calculate its surface **temperature**. [2]

3.3 Star P has radius 7.0×10^8 m and surface temperature 5800 K. Star Q has the **same** surface temperature but **three times** the radius. ($\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$.)

(a) Calculate the luminosity of star P. [2]

(b) Without further calculation, state and explain the luminosity of star Q. [2]

3.4 Outline how a star's **radius** can be estimated from its spectrum. [2]

3.5 The light from a distant star is analysed. Its intensity is greatest at a wavelength of 580 nm, and its radiant flux intensity at the Earth is $3.6 \times 10^{-10} \text{ W m}^{-2}$. The star is 8.4×10^{17} m away. Take Wien's displacement constant as $2.90 \times 10^{-3} \text{ m K}$ and $\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$.

(a) **State** Wien's displacement law. [2]

(b) **Determine** the surface temperature of the star. [2]

(c) **Determine** the luminosity of the star. [2]

(d) **Determine** the radius of the star, and **compare** it with the Sun's radius of 7.0×10^8 m. [3]

(e) A second star has the **same** luminosity but a surface temperature twice as high. **Determine** the ratio $\frac{\text{radius of the second star}}{\text{radius of the first}}$, and **state** what kind of star that suggests.^[3]