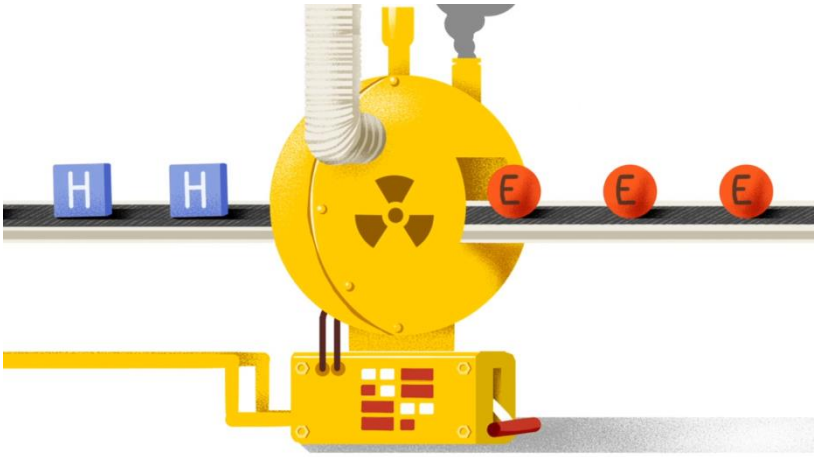
ROYAL OBSERVATORY GREENWICH

When will the Sun become a red giant?

Post-16

Topics covered: Energy, power, mass-energy equivalence, nuclear fusion

Watch the video "How do we know how old the Sun is?"
https://vimeo.com/88978362



Nuclear fusion of hydrogen takes place in the core of the Sun where temperatures reach 15 million °C and helium is produced along with energy. Around 10% of the mass of the Sun will be converted into helium during its lifetime, only the hydrogen in the very hot centre can undergo fusion.

In the core 0.7% of this mass is converted into **energy**, this can be calculated using the energy-mass equivalence relationship:

$$E = mc^2$$

where E is the energy released, m is the mass converted into energy and c is the speed of light = 3×10^8 m s^{-1}.

1. Using the total power output of the Sun (the energy released per second = 3.8×10^{26} W), work out the mass converted into energy every second (in kg).

2. Only 0.7% of protons are converted into energy powering the Sun, find the total number of protons used in nuclear fusion every second. The mass of a proton is 1.67×10^{-27} kg.

3. Only 10% of the Sun's mass is converted into helium, find out the approximate lifetime of the Sun assuming the rate of nuclear fusion stays constant. The mass of the Sun is 1.989×10^{30} kg.

4. How long will the Sun's core hydrogen last?

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When will the Sun become a red giant?: ANSWERS

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1. 4.22×10^{9} kg per sec
2. 3.6×10^{38} protons
3. 10.5 billion years
4. ~ 5 billion years (current age of Sun is 4.6 billion years)