Name: ....

ASTRONOMY 1102 - Section 1

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Homework # 6 due Wed. Mar. 24

The Evolution of Massive Stars: Supernovae

1) During the evolution of a massive star the following nuclear fuels are consumed by fusion at ever increasing temperatures and rates, in the following order: H, He, C, O, Ne, Mg, Si, (see also table on handout) until an inert "iron" core forms with the ashes of the burning.

a) Sketch schematically the internal structure of that massive star just before core collapse

The sketch should show a core of Fe, surrounded by shells in the order Si, Mg, Ne, O, C, He, and H, as one moves out from the core. Finally the whole is surrounded by a H-rich envelope in which no burning is taking place.

b) Look over the table of elements on page A-10, and locate all the fuels mentioned above. Do you notice a regular pattern? What is the cause of this pattern? BONUS: How come there is no S, Ar,Ca,Ti, Cr burning shells?

The pattern is that from C^{12} on, the successive elements are obtained by the addition of one He^{4} nucleus or alpha particle. This goes on until Silicon is reached. Then the direct fusion of two Si^{28} atoms becomes possible which produces Ni^{56}, which then decays to Co^{56} and finally to Fe^{56}.

2) What is approximately the peak absolute magnitude of a SN of type I? (take $L = 10^{11} L_\odot$ for the peak luminosity). Assuming the limiting magnitude of a 4m class telescope is 25, how far can we detect SN of type I with such a telescope?

Every factor of 100 in luminosity corresponds to 5 magnitudes, every factor of 10 to 2.5 magnitudes. The absolute magnitude corresponding to $10^{11} L_\odot$ is therefore 11x2.5 = 27.5 magnitudes brighter than the sun. Since the sun has absolute magnitude 5, the result is 5 - 27.5 = -22.5.
The distance modulus for the observed SN is m-M = 25 - (-22.5) = 47.5.
Then the distance is obtained in the usual manner: 45 mags corresponds to 10^{9}x10pc = 10^{10} pc = 10 Gpc. A further 2.5 mags gives you a factor close to 3 in distance. So in summary one should see this SN out to 30 Gpc near the edge of the visible Universe. We shall see later why this naive calculation is wrong.