Classnotes 12

The H-R diagram will be used extensively in the coming classes. I provide the following simple exercise so that you may become more familiar with this diagram.

I challenge you to plot up two samples of stars on the blank H-R diagram at the end of the classnotes.

Sample One: the stars within 12 light years of the Earth

Sample Two: the 20 brightest stars

The blank diagrams show luminosity (in solar units, L) versus the color B-V. Luminosity is given on a log scale. B-V is a numerical measure (in magnitudes) of the color: crudely the ratio of blue to red light. Large B-V denotes a red star. Small B-V denotes at blue star.

On the diagram labeled "Nearest Stars,' I've placed 61 Cyg. On the diagram labeled 'Brightest Stars,' I've placed Regulus.

These two examples should help you place the other stars. It is not necessary to write the names of the stars besides the points.

After completing the two diagrams, please answer the following questions:

1. Describe in your own words the key differences between the HR diagrams of the two samples.
2. Main sequence stars of spectral types K and M are the commonest stars in the Galaxy. Why are there none in the sample of the brightest stars?
3. Red giants such as Arcturus and Betelgeuse are very rare—in large part because they are in phase of their lives, which is short-lived. These rare stars are well represented in Sample 2 but there are none in Sample 1. Why do red giants turn up in Sample 2 but not in Sample 1?

Sample One: Stars Within 12 Light Years

Star Designation	Distance (ly)	Spectral Type	B-V Color	Luminosity ($L_\odot$)
Sun	0.0	G2 V	+0.65	1.0
Alpha Centauri	4.3	G2 V	+0.68	1.5
Barnard's Star	5.9	M5 V	+1.74	0.00044
Wolf 359	7.6	M8 V	+2.01	0.00002
BD +36°2147	8.2	M2 V	+1.51	0.0052
Luyten 726-8	8.5	M6 V	+1.85	0.00006
Sirius	8.6	A1 V	+0.00	29.0
Ross 154	9.5	M5 V	+1.70	0.0004
Ross 248	10.2	M6 V	+1.91	0.0001
Epsilon Eridani	10.7	K2 V	+0.88	0.30
Luyten 789-6	10.8	M6 V	+1.76	0.00012
Ross 128	10.8	M5 V	+1.96	0.00033
61 Cygni	11.2	K5 V	+1.17	0.083
Epsilon Indi	11.2	K5 V	+1.05	0.13
Tau Ceti	11.3	G8 V	+0.72	0.39
Procyon	11.4	F5 IV-V	+0.42	7.0
Σ 2398	11.5	M4 V	+1.54	0.0028
BD +43°44	11.6	M1 V	+1.56	0.0058
CD -36°15693	11.7	M2 V	+1.48	0.012
G51-15	11.9	M? V	+2.06	0.00001

Sample Two: The 20 Brightest Stars

Star Designation	Constellation Designation	Distance (ly)	Spectral Type	B-V Color	Luminosity ($L_\odot$)
Sirius	α CMa	8.6	A1 V	+0.00	29
Canopus	α Car	120	F0 II	+0.15	2200
Arcturus	α Boo	35	K1 III	+1.28	370
Rigel Kent	α Cen	4.3	G2 V	+0.68	1.5
Vega	α Lyr	25	A0 V	+0.00	63
Capella	α Aur	40	G5 III	+0.80	140
Rigel	β Ori	850?	B8 I	-0.03	120,000
Procyon	α CMi	11.4	F5 IV-V	+0.42	6.6
Achemar	α Eri	125	B3 V	+0.16	6,000
Betelgeuse	α Ori	650?	M1 I	+1.85	120,000
Hadar	β Cen	360?	B1 III	-0.23	61,000
Altair	α Agl	16.1	A7 V	+0.22	10.6
Aldebaran	α Tau	60	K5 III	+1.54	300
Acrux	α Cru	400?	B1 IV	-0.26	71,000
Antares	α Sco	300?	M2 I	+1.83	16,000
Spica	α Vir	260?	B1 III	-0.23	23,000
Pollux	β Gem	35	K0 III	+1.00	50
Fomalhaut	α PsA	22	A3 V	+0.09	15
Deneb	α Cyg	1600?	A2 I	+0.09	90,000
Mimosa	β Cru	500?	B0 III	-0.23	82,000
Regulus	α Leo	70	B7 V	-0.11	310
Adhara	ε CMa	650?	B2 II	-0.21	72,000
Castor	α Gem	50	A1 V	+0.03	55
Shaula	λ Sco	330?	B2 IV	-0.22	13,000
Gacrux	γ Cru	230?	M4 III	+1.59	8,700
Bellatrix	γ Ori	300?	B2 III	-0.22	17,000
El Nath	β Tau	120	B7 III	-0.13	240
Miaplacidus	β Car	160	A2 IV	+0.00	550
Alnilam	ε Ori	1500?	B0 I	-0.19	550,000
Al Nair	α Cru	55	B7 IV	-0.13	150

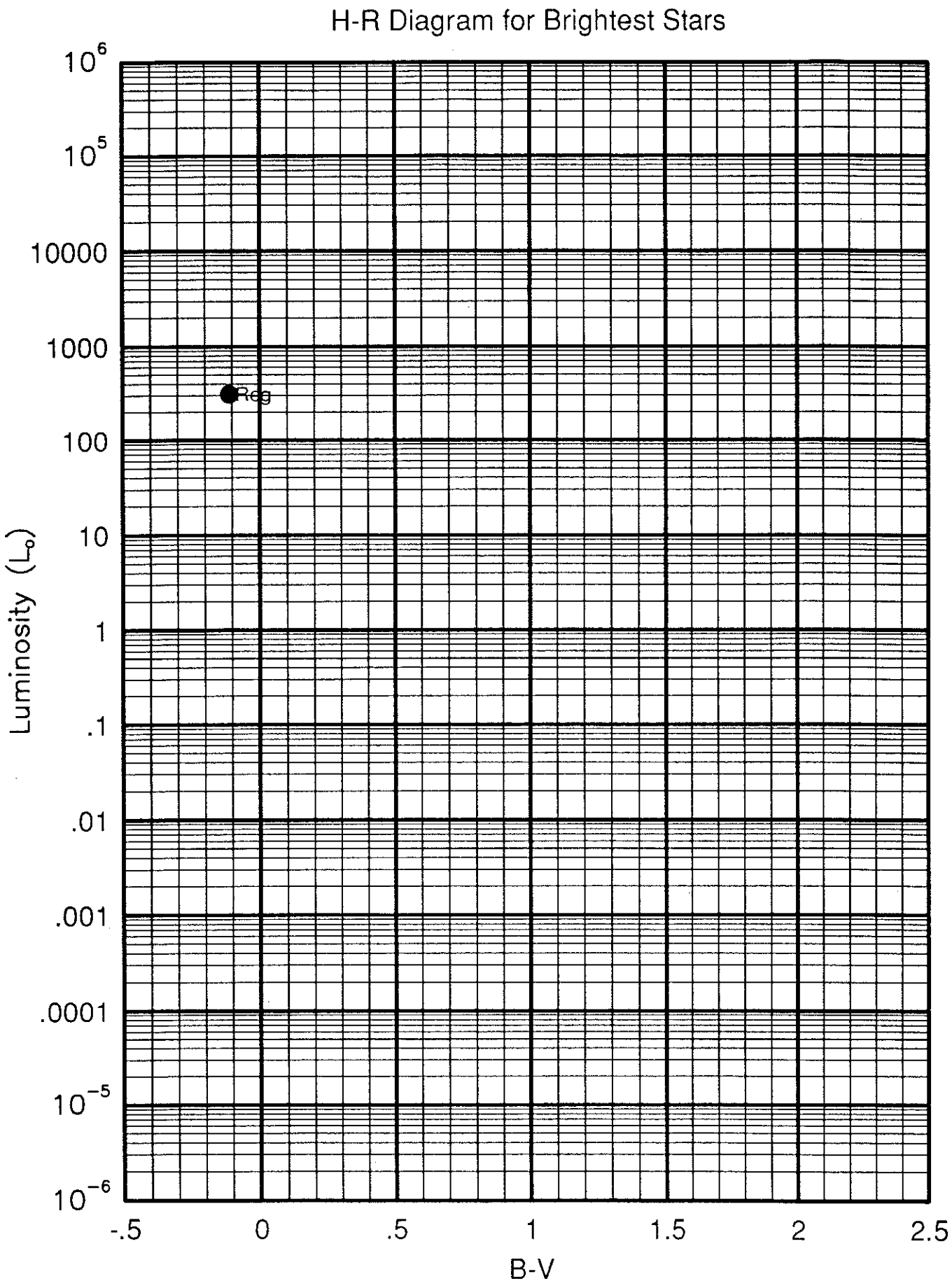
The excitement of doing science is not conveyed by the textbooks such as ours. I came across the following piece in an essay ("Blood, Birds, and the Old Road") written by Sir Denys Wilkinson whose lectures on nuclear physics I attended long, long ago.

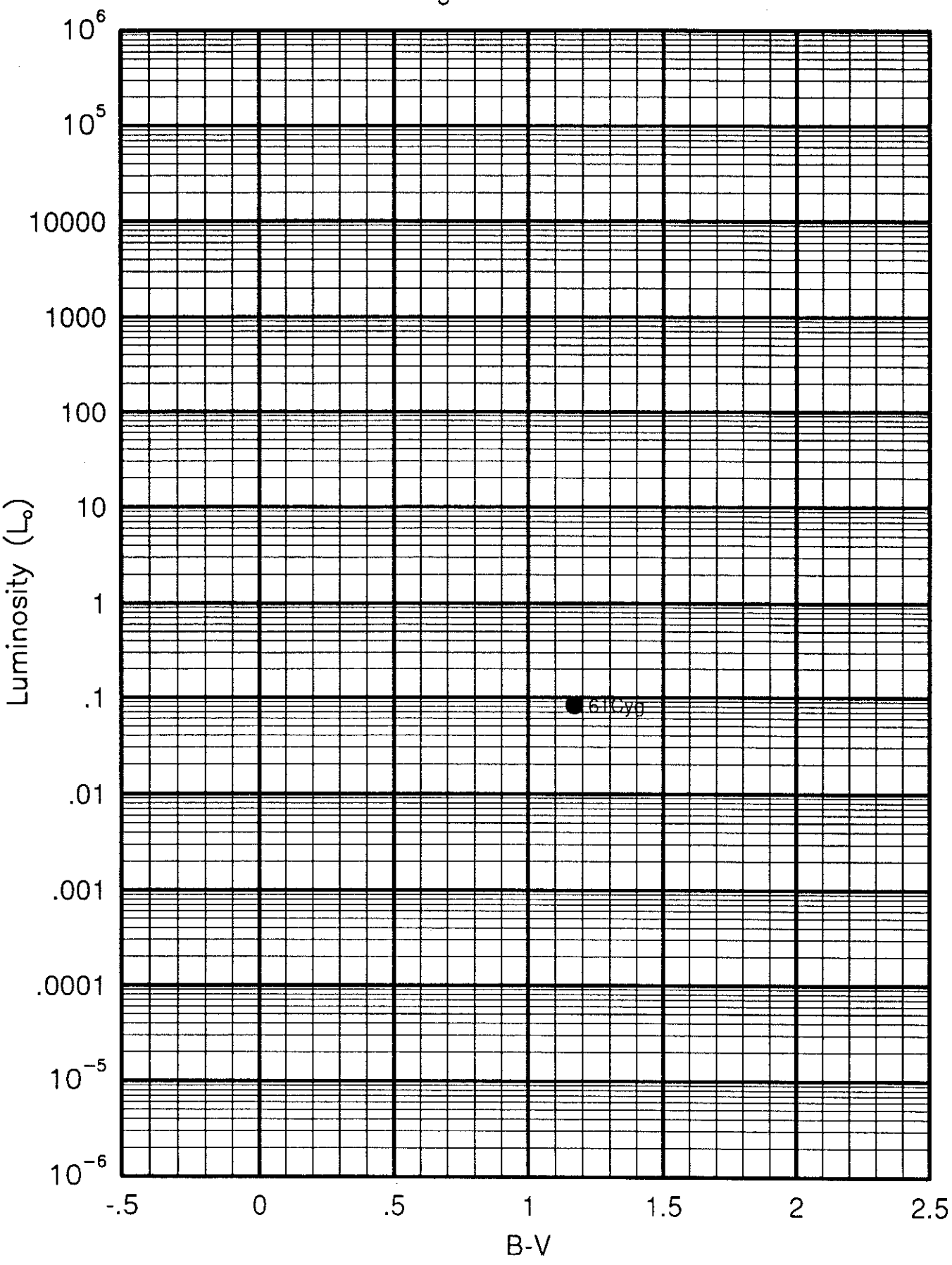
Sir Denys suffered extensively at an early time in his career from radiation sickness. His doctor ordered him to take a complete rest. He took up bird watching. I hope he conveys the excitement of experiments—when they work!

He was fascinated by how birds released far from home, find their way back. Here is his account of one experiment:

> The Manx Shearwater (*Puffinus puffinus*), a strictly pelagic bird never seen inland unless tempest-tossed, comes to land for only a few weeks per year to breed in a burrow close to the sea. We brought these birds, deprived of sensory clues, from Skokholm, their breeding island off the Welsh coast, and released them singly from the top of the Cambridge University library tower, for them totally unknown territory, and watched until each was out of sight before releasing the next. The angular distribution of their disappearances formed a tight fan pointing toward their island home 230 miles away. I have had many thrills in my life in physics, when something has worked or when I have though that I have understood something, but never that eerie feeling as when I watched those shearwaters disappear.

His next paragraph opens with the question 'How is it done?' We don't know!!


H-R Diagram for Brightest Stars
10^6
10^5
10000
1000
100
10
1
.1
.01
.001
.0001
10^{-5}
10^{-6}
Luminosity ($L_\odot$)
Reg
-.5
0
.5
1
1.5
2
2.5
B-V


H-R Diagram for Nearest Stars
10^6
10^5
10000
1000
100
10
1
.1
.01
.001
.0001
10^{-5}
10^{-6}
Luminosity (L_o)
61Cyg
-.5
0
.5
1
1.5
2
2.5
B-V