It's A Heat Wave

Using a Radiometer to compare infrared radiation (heat) of different "star types".

Materials: (for each station)
- Radiometer
- Bulb and dimmer set-up (as described)
- Stopwatch
- Student data sheets

To Do and Notice:

1. Turn the dimmer switch Off. Place the radiometer so that the edge of the base is 50 cm from the edge of the ceramic bulb holder base. (This distance might need to be adjusted for individual radiometers so that the rotations of the vane are neither too slow nor too fast to be counted.) Make sure the radiometer vanes are not turning.

2. Turn the dimmer to the "A" star mark. Wait 30 seconds. Record the number of times the vanes go around in 10 seconds. (You will need a partner to time it for you.)

3. Repeat this procedure for "G" star and "M" star settings. Each time, gently stop the radiometer, then wait 30 seconds for it to reach speed before counting. Record all data.

Extension:

Find the "Habitable Zone" around different star types.
Set a certain number of turns per minute—say 30—and define that as the habitable zone, where the temperature would be within a range that water could exist in a liquid state. Find that zone around each of the star types on your radiometer. Measure and compare the distances.

What's Going On:

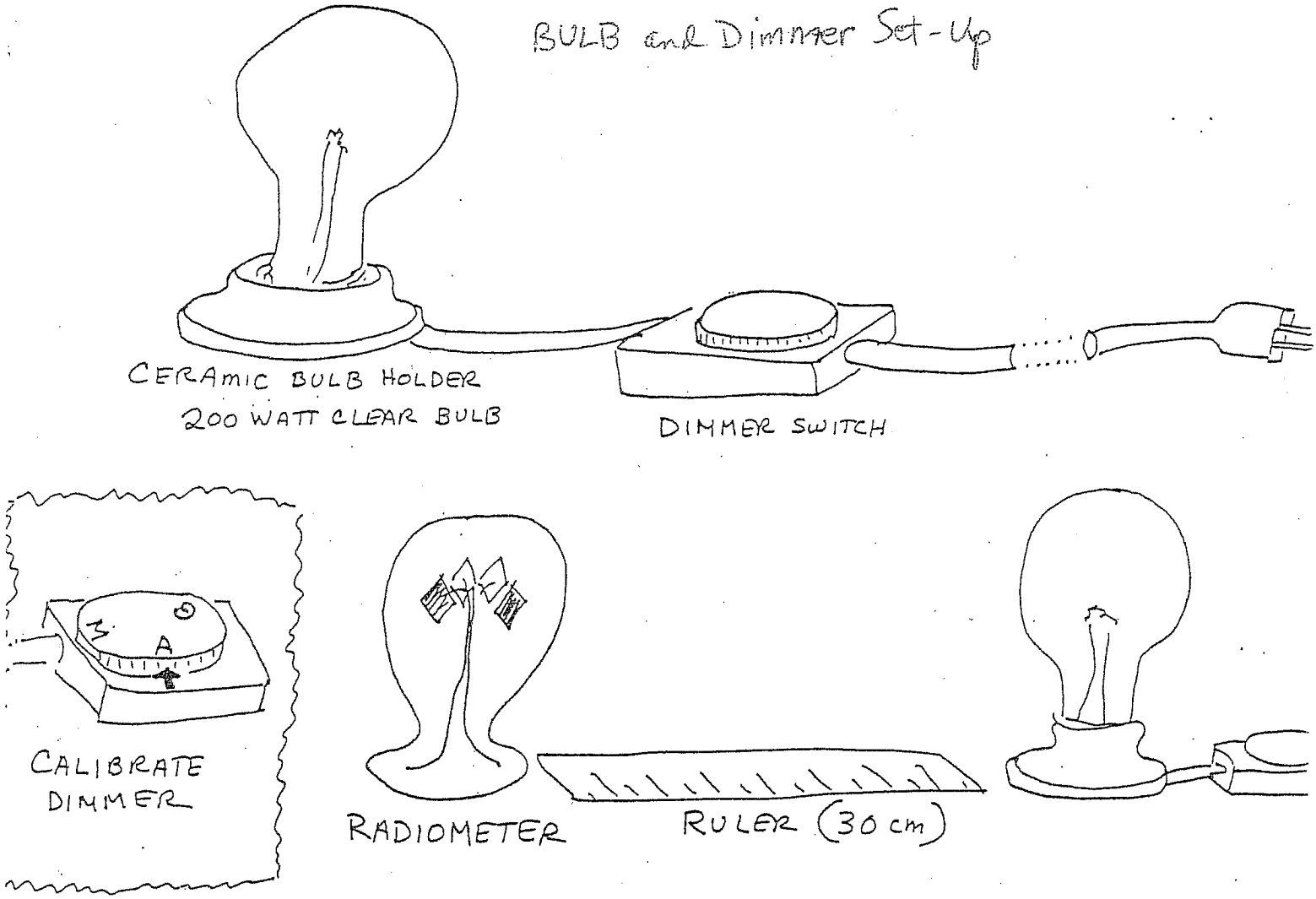
A star's color is determined by its temperature. Two astronomers, Ejnar Hertzsprung and Henry Russell, found this relationship between the magnitude (brightness) of a star and its temperature. As the temperature increases, the brightness increases, unless the star appears bright just because it is close. This relationship forms a pattern—see the Hertzsprung-Russell Diagram.

Other scientists discovered that there is a relationship between a star's temperature and its mass. Stars with more mass burn differently and have higher temperatures than stars with less mass. The largest hottest stars are blue or white. Medium-sized stars are cooler, and they are yellow or orange. The smallest, coolest stars are red.

Stars are catalogued by temperature, or spectral type. Hot stars show a different pattern of light absorption lines than cooler stars. Ranging from hottest to coolest, the spectral types are: O, B, A, F, G, K, M. (You can remember these types with the mnemonic "**O**h **B**e **A** **F**ine **G**uy (or **G**irl), **K**iss **M**e!")

Large hot stars such as O-type, B-type, and A-type burn out faster, while smaller cooler stars burn slower and have longer lives. The larger stars probably do not last long enough for life to evolve on any planets they may have. Our Sun is a yellow, G-type star.

Star brightness in visible light is measured by magnitude. On the magnitude scale, larger numbers represent dimmer stars. Apparent magnitude is affected by a star's distance from the observer, so that very bright stars that are far away may seem dimmer and have a higher magnitude number.

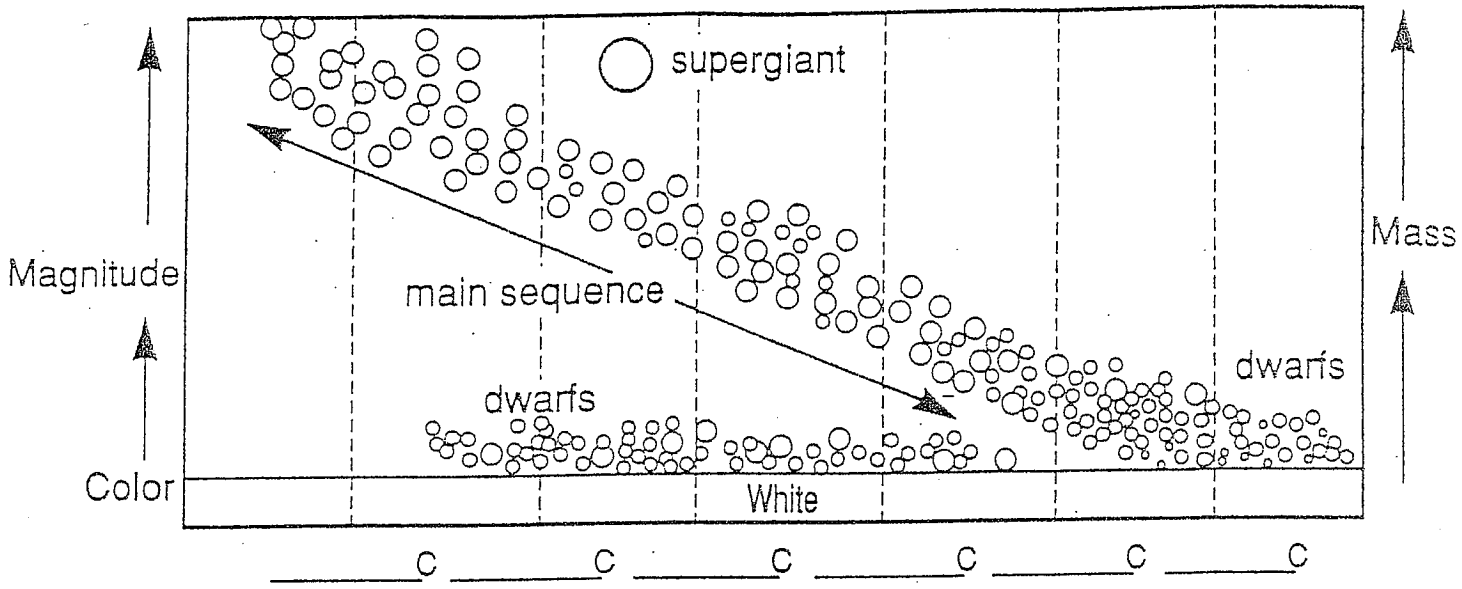


↖ STAR TYPE EXPERIMENT SET-UP ↗

200-watt lightbulb (clear)
Ceramic lightbulb socket
Dial-type dimmer switch that can be installed into lamp wire
6 feet of lamp wire
Electrical plug
Electrical tape
Wire cutters, strippers
Screwdrivers--flat and Phillips

Set-up: (See diagram.) Attach ceramic socket to one end of lamp wire. Splice in the dimmer switch about a foot away. Attach the plug to the end of the wire. Cover any exposed wire with electrical tape. Screw in the 200 watt bulb and plug it in. Place radiometer 30 cm. away from bulb. Turn dimmer to highest setting. With marking pen, draw arrow on dimmer base and make a mark on the dial to line up with the arrow. This is star type"A". Now slowly turn the dimmer until the bulb filament glows orange-red. (Turn it up a bit if it flickers.) Make sure the radiometer vanes are turning, or turn up the dimmer until they do turn. Make a mark at the lowest place they turn and label it "M". Now turn the dimmer up to its highest point, and then slowly down until the bulb glows yellow. This should be about halfway between "A" and "M". Label this point "G".

The Hertzsprung-Russell Diagram



Temperatures
5,000°, 7,000°, 3,500°,
20,500°, 5,500°, 10,000°

Colors
red, indigo, yellow,
violet, orange, blue

Step 1: Fill in the temperatures in the spaces at the bottom of the chart. Remember that the stars in the upper left corner are the hottest. Where will the highest temperature go?

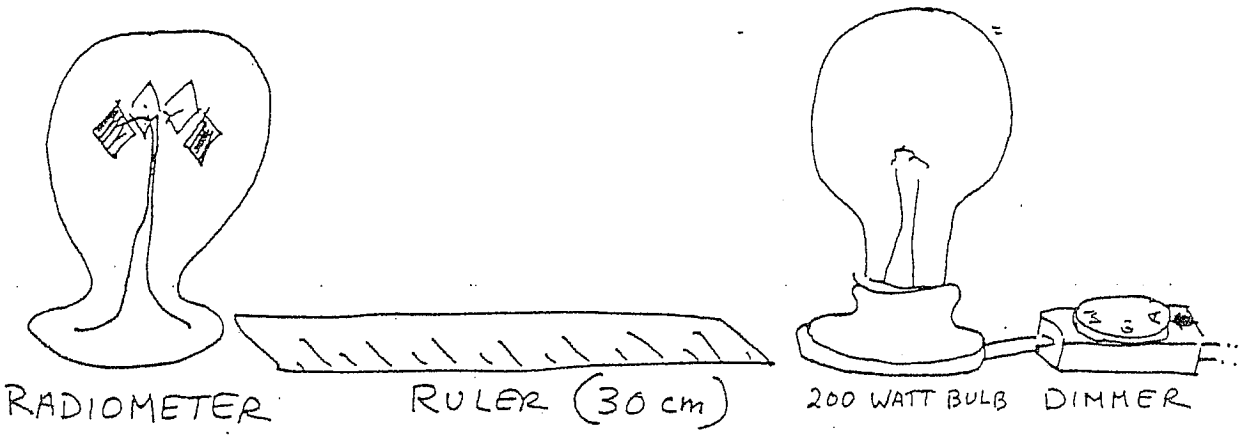
Step 2: Some of the colors are missing from the chart. Use what you have learned about star colors (colors in the shorter frequencies, like ultraviolet, are from hotter objects) to fill the missing colors. Read carefully.

Questions

1. As magnitude increases, what happens to mass?
2. What color will the supergiant in the upper left be?
3. What color will the dwarfs in the lower right be?
4. What color will the dwarfs in the center be?

from Astro 1 "Seeing in a New Light" NASA Publications 1990

Student Data sheet-- Star types



Instructions:
1) Turn the dimmer switch off. Make sure the radiometer is 30 cm from the bulb, and that its vanes are not turning.
2) Turn the dimmer dial to the "A" star mark. Wait 30 seconds. Record the number of times the vanes go around in 10 seconds. (You will need your partner to time it for you.)
3) Repeat this procedure for "G" star and "M" star settings. Each time, gently stop the radiometer, then wait 30 seconds for it to reach speed, and count. Record all data here and on class chart.

STAR TYPE	# of Turns in 10 Secs	Color
A-Type Star		
M-Type Star		
G-Type Star		

Type	Color	Temperature, in °C	Lifetime
O	Blue	35,000	10 million years
B	Blue-White	21,000	40 million years
A	White	10,000	100 million years
F	Yellow-White	7,500	5 billion years
G	Yellow	6,000	10 billion years
K	Orange	4,700	50 billion years
M	Red	3,300	100 billion years