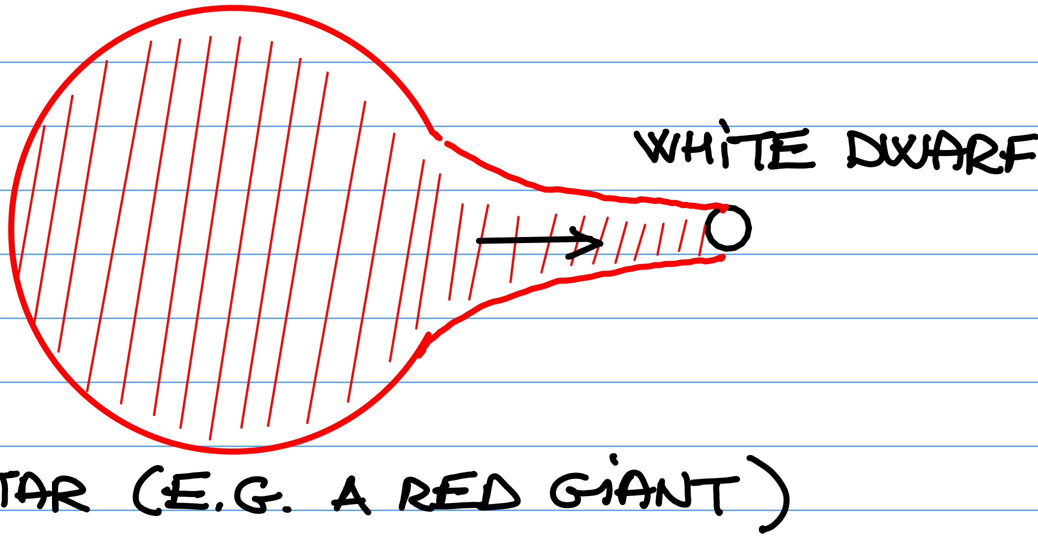
TYPE Ia SUPERNOVA:

WHITE DWARF – STAR BINARY SYSTEM



STRONG GRAVITY NEAR A DENCE WHITE DWARF ATTRACTS SOME OF THE MATERIAL FROM THE COMPANION STAR (E.G. THE STELLAR WIND PARTICLES) 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 THE RUNAWAY FUSION REACTIONS START. 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 THE TYPE Ia SUPERNOVAE ARE EASY TO SEE AT VERY LARGE DISTANCES. SINCE THEY ALL OCCUR VIA THE SAME MECHANISM AND WE KNOW HOW MUCH "EXPLOSIVE" THERE IS (THE CHANDRASEKHAR LIMITING MASS) THEY ALL HAVE THE SAME LUMINOSITY L. THEN ONE CAN USE

MEASURE → $B = \dfrac{L}{4\pi d^2}$ ← L: DETERMINED FROM A NEARBY TYPE Ia SUPERNOVA USING THIS SAME RELATION

↑ d: DEDUCE

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 ($M > 8 M_\odot$):

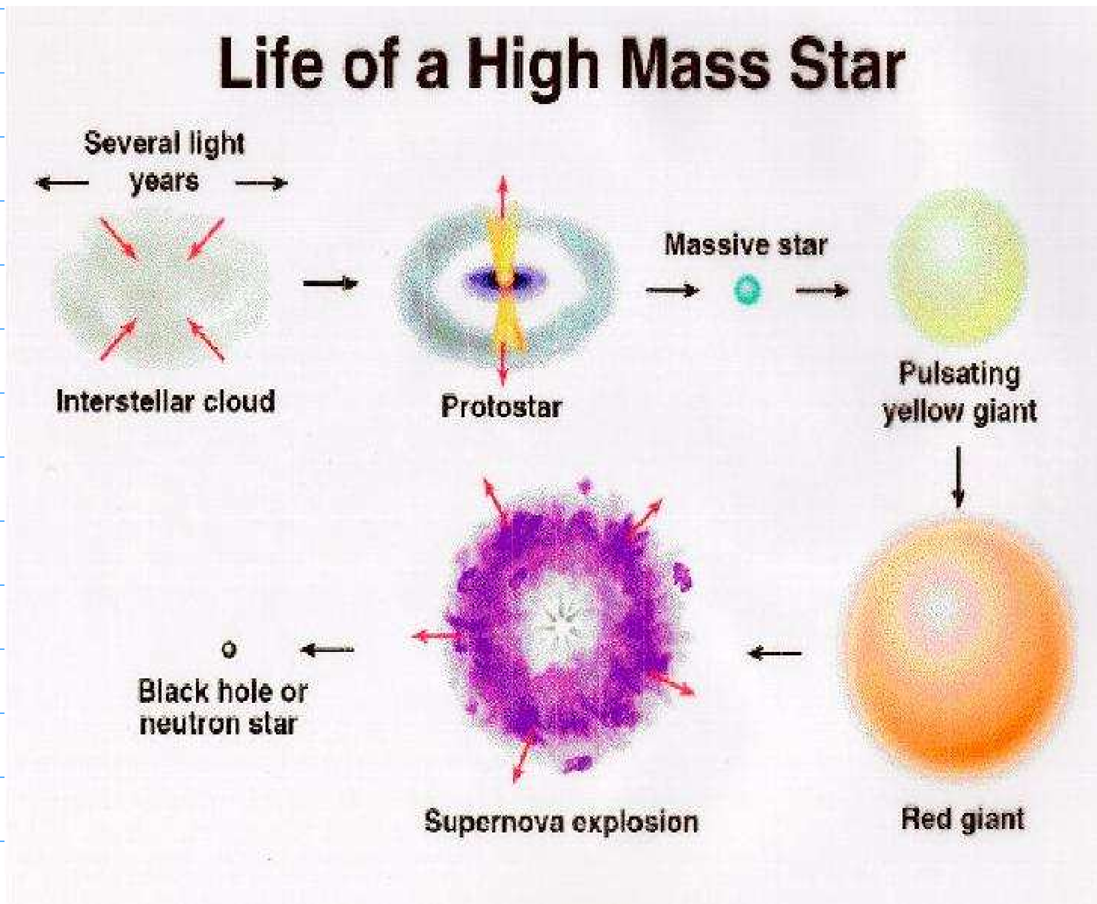
BECAUSE OF THEIR HIGH MASS ALL STAGES LAST A SHORTER PERIOD OF TIME:

PROTOSTAR STAGE, MAIN SEQUENCE LIFE, ...

THE STAR CONTRACTS QUICKLY BECAUSE IT HAS A HIGH MASS

$L \propto M^{3.5}$

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



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

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

<u>NUCLEOSYNTHESIS</u>: FORMATION OF HEAVIER NUCLEI BY FUSION OF THE LIGHTER NUCLEI

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	1,000 YEARS
$N \rightarrow O, Mg$	1.6×10^9 K	3 YEARS
$O \rightarrow Si, S, Ar, Ca$	1.8×10^9 K	0.3 YEARS
$Si \rightarrow Ni \rightarrow Fe$	2.5×10^9 K	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: