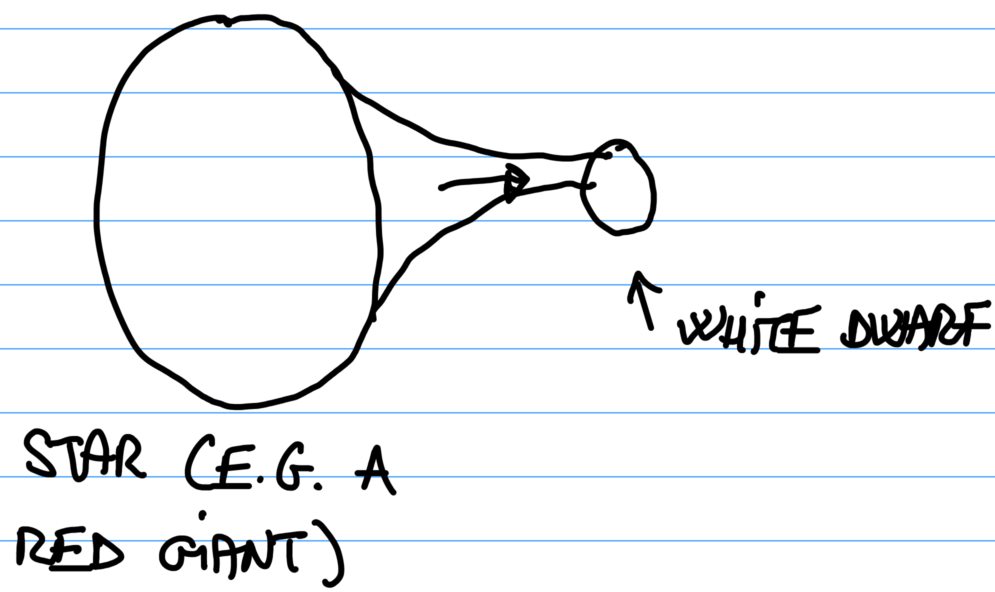
TYPE Ia SUPERNOVA:

WHITE DWARF – STAR BINARY SYSTEM



STRONG GRAVITY NEAR A DENSE WHITE DWARF ATTRACTS SOME OF THE MATERIAL FROM COMPANION STAR AND THE MASS OF THE WHITE DWARF INCREASES. IT COMPRESSES AND HEATS UP. ONCE ITS MASS GETS CLOSE TO THE CHANDRASEKHAR LIMIT (AT $1.38\,M_\odot$) THE TEMPERATURE IS SO HIGH THAT THERE ARE RUNAWAY FUSION REACTIONS. SO MUCH ENERGY IS RELEASED THAT THE ENTIRE SYSTEM IS DISRUPTED IN A GIGANTIC EXPLOSION (TYPE Ia SUPERNOVA).

NOTE: THERE ARE NO HYDROGEN SPECTRAL LINES IN THE SPECTRUM OF TYPE Ia SUPERNOVA.

BECAUSE OF THEIR HIGH LUMINOSITY THEY ARE EASY TO SEE AT VERY LARGE DISTANCES. SINCE THEY ALL OCCUR VIA THE SAME MECHANISM AND WE KNOW HOW MUCH EXPLOSIVE THERE IS (CHANDRASEKHAR LIMITTING MASS) THEY ALL HAVE THE SAME LUMINOSITY L. THEN ONE CAN USE

$$B = \frac{1}{4\pi}\frac{L}{d^2}$$

B ← MEASURE

L ← DETERMINED FROM NEARBY TYPE Ia SUPERNOVA USING THIS SAME RELATION

d → DEDUCED

TO FIND THEIR DISTANCE d. THIS METHOD IS USED TO FIND THE DISTANCES OF THE MOST DISTANT GALAXIES.

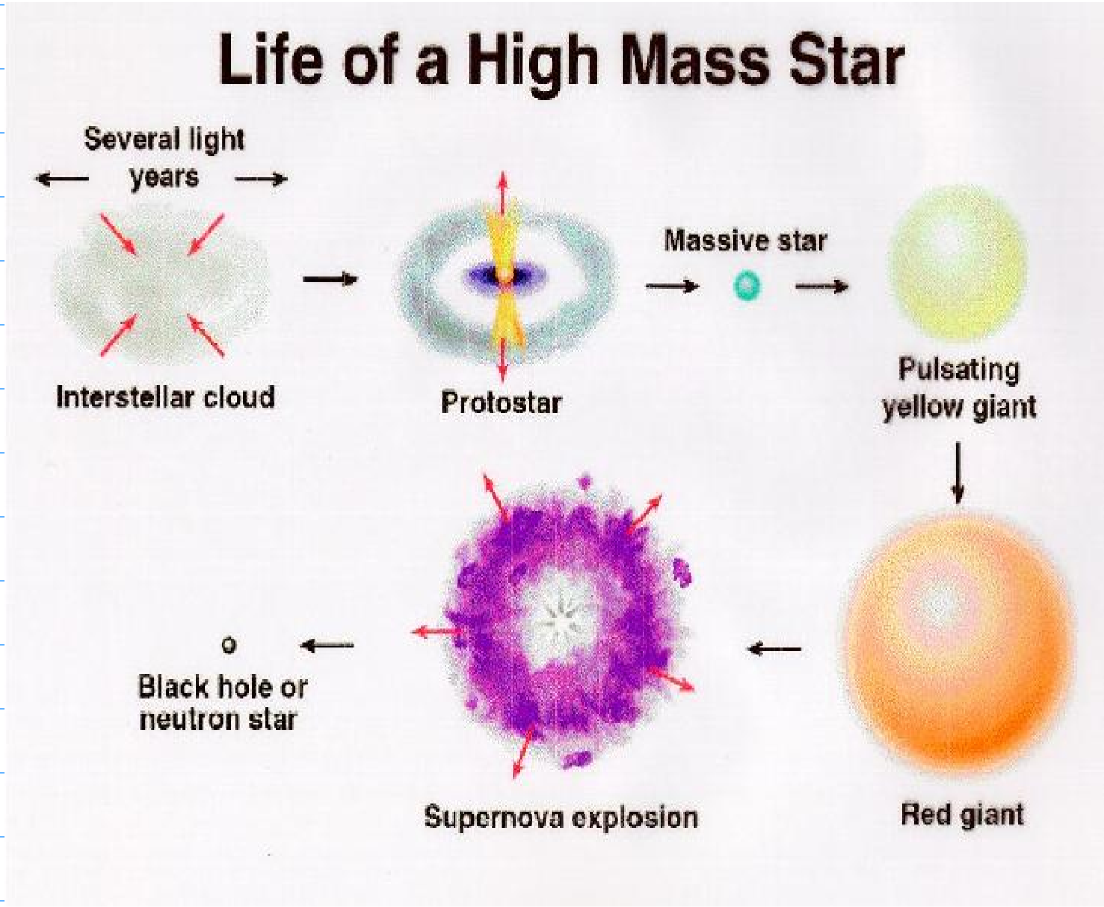
THE LIFE STORY OF A HIGH MASS STAR ($M > 8M_\odot$)

BECAUSE OF THE HIGH MASS ALL STAGES LAST SHORTER PERIOD OF TIME.

PROTOSTAR STAGE, MAIN SEQUENCE LIFE, ...

THE STAR CONTRACTS QUICKLY BECAUSE OF THE HIGH MASS

$$\text{LIFETIME} = \frac{M}{L \simeq M^{3.5}} = \frac{1}{M^{2.5}}$$



BECAUSE OF VERY HIGH MASS THE HELIUM CORE IS COMPRESSED AND HEATED RIGHT AWAY

AND FUSION OF ^4He INTO ^{12}C AND ^{16}O PROCEEDS WITHOUT A PAUSE (NO FIRST RED GIANT STAGE).

NUCLEOSYNTHESIS: FUSION OF HEAVIER NUCLEI FROM THE LIGHTER ONES.

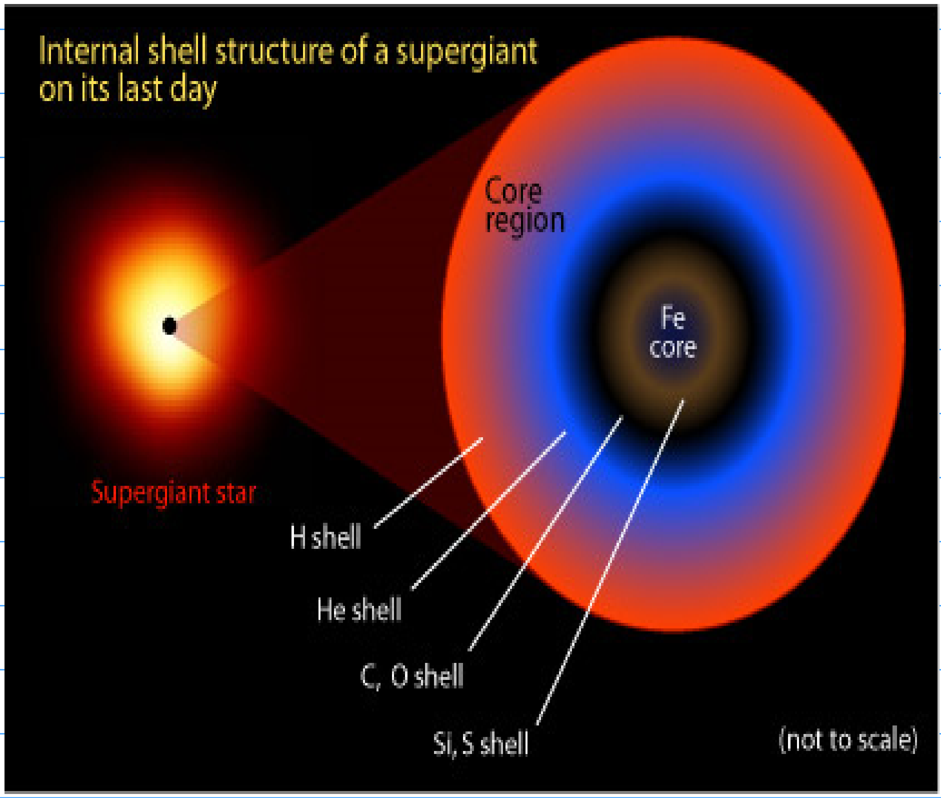
CALCULATION FOR A STAR WITH $M = 25\,M_\odot$:

FUSION REACTION	T	DURATION
$H \rightarrow He$	7×10^7 K	10^7 YEARS
$He \rightarrow C, O$	2×10^8 K	10^6 YEARS
$C \rightarrow Ne, Na, Mg, Al$	8×10^8 K	1000 YEARS
$Ne \rightarrow O, Mg$	1.6×10^9	3 YEARS
$O \rightarrow Si, S, Ar, Ca$	1.8×10^9	0.3 YEARS
$Si \rightarrow Ni \rightarrow Fe$	2.5×10^9	5 DAYS

EACH FUSION REACTION RELEASES LESS ENERGY THAN THE PREVIOUS ONE AND THE RATE AT WHICH THE NUCLEAR FUEL IS USED INCREASES WITH THE MASS OF THE NUCLEI THAT MAKE UP THE FUEL.

A MATURE SUPERGIANT NEAR THE END OF ITS

LIFE :


Internal shell structure of a supergiant on its last day
Core region
Fe core
Supergiant star
H shell
He shell
C, O shell
Si, S shell
(not to scale)