

A.C.A. - Associazione Cernuschese Astrofili

FATTI DI POLVERE DI STELLE



by Andrea Grieco

FISSE ?

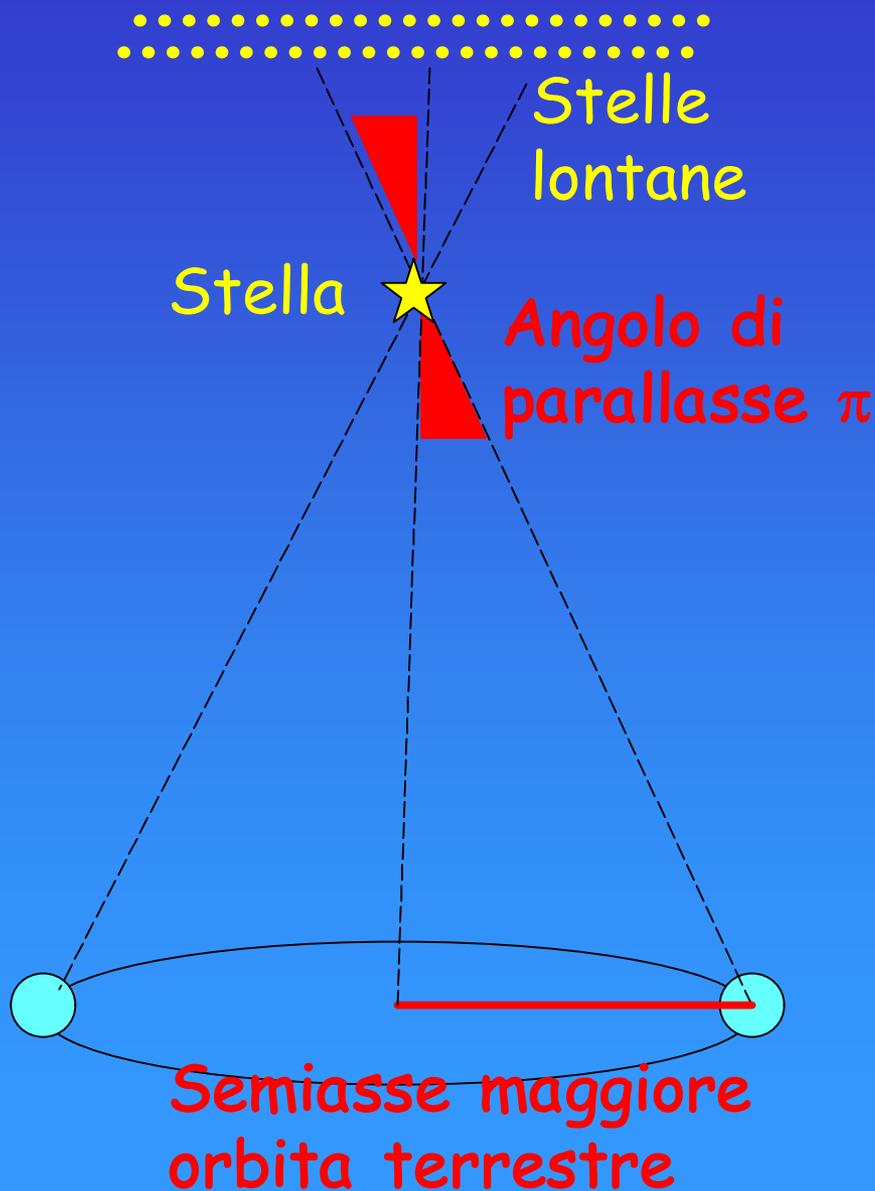
IMMUTABILI?

ETERNE ?

Twinkle, twinkle little star
I don't wonder what you are
For the spectroscopic ken
I know taht you are hydrogen
I.D. Bush



DISTANZA DELLE STELLE



W. Bessel 1837 61
Cygni $\pi=0",762$ $d=11,1$ al

W. Struve 1838 α Lyrae
 $\pi=0",123$ $d=26$ al

Metodo della parallasse

Hipparcos ~ 500 al

$1 \text{ pc} \approx 3,26 \text{ al}$



LA NOSTRA GALASSIA



1918 H. Shapley Prima stima della struttura della Via Lattea

Galassia M101 - Pinwheel in Ursa Major a 27 Mly

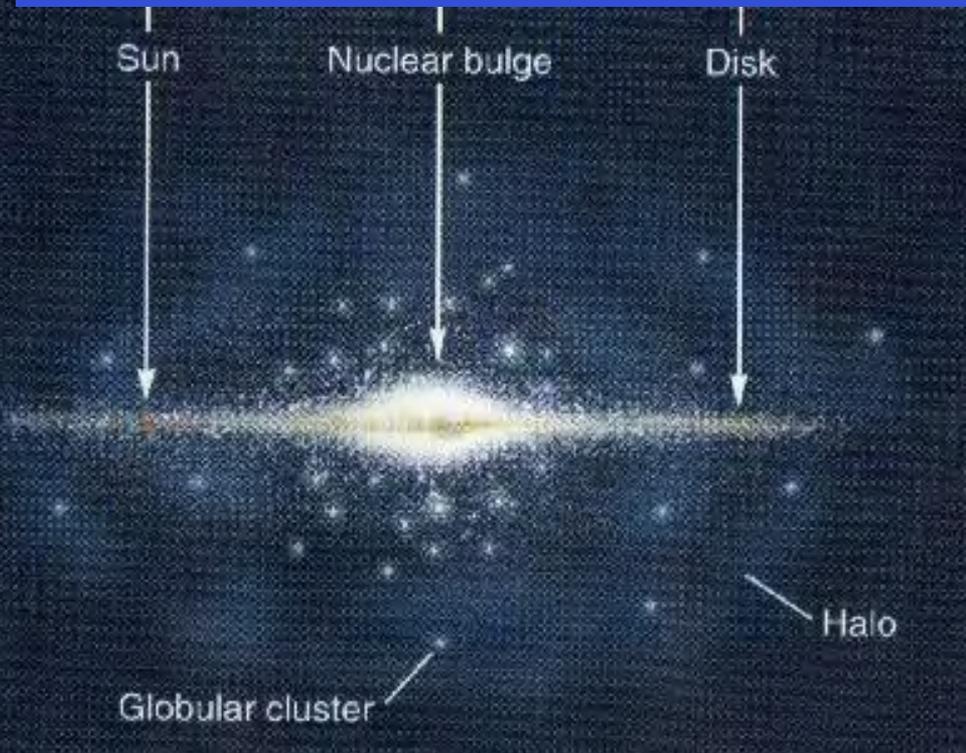
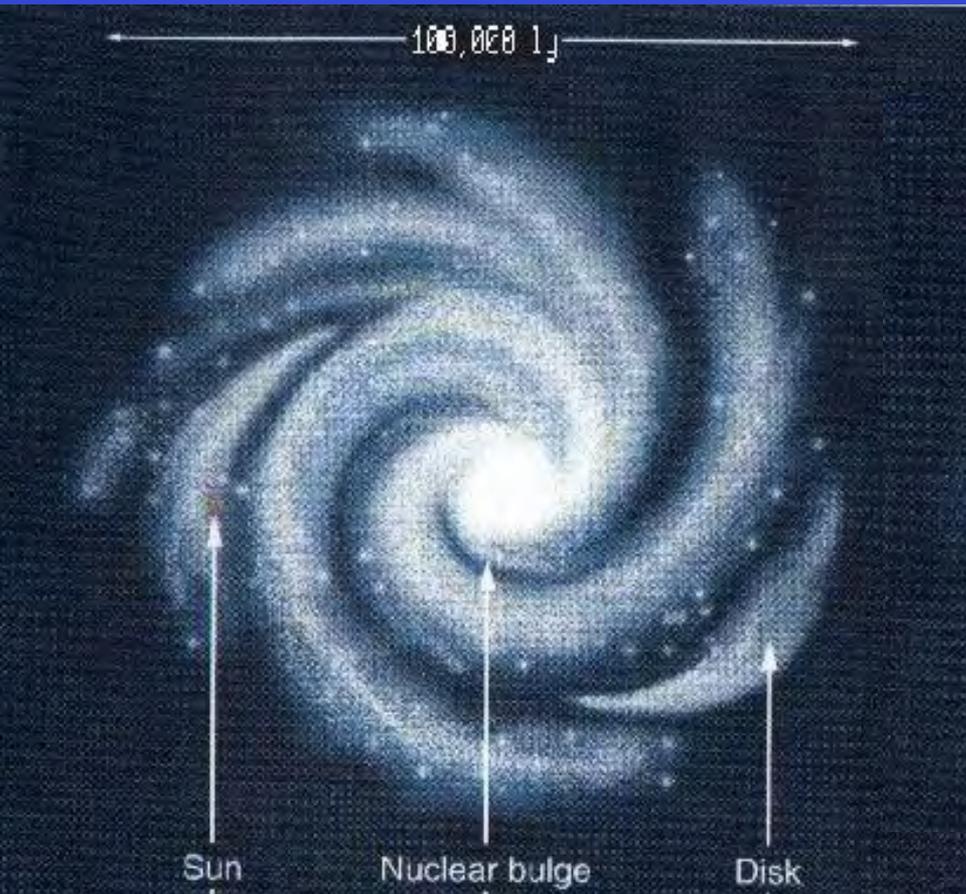
La Via Lattea ha una struttura simile.

Sotto: immagine della Via Lattea nell'infrarosso ripresa da satellite IRAS





STRUTTURA DELLA VIA LATTEA



LE GALASSIE

1924 E. Hubble Molte nebulose sono sistemi stellari simili alla Via Lattea



Fonte HST - NASA

The Hubble Deep Field North  HUBBLESITE.org



LA LUMINOSITA' DELLE STELLE



LUMINOSITA' ASSOLUTA $L_B > L_A$

MAGNITUDINE ASSOLUTA $M_B < M_A$

LUMINOSITA' APPARENTE $I_B < I_A$

MAGNITUDINE APPARENTE $m_A > m_B$

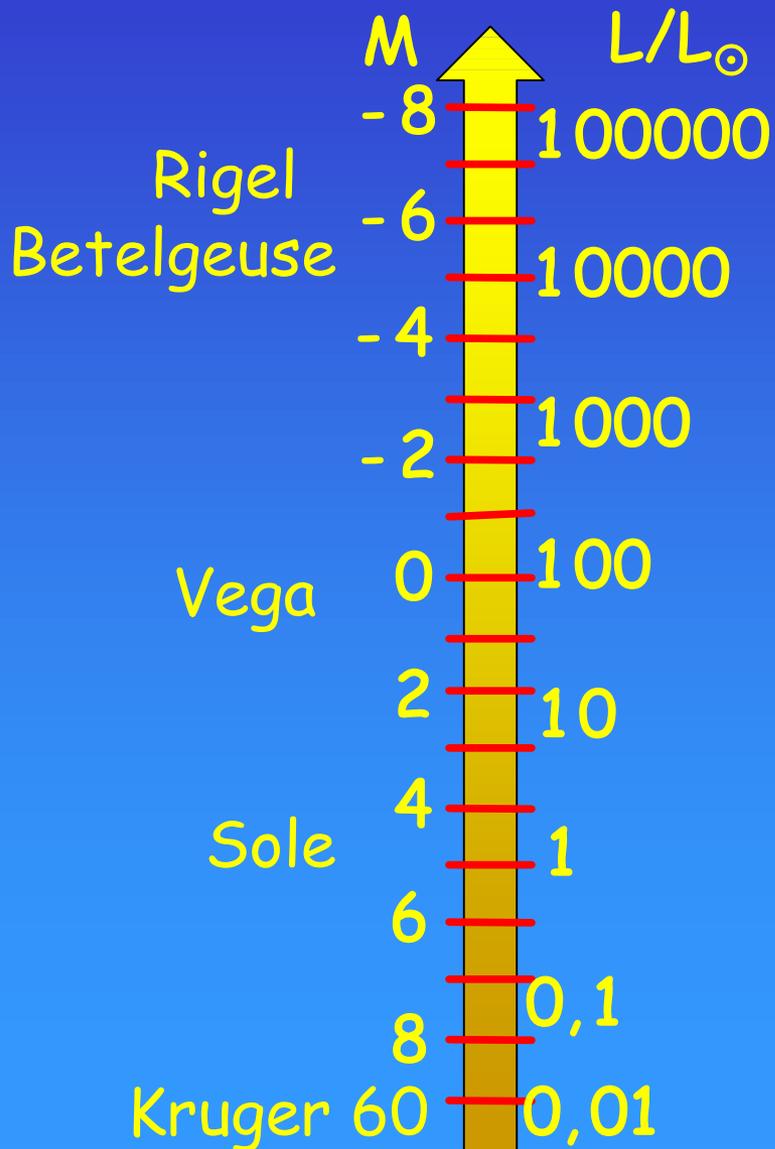


Relazione di Pogson

$$m_A - m_B = -2,5 \text{Log}(I_A / I_B)$$



MAGNITUDINI ASSOLUTE



LA MAGNITUDINE ASSOLUTA M E' LA MAGNITUDINE DI UNA STELLA POSTA A

$$10 \text{ pc} = 32,6 \text{ ly}$$

$$M_{\odot} = +4,87$$

$$M_{\text{Bet}} = -5,26$$

$$L_{\text{Bet}}/L_{\odot} = 11.000$$

$$L_{\odot} = 3,86 \times 10^{26} \text{ W}$$



I COLORI DELLE STELLE

ORION

Betelgeuse

Rigel

ANCHE AD OCCHIO NUDO
IN UNA NOTTATA LIMPIDA
E' POSSIBILE DISTINGUERE
STELLE DI COLORE DIVERSO

TAURUS

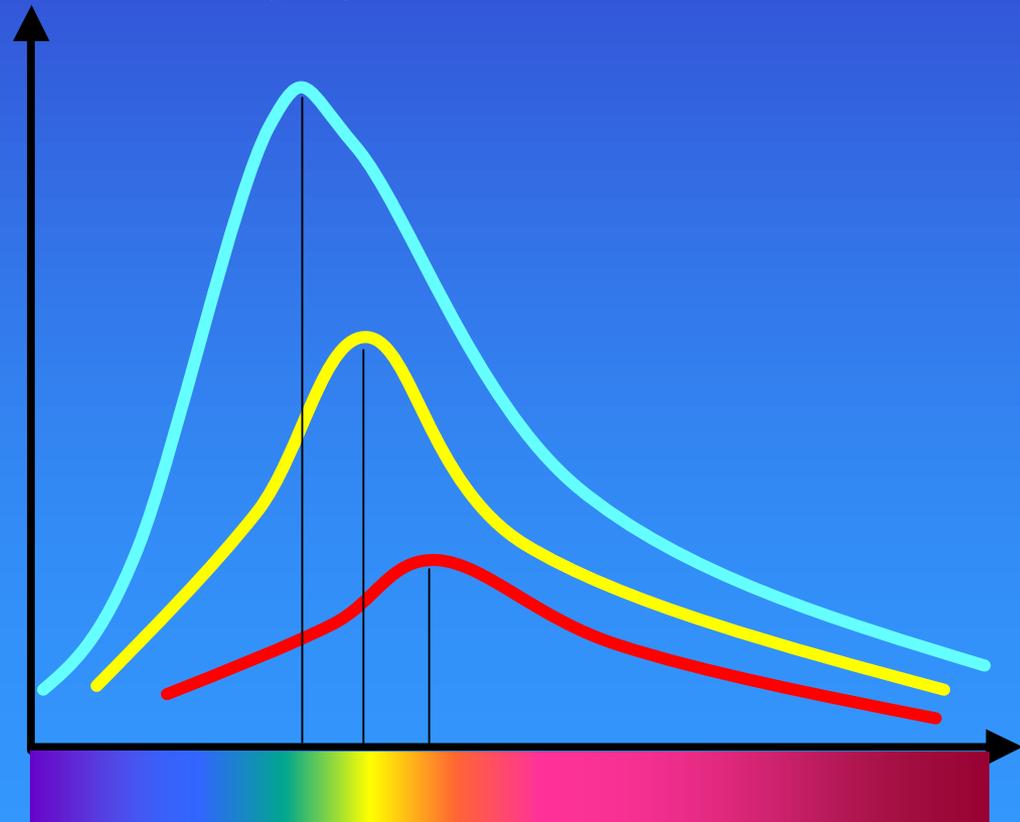
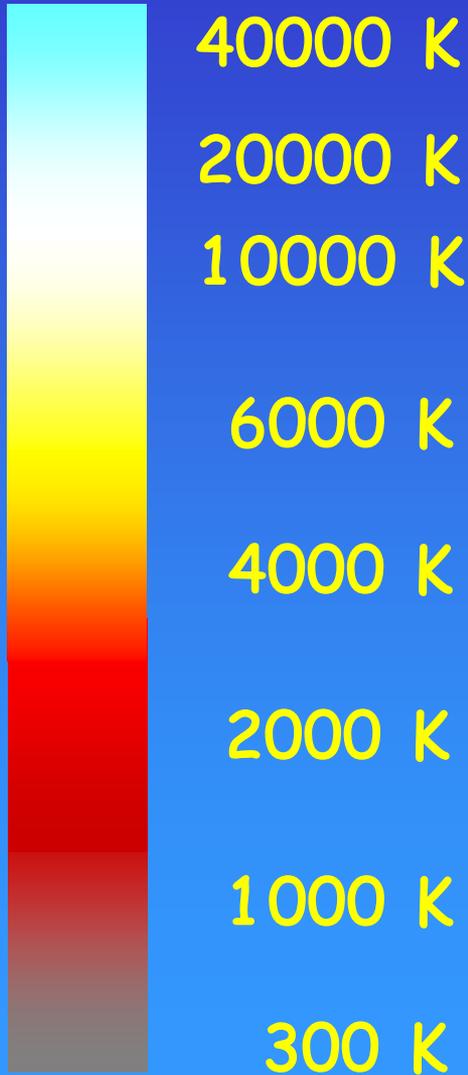
Aldebaran



IL TERMOMETRO DEI COLORI

LEGGE DI WIEN

$$\lambda_{MAX} T = \text{cost.}$$





QUANTO SONO GRANDI?



LUMINOSITA' \div (RAGGIO)²



LUMINOSITA' \div (TEMPERATURA)⁴



$$L = 4\pi R^2 \sigma T^4$$



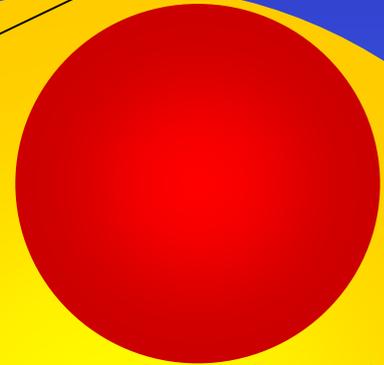
RAGGI STELLARI



Rigel (19)

Sole (1)

Scheat (112)



Nana Rossa (0,3)

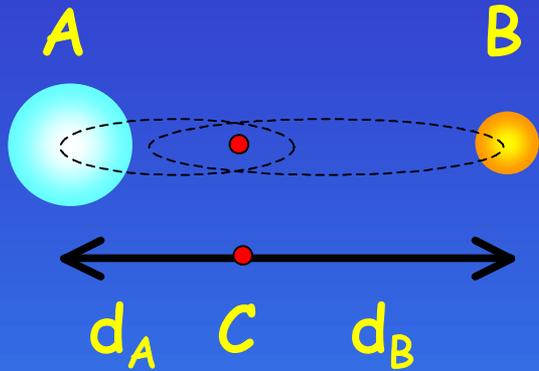
Sirio B
(0,01)

Sole (1)

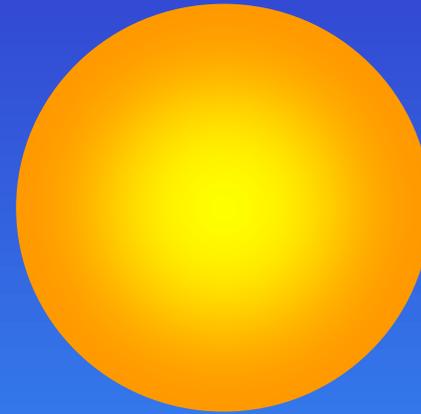
$R_{\odot} \approx 0,7 \times 10^9 \text{ m}$

Betelgeuse (400)

LE MASSE



SISTEMA BINARIO



$$T^2/d^3 \div (M_A + M_B)$$

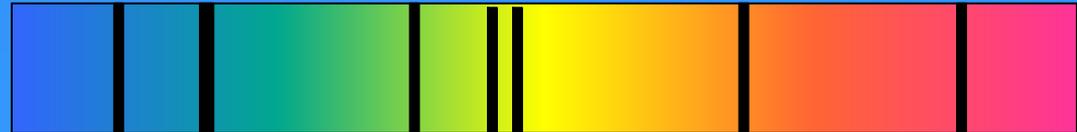
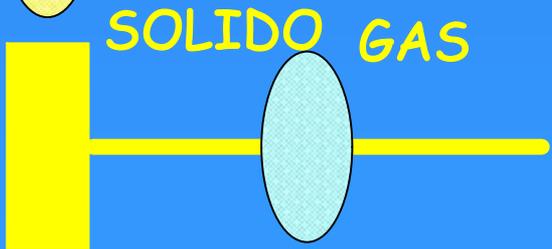
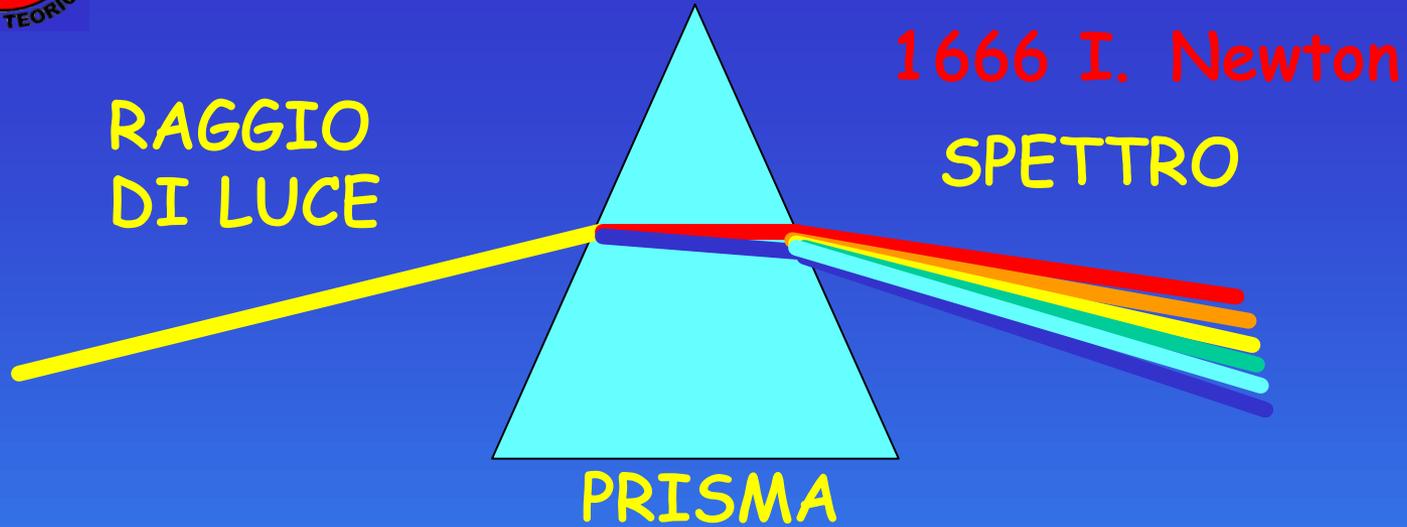
$$M_{\odot} \approx 2,0 \times 10^{30} \text{ Kg}$$

$$M_A/M_B \div d_B/d_A$$

$$M_{\star} \approx 0,04 - 100 M_{\odot}$$



L'IMPRONTA DELLA LUCE





GLI SPETTRI DEGLI ELEMENTI

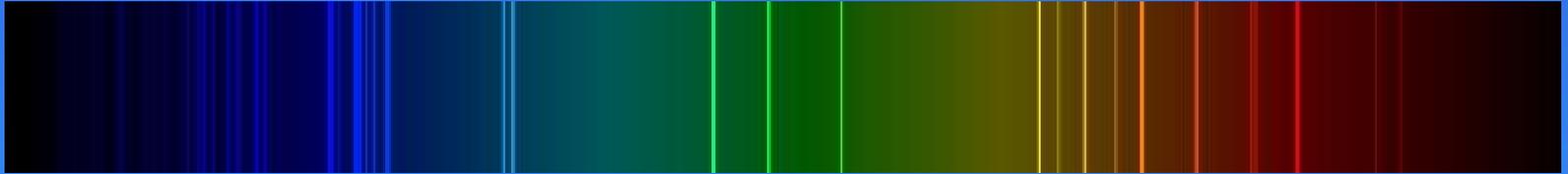
H



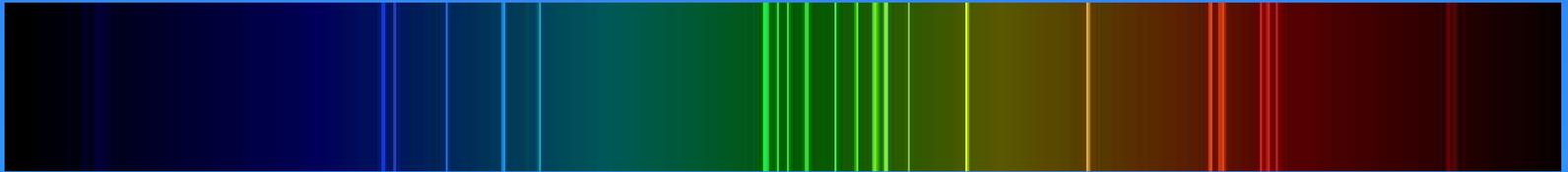
He



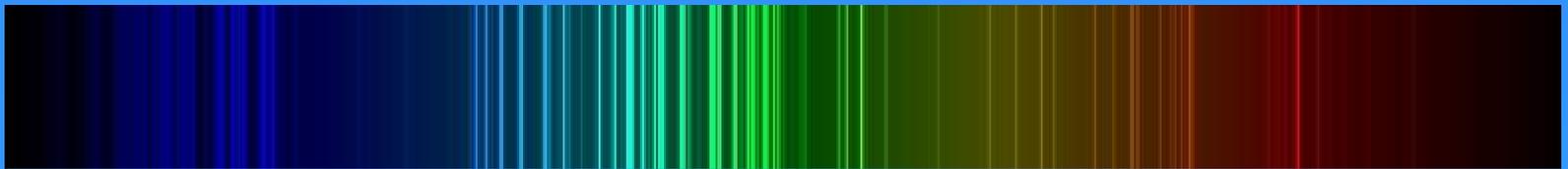
O



S



Fe





GLI SPETTRI STELLARI

O5V

B1V

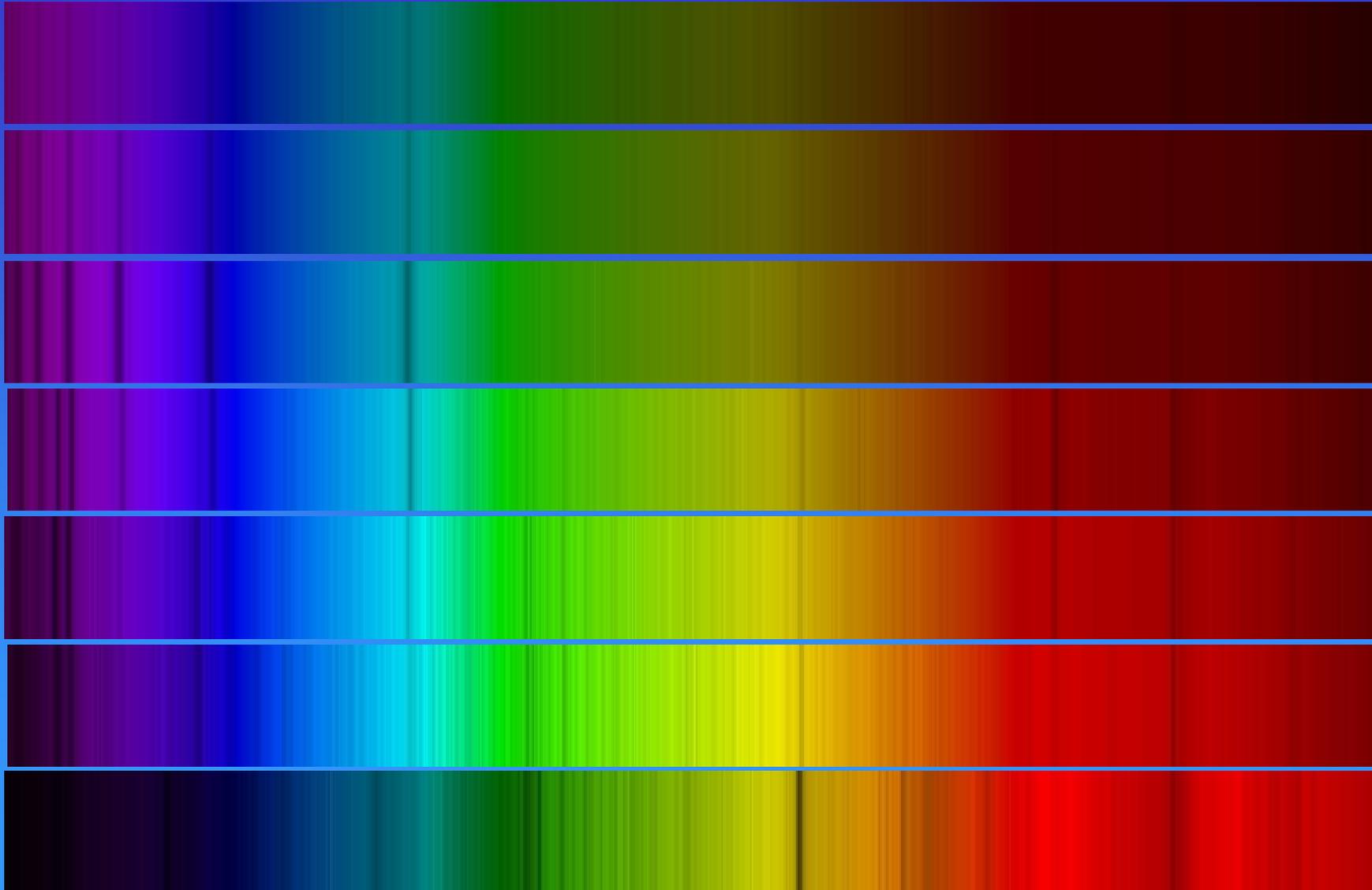
A1V

F3V

G2V

K0V

M0V

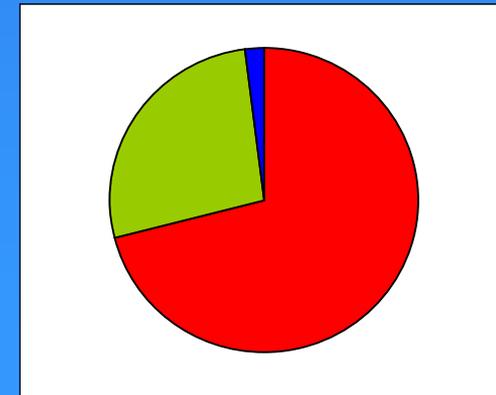
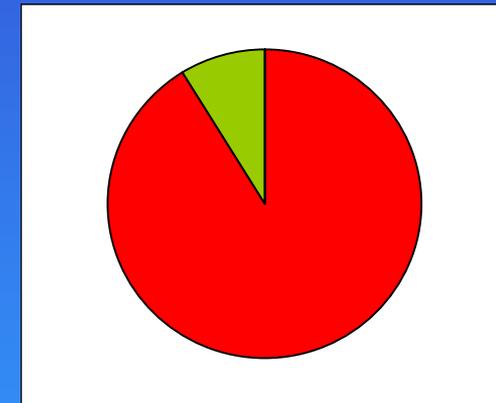




LA MATERIA DELLE STELLE

ELEMENTO	% ATOMI	% MASSA
Idrogeno	91.2	71.0
Elio	8.7	27.1
Ossigeno	0.078	0.97
Carbonio	0.043	0.40
Azoto	0.0088	0.096
Silicio	0.0045	0.099
Magnesio	0.0038	0.076
Neon	0.0035	0.058
Ferro	0.030	0.014
Zolfo	0.15	0.040

Composizione
chimica del
Sole

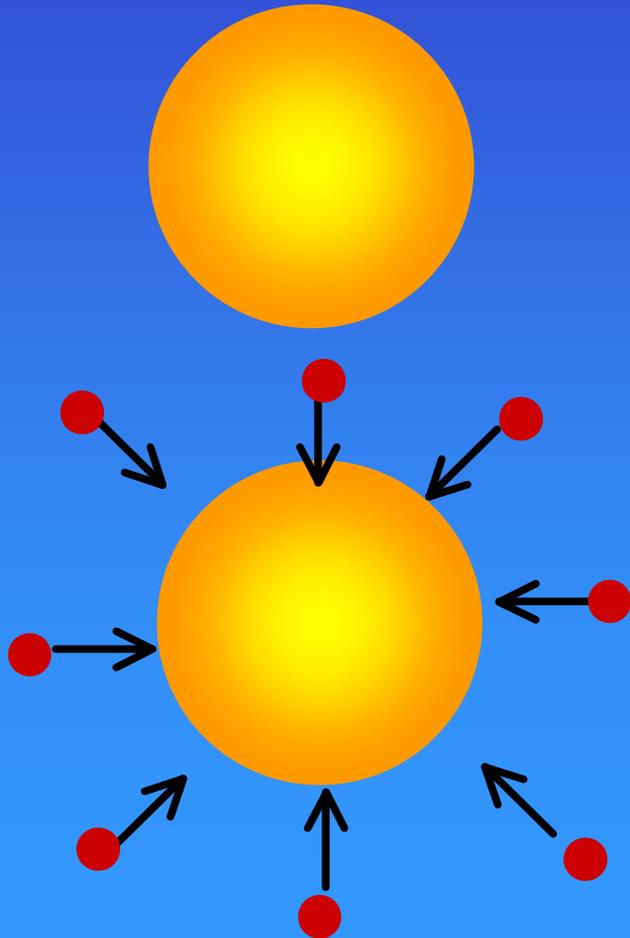




DA DOVE VIENE L'ENERGIA?

CONSERVAZIONE DELL'ENERGIA \Rightarrow DA DOVE VIENE L'ENERGIA?

SOLE $L \approx 3,8 \times 10^{26} \text{ W}$



~1850 J. V. MAYER
COMBUSTIONE CHIMICA

$t \approx 6.000 \text{ My}$

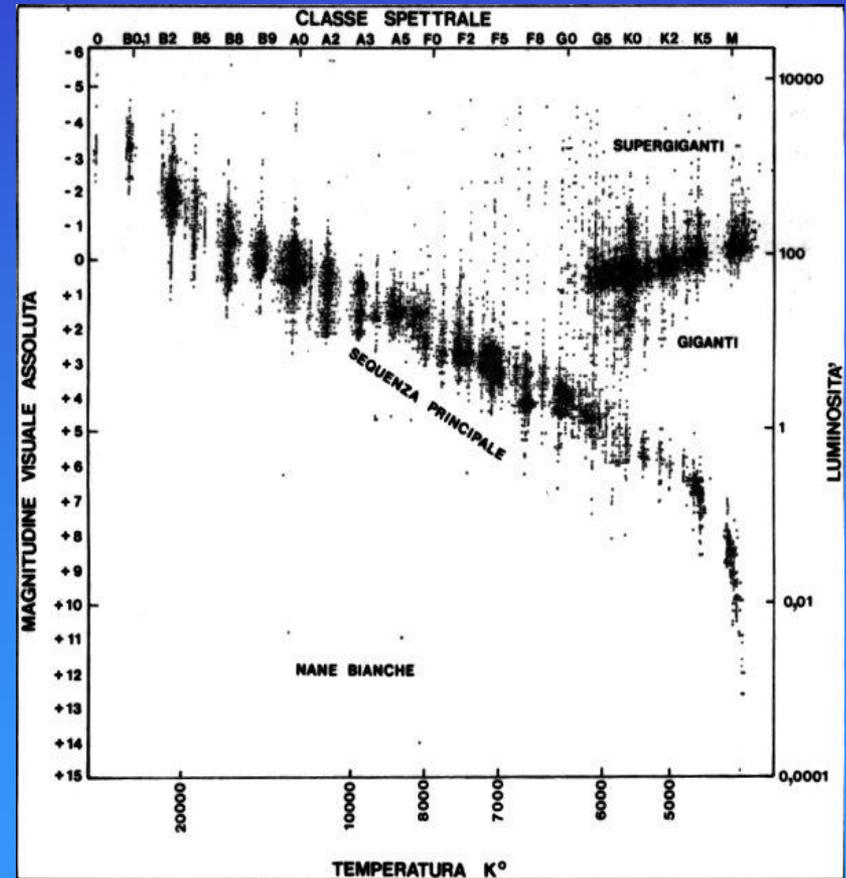
~1850 J. V. MAYER
CADUTA DI METEORITI

W. T. LORD KELVIN
VARIAZIONE ORBITE
INCOMPATIBILE



IL DIAGRAMMA H-R

1905-14 E. Hertzsprung e H.N. Russel In un diagramma Luminosità-**Temperatura** le stelle si distribuiscono in modo non casuale

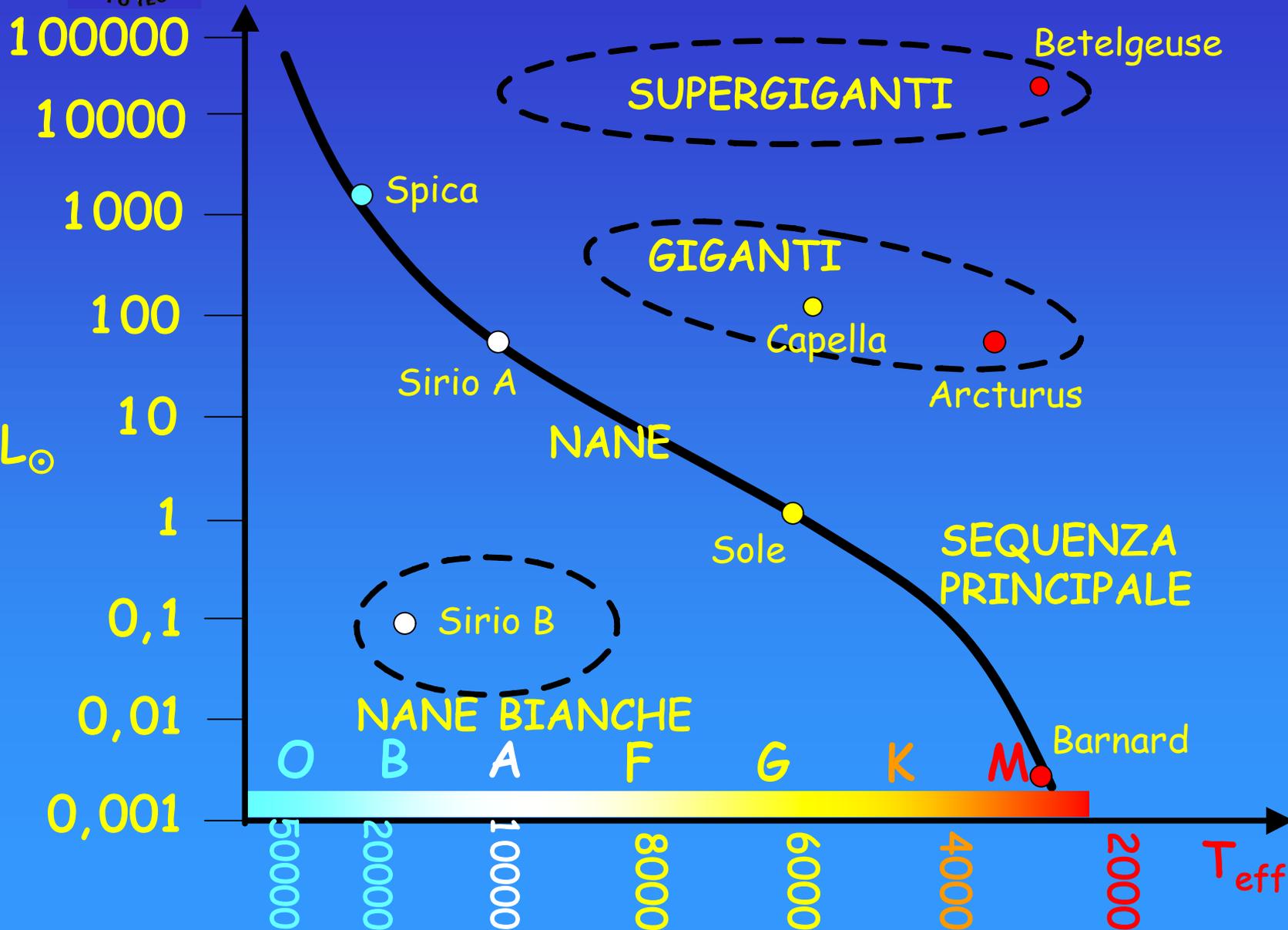


1914 H.N. Russel "Nature"

H-R con dati da terra



IL DIAGRAMMA H-R

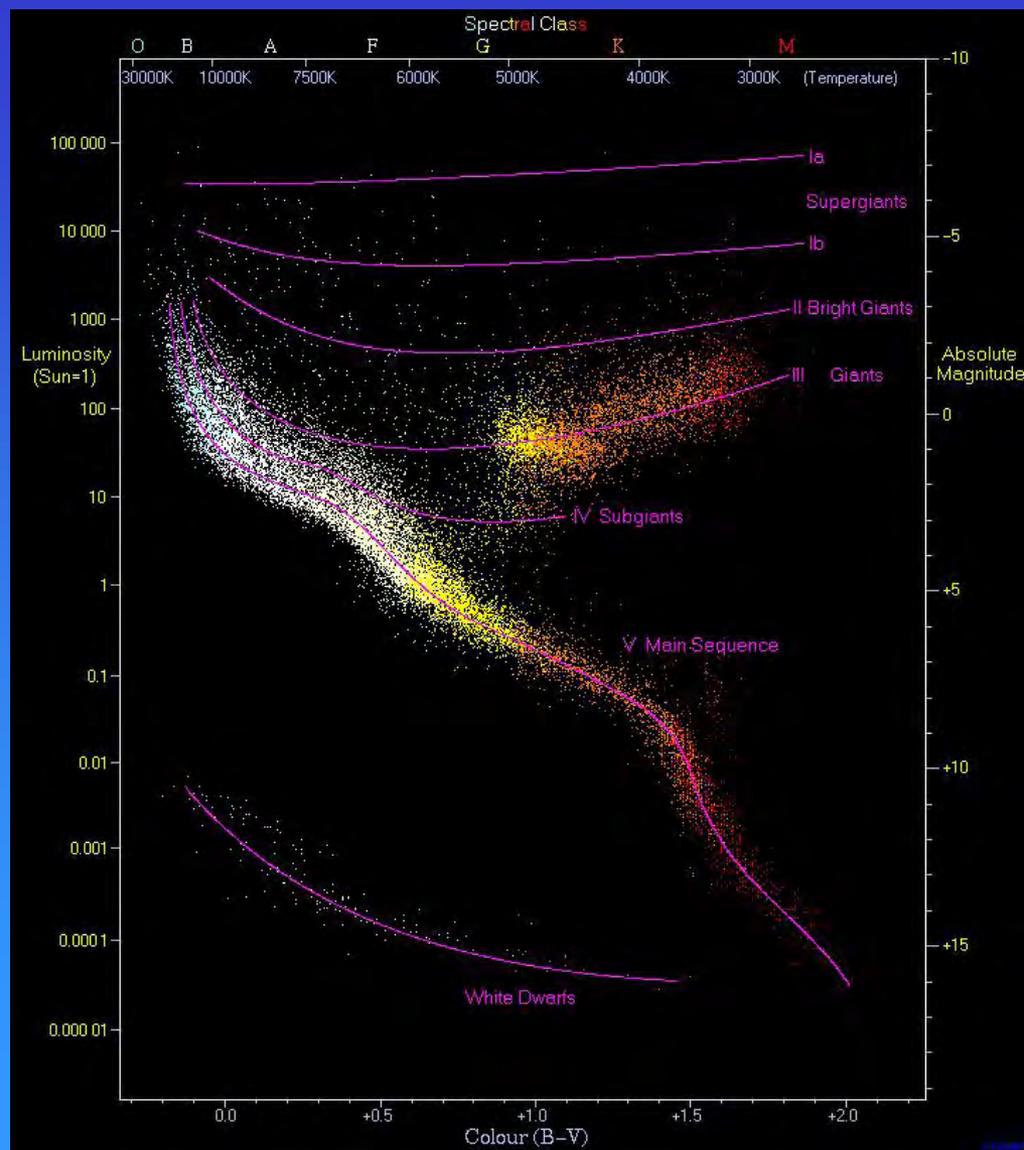




DATI RECENTI

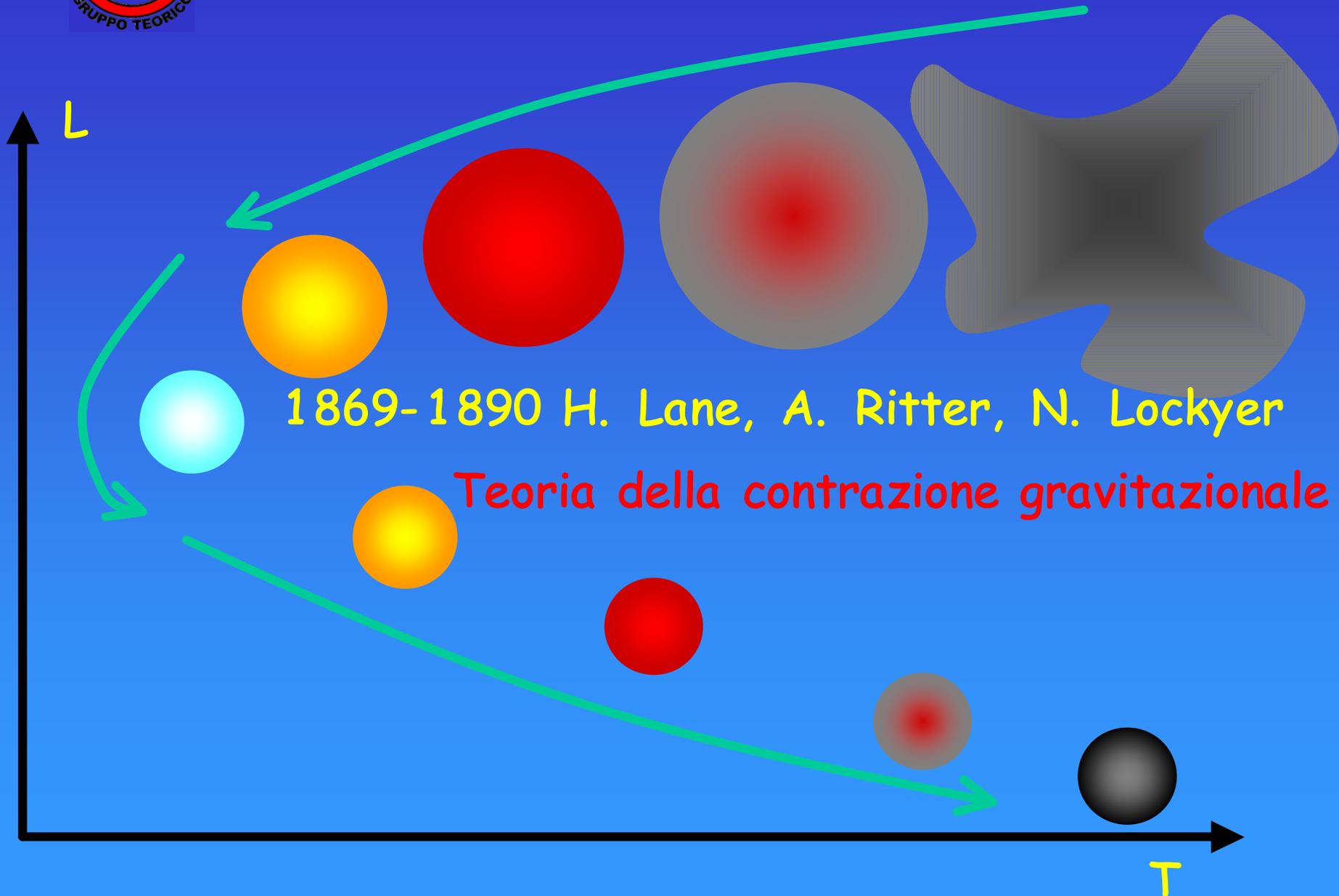
UTILIZZANDO
DATI RECENTI
SONO BEN
VISIBILI LE
REGIONI IN CUI
È SUDDIVISO IL
DIAGRAMMA H-R

H-R dati da
Hipparcos e Gliese
by R. Powell





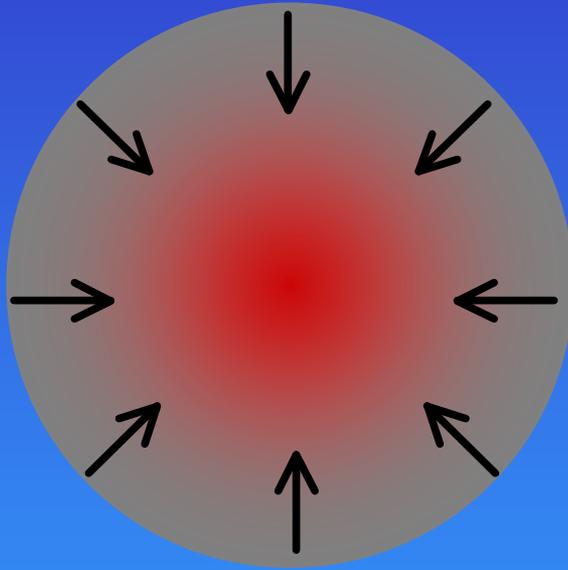
UNA PRIMA TEORIA





ENERGIA GRAVITAZIONALE

CONTRAZIONE GRAVITAZIONALE \Rightarrow AUMENTO DI TEMPERATURA



~ 1890 Lockyer, Emden
Helmholtz, Kelvin



PER IL SOLE

$$E \approx 3,8 \times 10^{41} \text{ J}$$

$$L \approx 3,8 \times 10^{26} \text{ W}$$

$$t \approx 2,5 \times 10^{14} \text{ s} \approx 30 \text{ My}$$

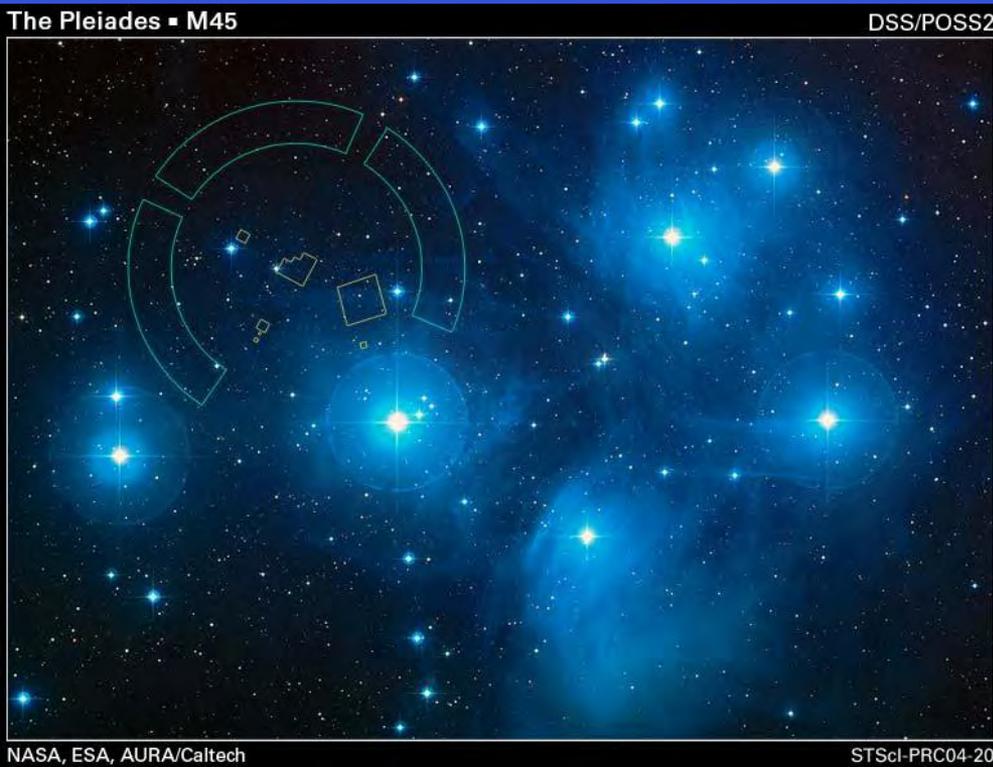
ENERGIA LIBERATA

$$E \approx GM^2/R$$



LE DUE POPOLAZIONI

1944 Baade Nella *Galassia* vi sono due sistemi stellari distinti per caratteristiche dinamiche e composizione chimica



Popolazione I

$$Z \approx Z_{\odot}$$



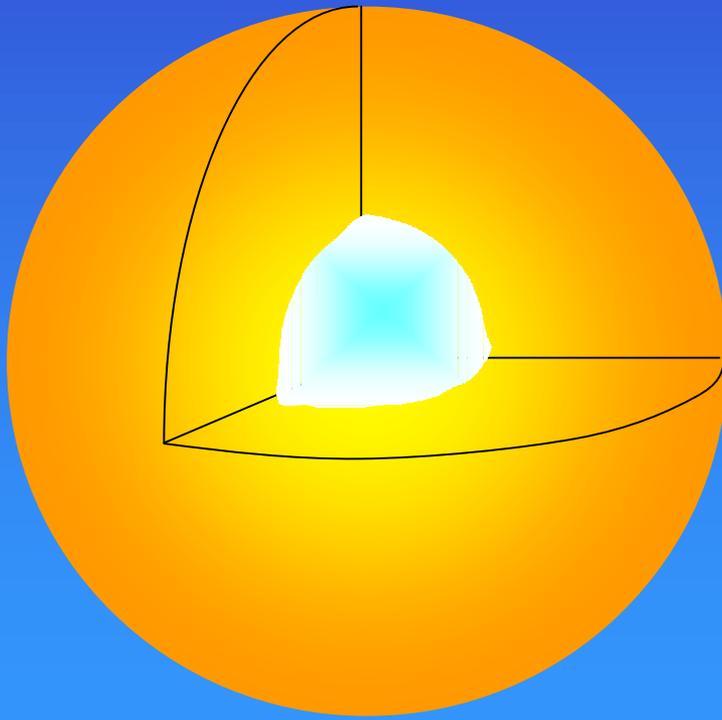
Popolazione II

$$Z \approx 0,01Z_{\odot}$$



LE CONDIZIONI INTERNE

1890-1940 MODELLI MATEMATICO-FISICI
DELL'INTERNO STELLARE



$$T \approx 5 - 15 \times 10^6 \text{ K}$$

$$P \approx 10^9 \text{ Pa} \approx 10^4 \text{ Atm}$$

$$\rho \approx 10^2 \text{ g/cm}^3$$



IL "FUOCO" NUCLEARE

1896 H. Bequerel **SCOPERTA DELLA RADIOATTIVITA'** ⇒ ENERGIA NUCLEARE

1919 E. Rutherford **PRIMA TRASMUTAZIONE RADIOATTIVA ARTIFICIALE**



1920 A. Eddington

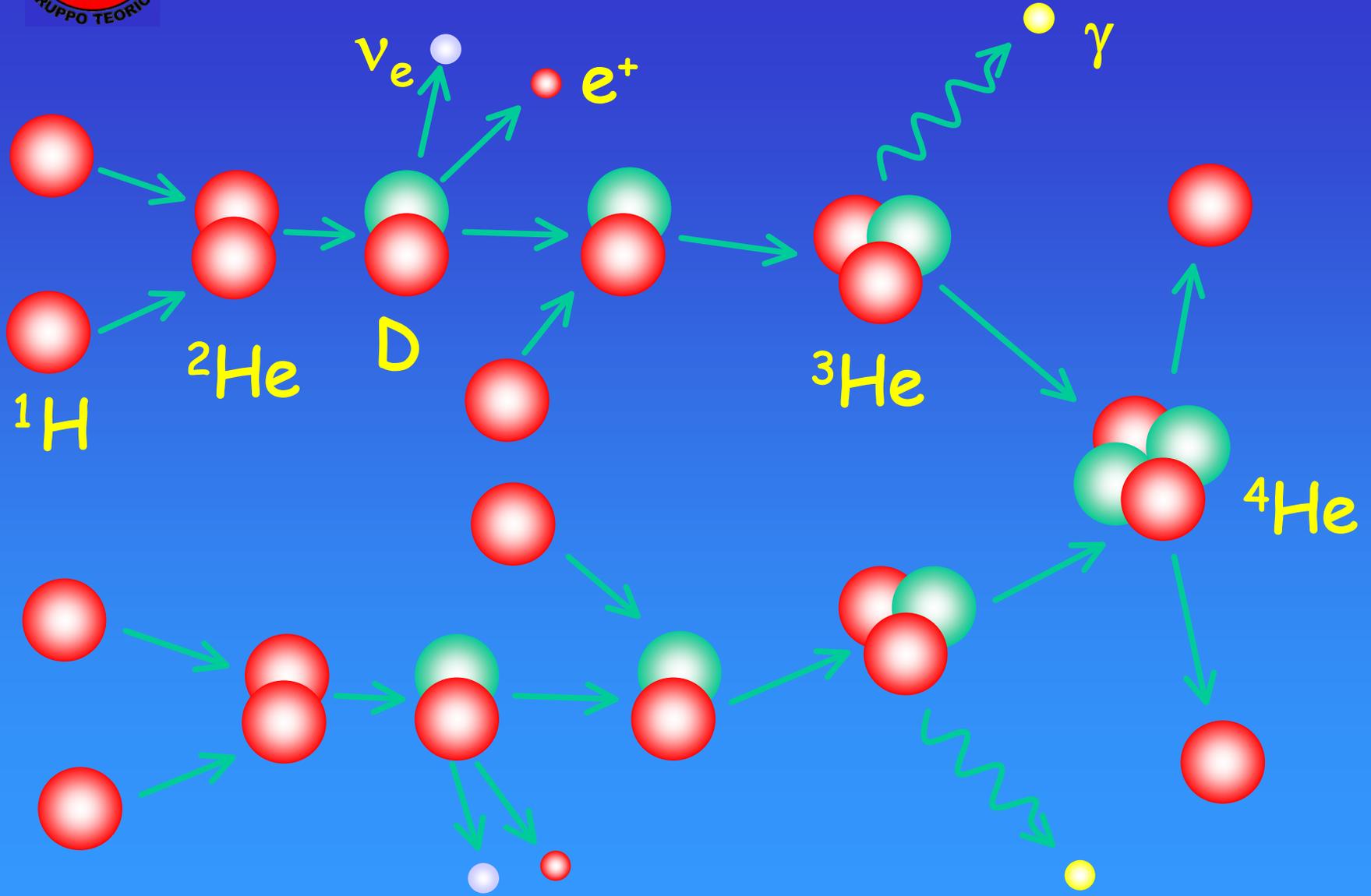
REAZIONI TERMONUCLEARI ⇒ ENERGIA STELLARE

1939 H. Bethe

CICLO PROTONE-PROTONE E CARBONIO

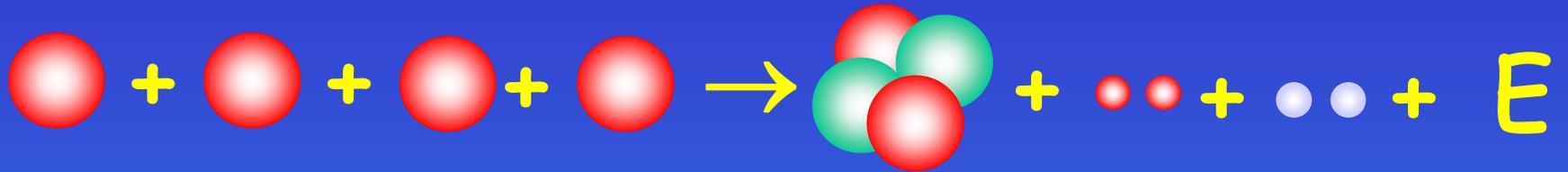


I NUCLEI SI FONDONO





$$\underline{E=mc^2}$$



Massa H $m_{\text{H}} = 1,672 \times 10^{-27} \text{ Kg} = 1,007276 \text{ uma}$

Massa He $m_{\text{He}} = 6,642 \times 10^{-27} \text{ Kg} = 4,001505 \text{ uma}$

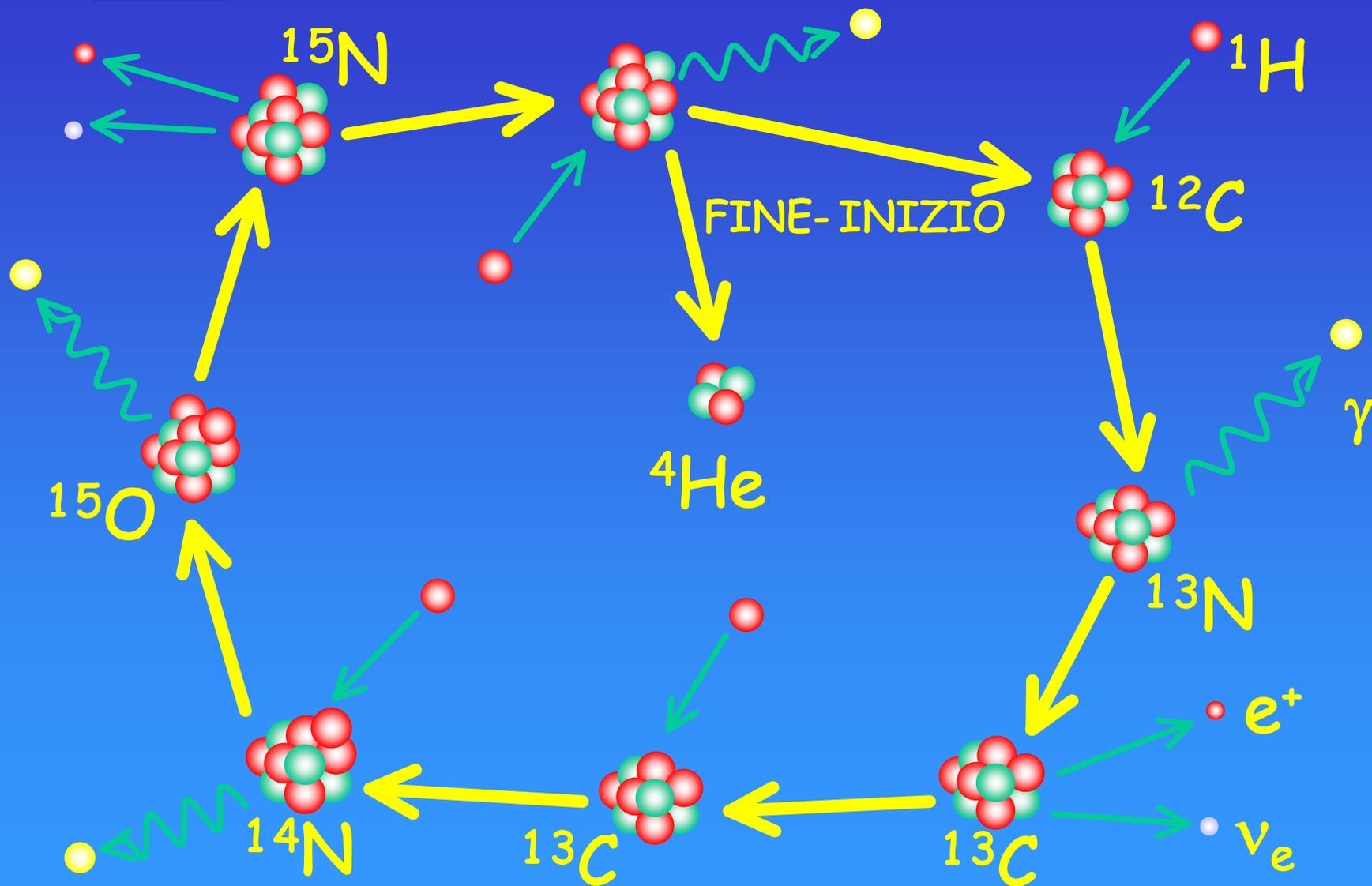
$$\Delta m = 4m_{\text{H}} - m_{\text{He}} = 0,68 \% 4m_{\text{H}} = 0,027599 \text{ uma} = 4,12 \times 10^{-12} \text{ J}$$

Per 1 g di H si sviluppano $6,12 \times 10^{11}$ Joule

fabbisogno energetico medio di una famiglia per 15 anni

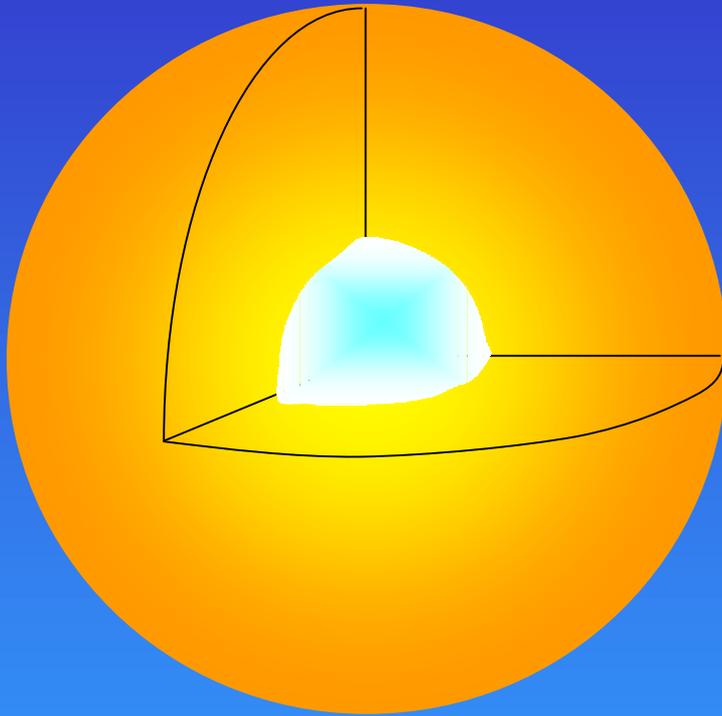


IL CICLO CNO





LA VITA SI ALLUNGA!



$$M_{\odot} \approx 2,0 \times 10^{30} \text{ Kg}$$

$$M_{\odot H} \approx 1,4 \times 10^{30} \text{ Kg}$$

$$15\% M_{\odot H} \approx 0,21 \times 10^{30} \text{ Kg}$$

$$E_{\odot H} \approx 1,3 \times 10^{44} \text{ J}$$

$$L_{\odot} \approx 3,8 \times 10^{26} \text{ W}$$

$$t \approx E_{\odot H} / L_{\odot} \approx 3,4 \times 10^{17} \text{ s} \approx 11 \times 10^9 \text{ y}$$



CHI PIU' BRILLA...



GIGANTE AZZURRA

$$M_{\star} \approx 20 M_{\odot} \quad t_{\star} \approx 22 \times 10^6 \text{ y}$$
$$L_{\star} \approx 10^4 L_{\odot}$$

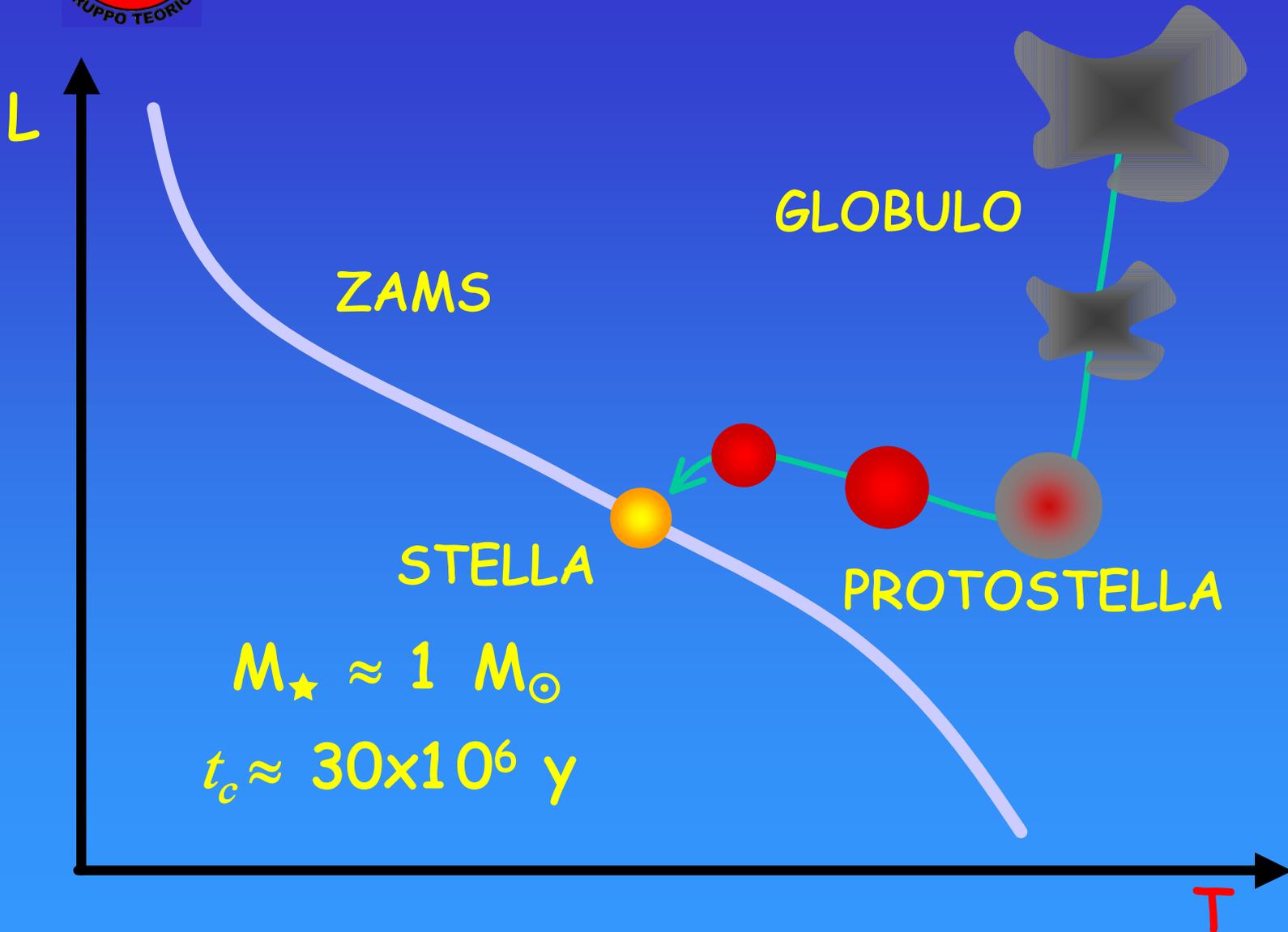


NANA ROSSA

$$M_{\star} \approx 0,2 M_{\odot} \quad t_{\star} \approx 220 \times 10^9 \text{ y}$$
$$L_{\star} \approx 10^{-2} L_{\odot}$$

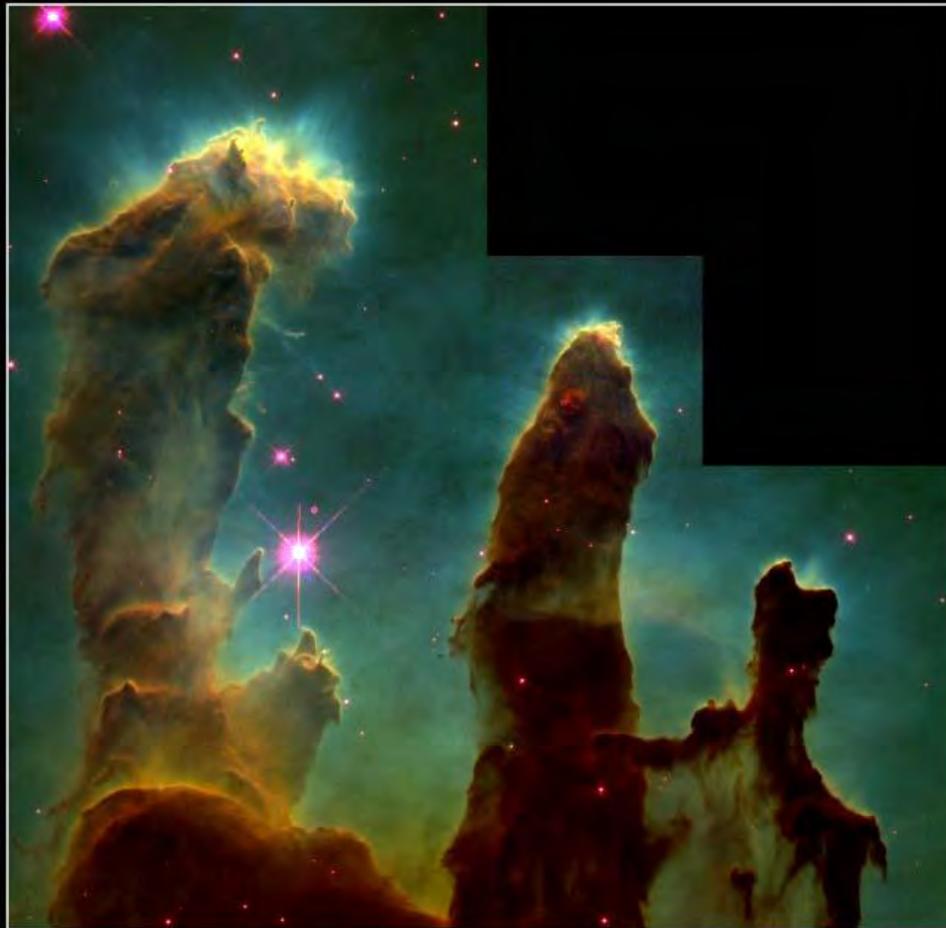


LA NASCITA DI UNA STELLA





LA CULLA DELLE STELLE



Gaseous Pillars • M16

HST • WFPC2

PRC95-44a • ST ScI OPO • November 2, 1995
J. Hester and P. Scowen (AZ State Univ.), NASA



*HST WFPC2
STScI-PRC95-45a
C.R. O'Dell (Vanderbilt)*

Fonte HST - NASA



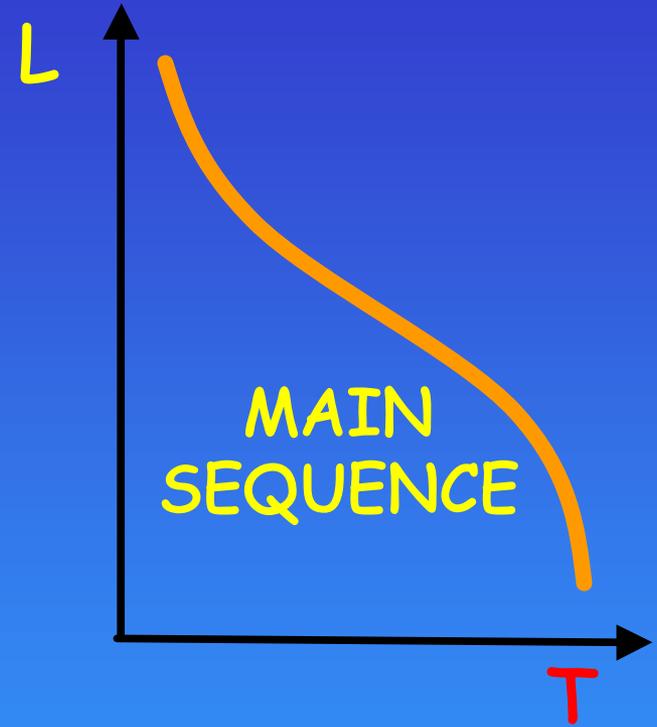
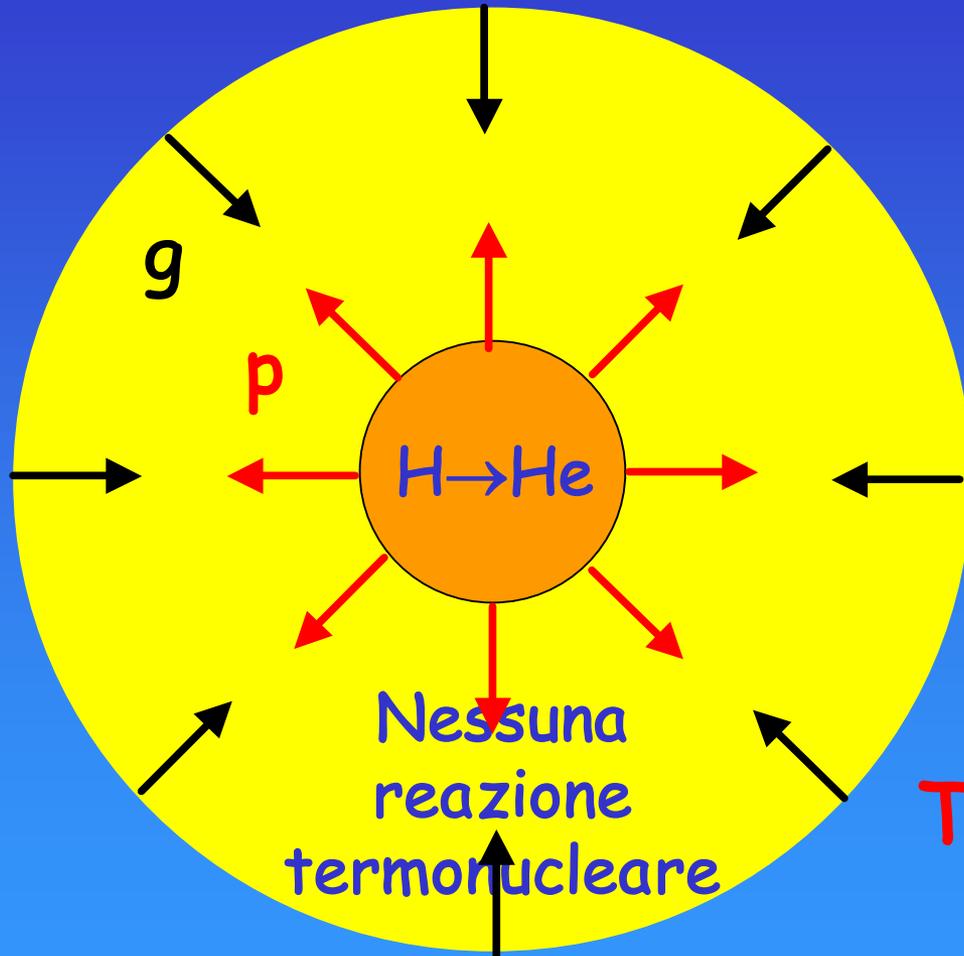
PRIMI VAGITI



Fonte HST - NASA



L'IDROGENO "BRUCIA"

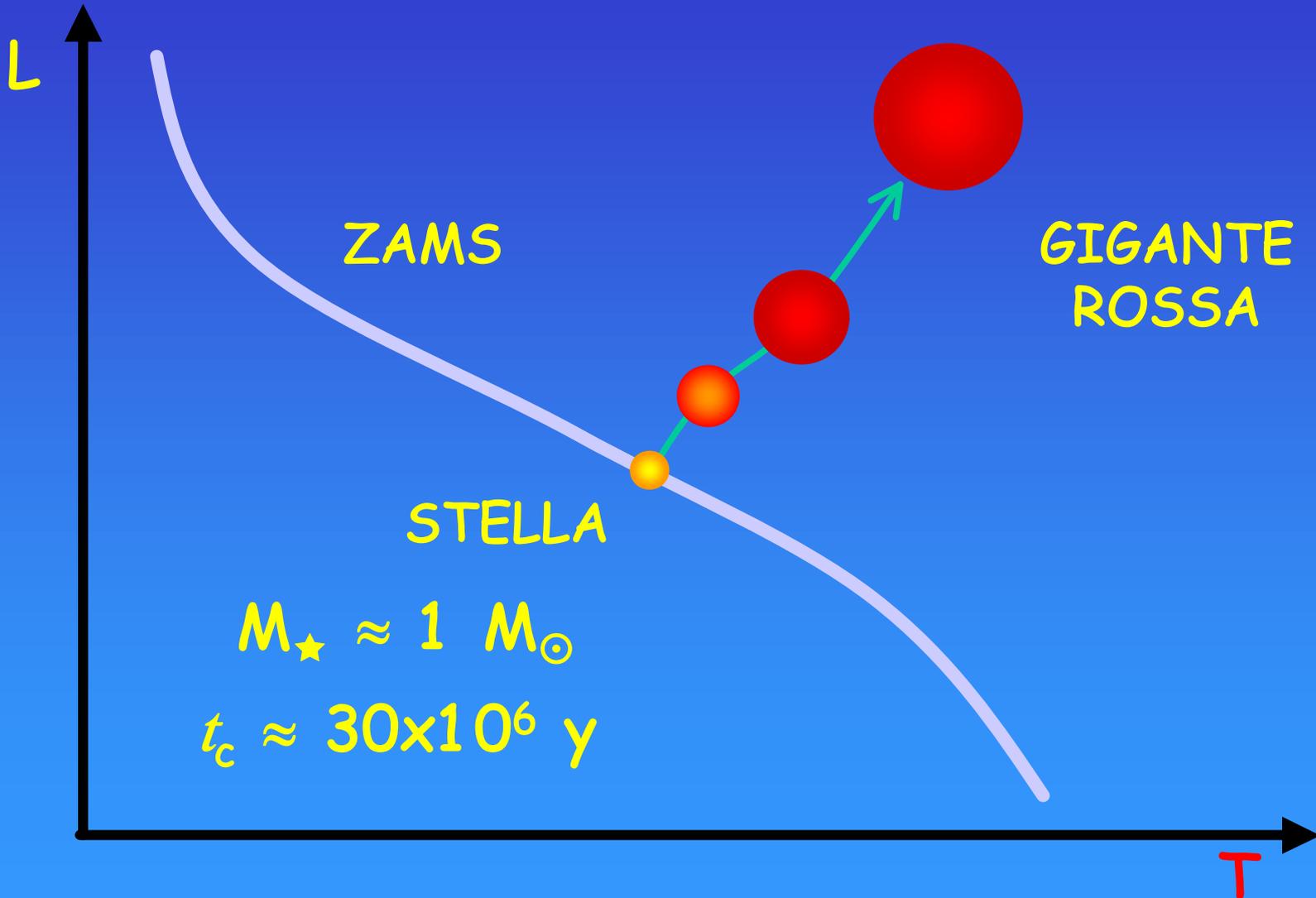


$$T_N \approx 5 - 30 \times 10^6 \text{ K}$$

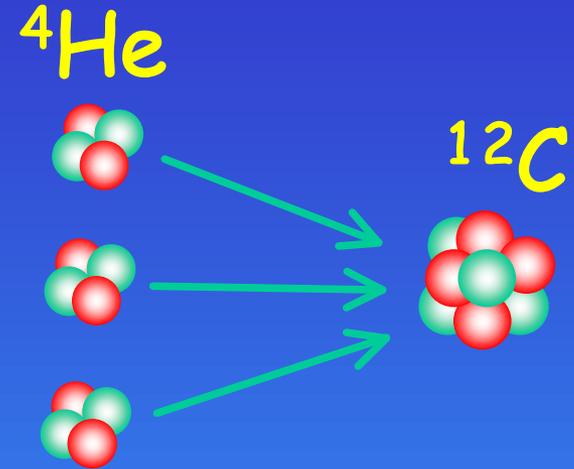
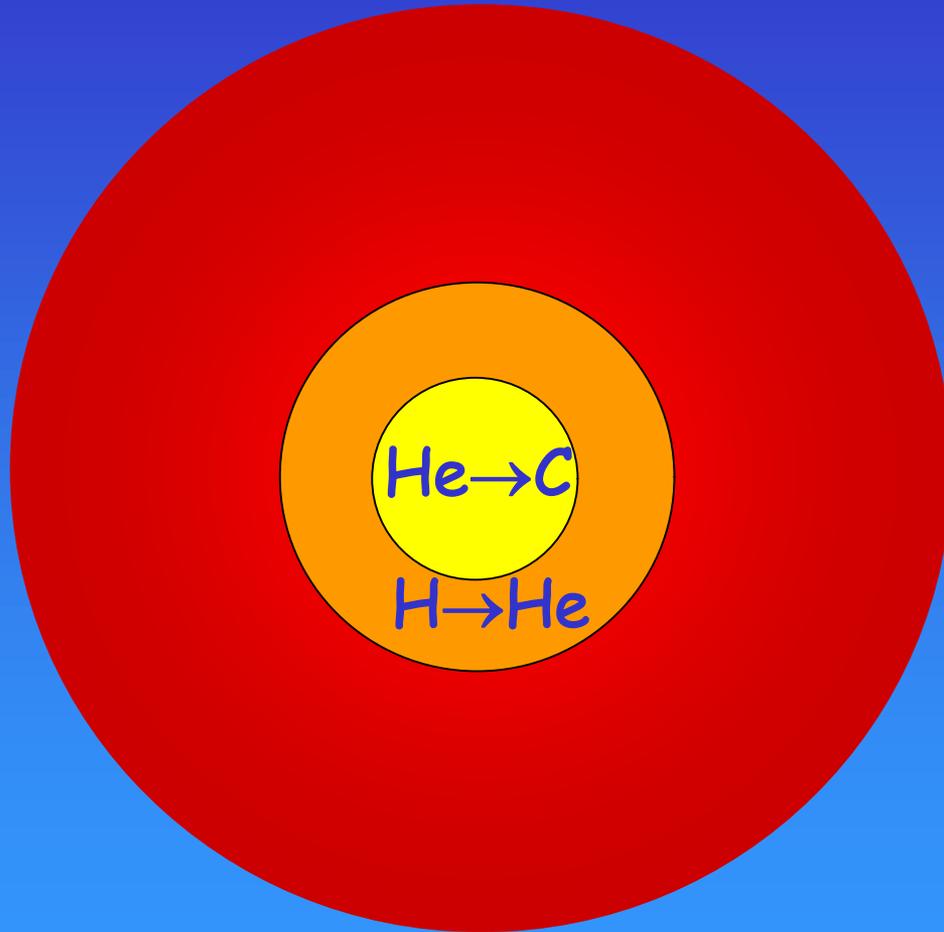
$$t_H \approx 0,02 - 200 \times 10^9 \text{ y}$$



DOPO L'IDROGENO



HELIUM FLASH



PROCESSO 3α

$$T_N \approx 100 \times 10^6 \text{ K}$$

$$t_{\text{He}} \approx 100 \times 10^6 \text{ y}$$



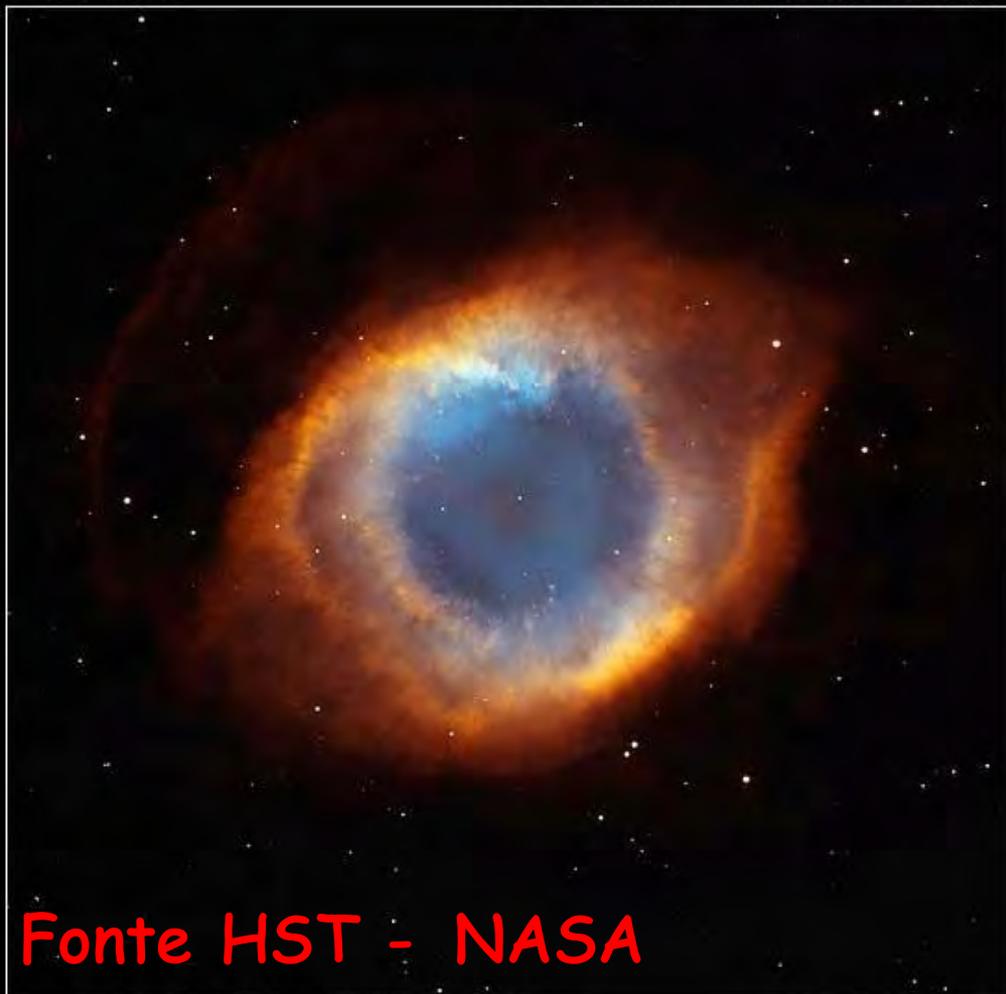
LE NEBULOSE PLANETARIE

Helix Nebula
NGC 7293

HST ■ ACS

NOAO 0.9m ■ Mosaic I Camera

Cat's Eye Nebula • NGC 6543



Fonte HST - NASA

Hubble
Heritage

NASA, NOAO, ESA, The Hubble Helix Team,
M. Meixner (STScI), and T.A. Rector (NRAO)

STScI-PRC03-11a

NASA, ESA, HEIC and The Hubble Heritage Team (STScI/AURA)
Hubble Space Telescope ACS • STScI-PRC04-27

LE NEBULOSE PLANETARIE



Fonte HST - NASA

Hourglass Nebula • MyCn18

HST • V

PRC96-07 • ST ScI OPO • January 16, 1996

R. Sahai and J. Trauger (JPL), the WFPC2 Science Team and NASA



NGC 2392 • "Eskimo" Nebula

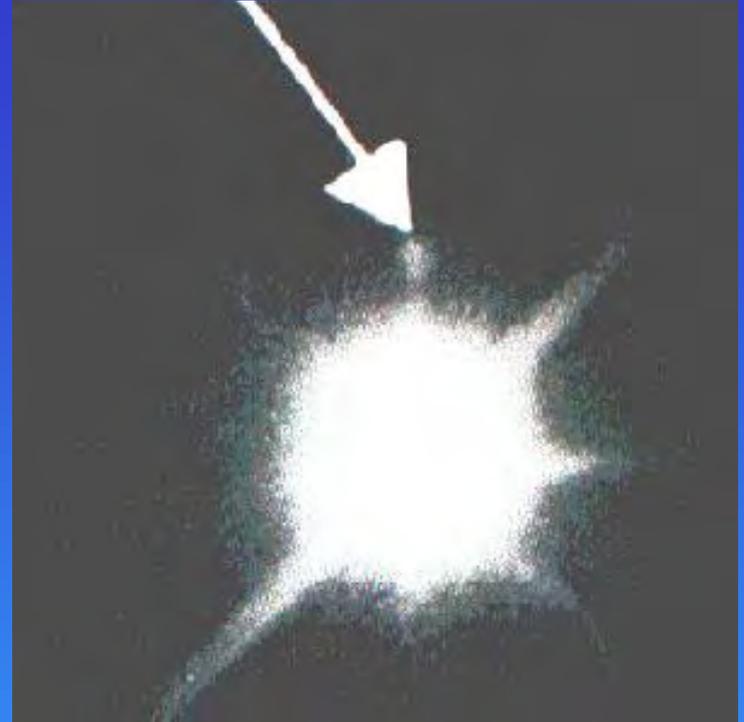
HST • WFPC2

NASA, A. Fruchter and the ERO Team (STScI) • STScI-PRC00-07

LE NANE BIANCHE



15.000 Km



$$M_{\star} < 1,44 M_{\odot}$$

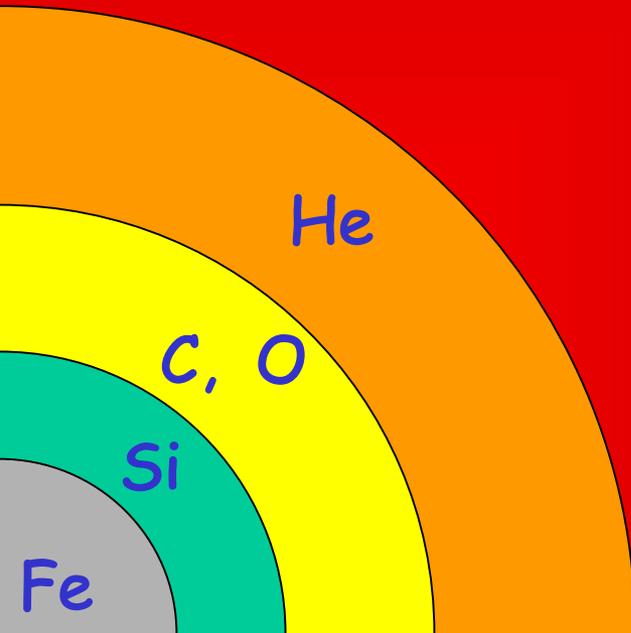
$$\rho \approx 10^6 \text{ g/cm}^3$$

$$T_s \approx 10^5 \text{ K}$$



OLTRE IL CARBONIO

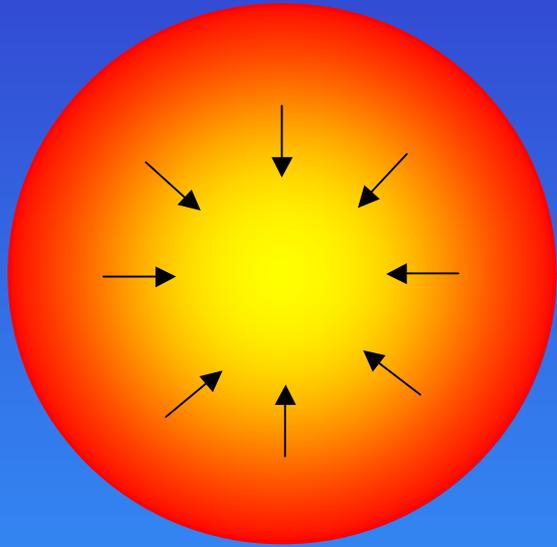
H, He



$$T_N \approx 4 \times 10^9 \text{ K}$$

$$t_{\text{He}} \approx 10^4 \text{ y}$$

LE SUPERNOVAE



COLLASSO DEL
NUCLEO



SUPERNOVA



PROCESSI r E s

CATTURA NEUTRONICA

S=SLOW

Basso flusso di
neutroni

$10^5 - 10^{11}$ n/cm²s



STELLE GIGANTI

Elementi fino a
A~210

R=RAPID

Alto flusso di
neutroni

$> 10^{22}$ n/cm²s



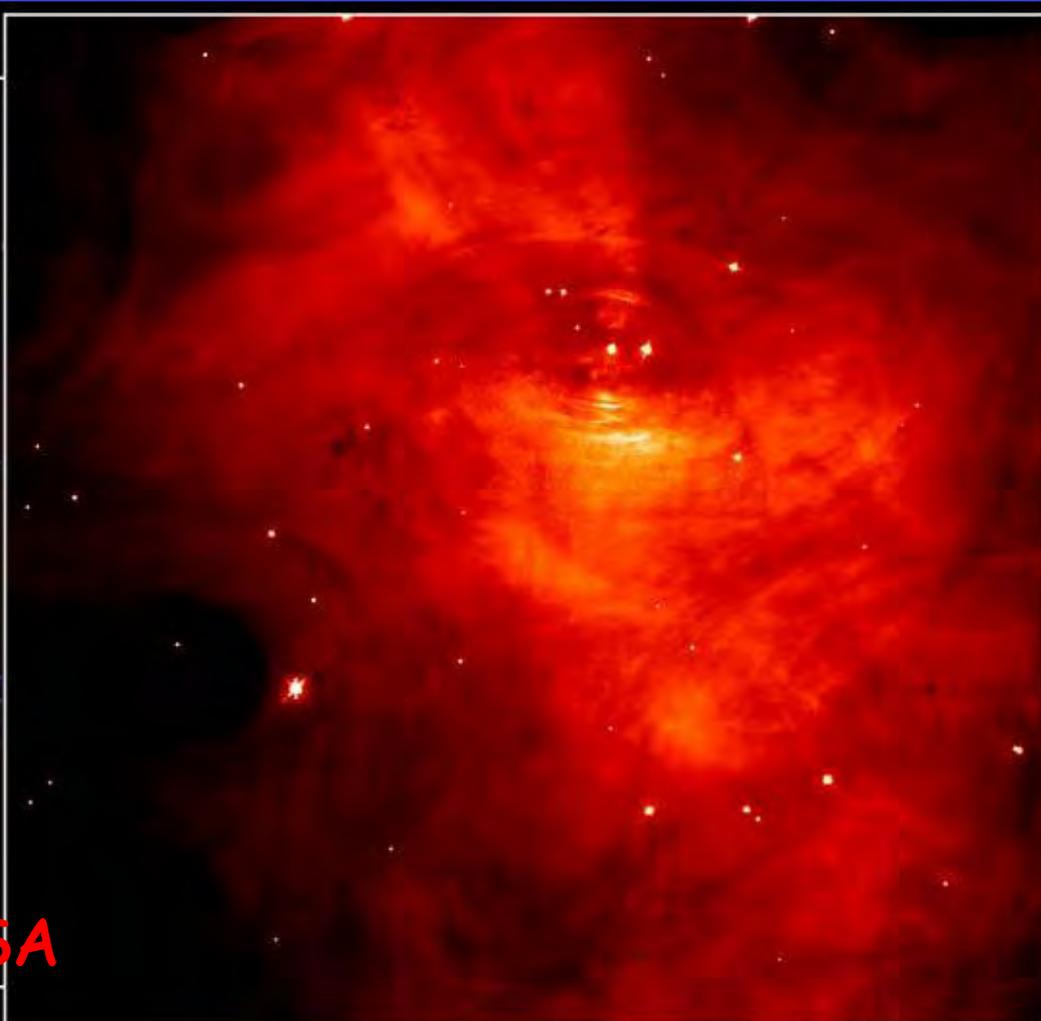
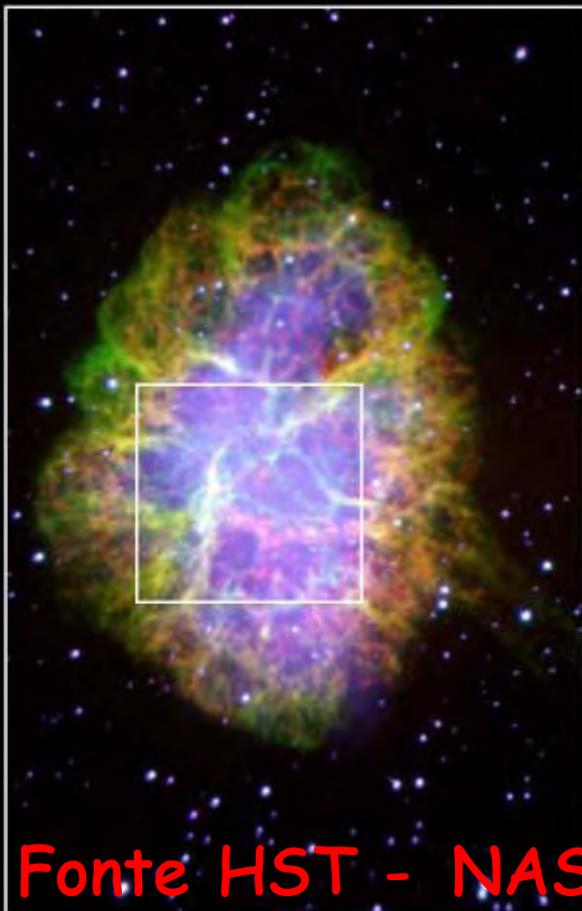
SUPERNOVAE

Elementi fino a
A~270



LE SUPERNOVAE

Crab Nebula



Fonte HST - NASA

Palomar

PRC96-22a · ST ScI OPO · May 30, 1996

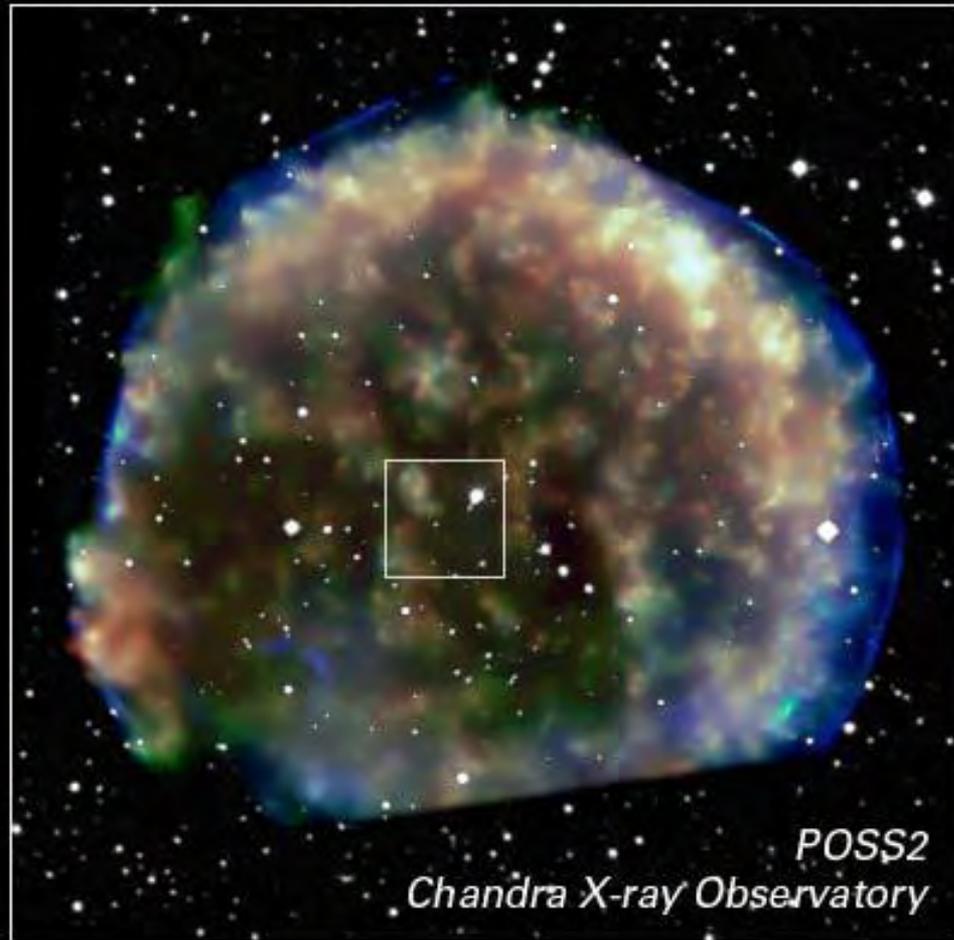
J. Hester and P. Scowen (AZ State Univ.) and NASA

HST · WFPC2

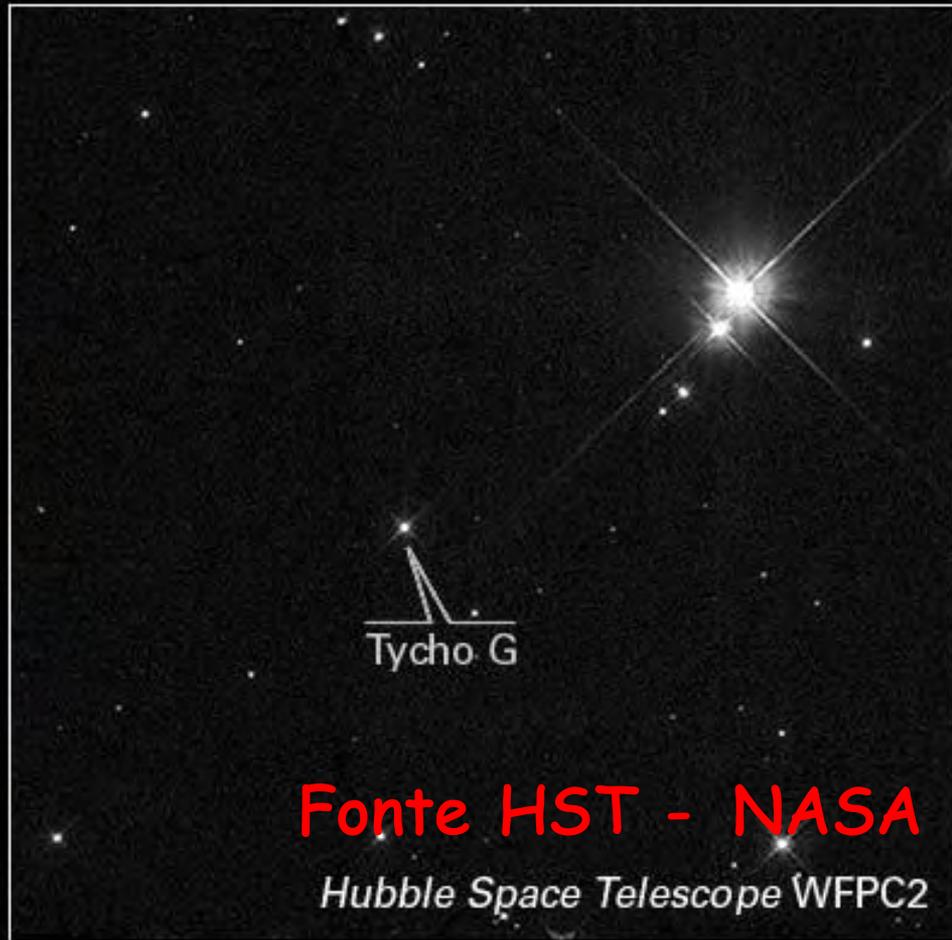


LE SUPERNOVAE

Candidate Progenitor Companion to Tycho's Supernova 1572



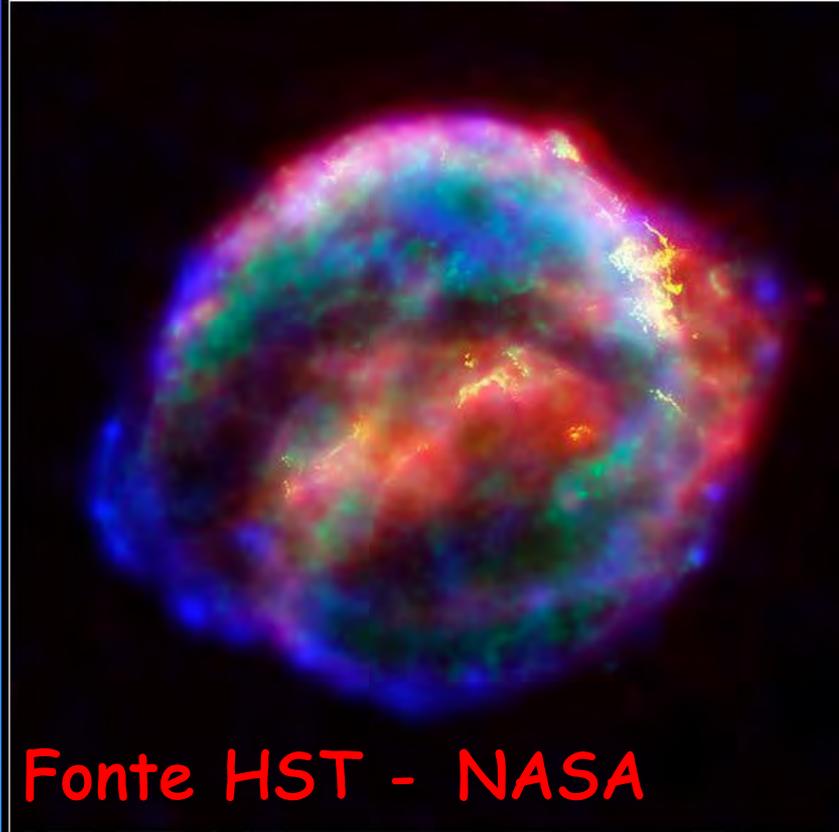
POSS2
Chandra X-ray Observatory



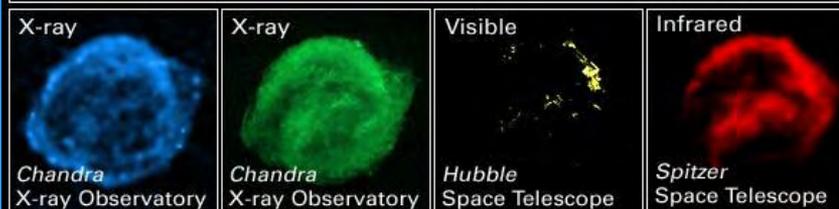
Fonte HST - NASA
Hubble Space Telescope WFPC2

LE SUPERNOVAE

Kepler's Supernova Remnant • SN 1604



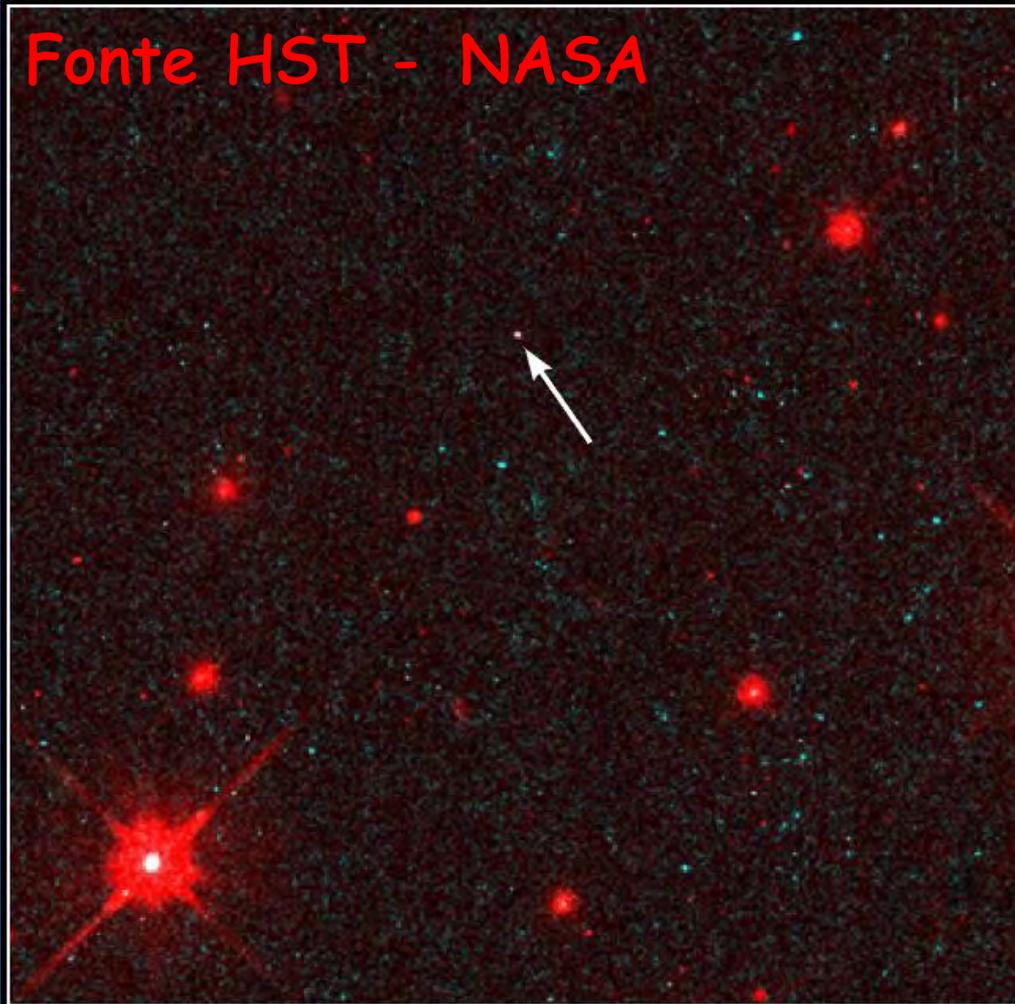
Fonte HST - NASA





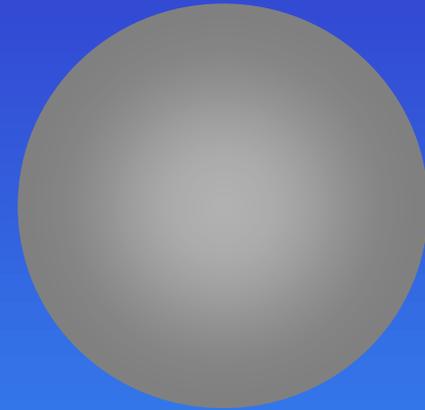
LE STELLE DI NEUTRONI

Fonte HST - NASA



Isolated Neutron Star RX J185635-3754 HST • WFPC2

PRC97-32 • ST ScI OPO • September 25, 1997
F. Walter (State University of New York at Stony Brook) and NASA



12 Km

$M_{\star} < 3 M_{\odot}$

$\rho \approx 10^{14} \text{ g/cm}^3$



LA MATERIA SI CONTRAE





I BUCHI NERI

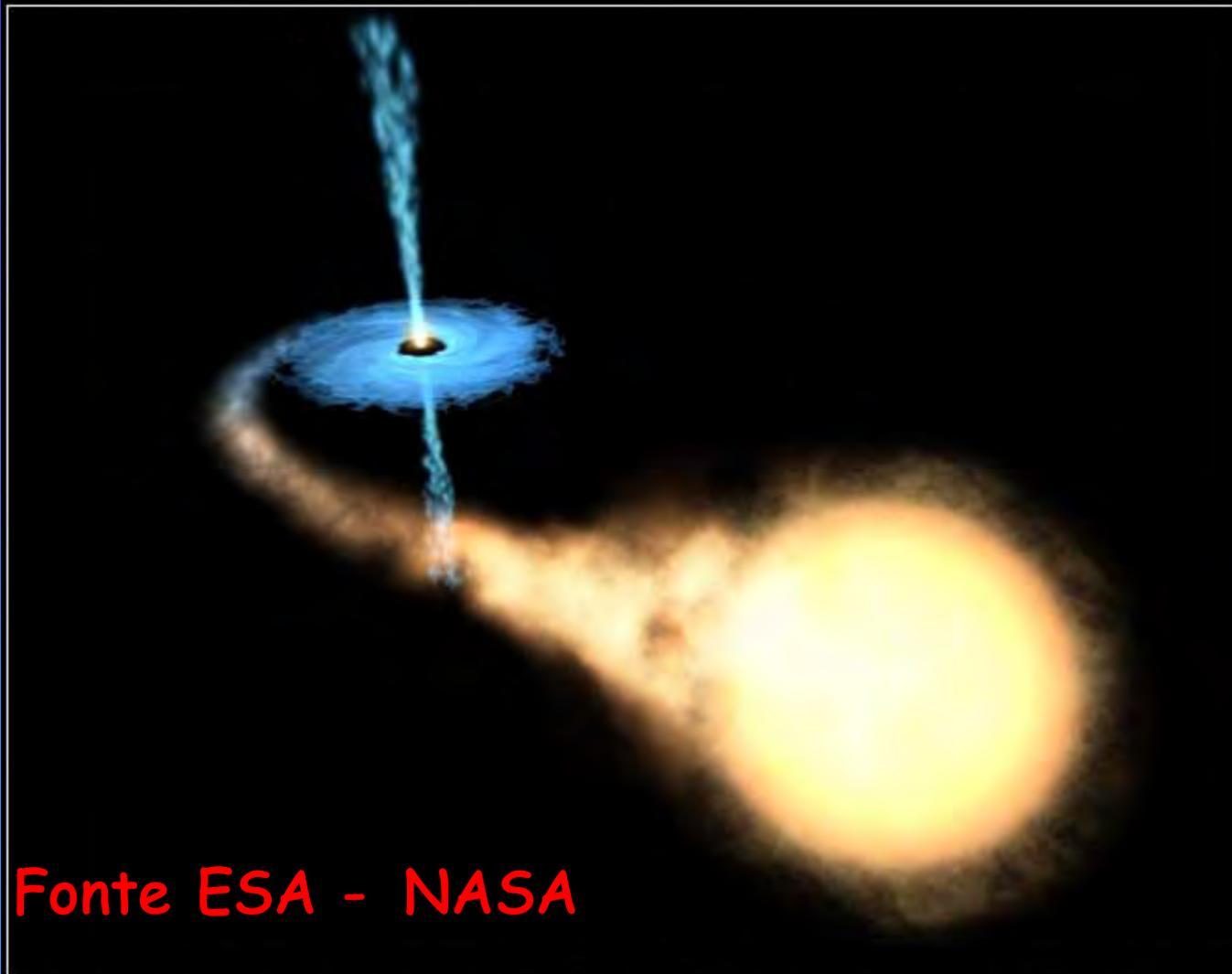


6 Km

$$R_S = 2GM / c^2$$

$$M_{\star} > 3 M_{\odot}$$

DIVORATORI DI MATERIA



Fonte ESA - NASA

Artist's View of Black Hole and Companion Star GRO J1655-40

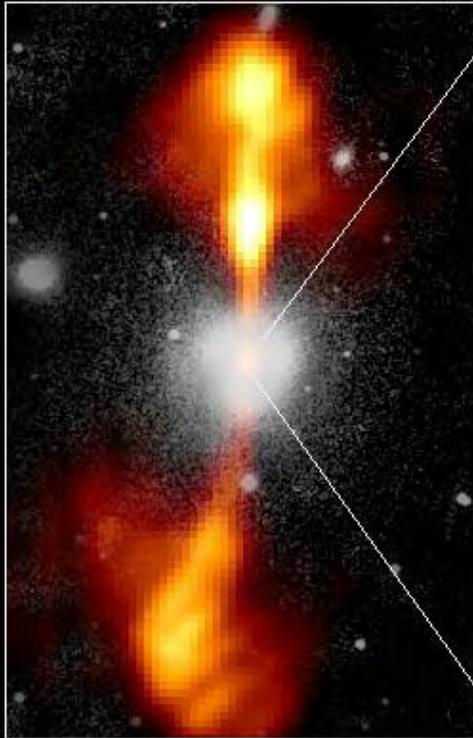
ESA, NASA and F. Mirabel (CEA) ■ STScI-PRC02-30

NEL CUORE DELLE GALASSIE

Core of Galaxy NGC 4261

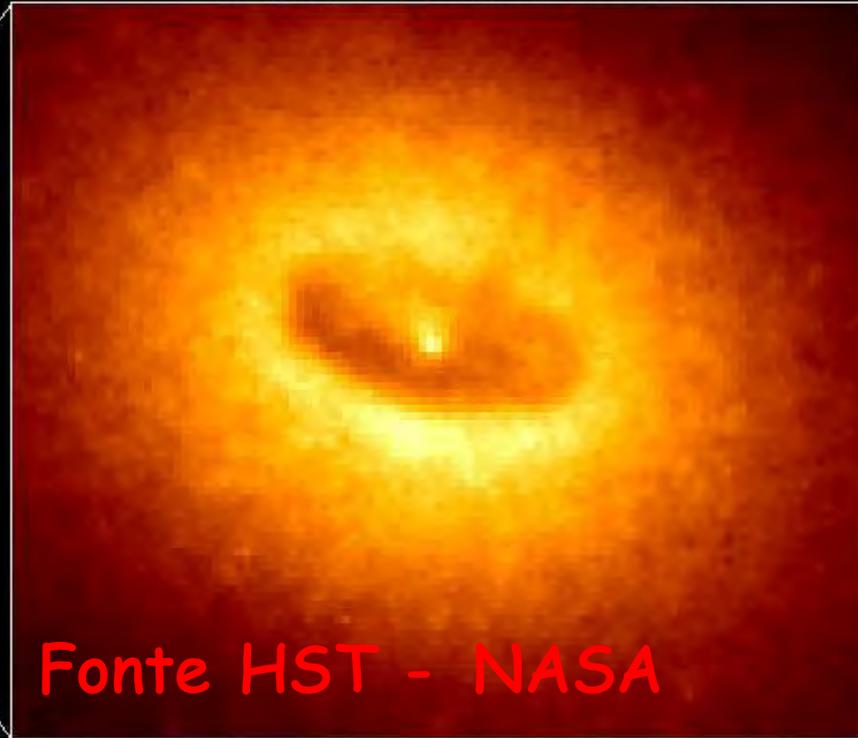
Hubble Space Telescope
Wide Field / Planetary Camera

Ground-Based Optical/Radio Image



380 Arc Seconds
88,000 LIGHT-YEARS

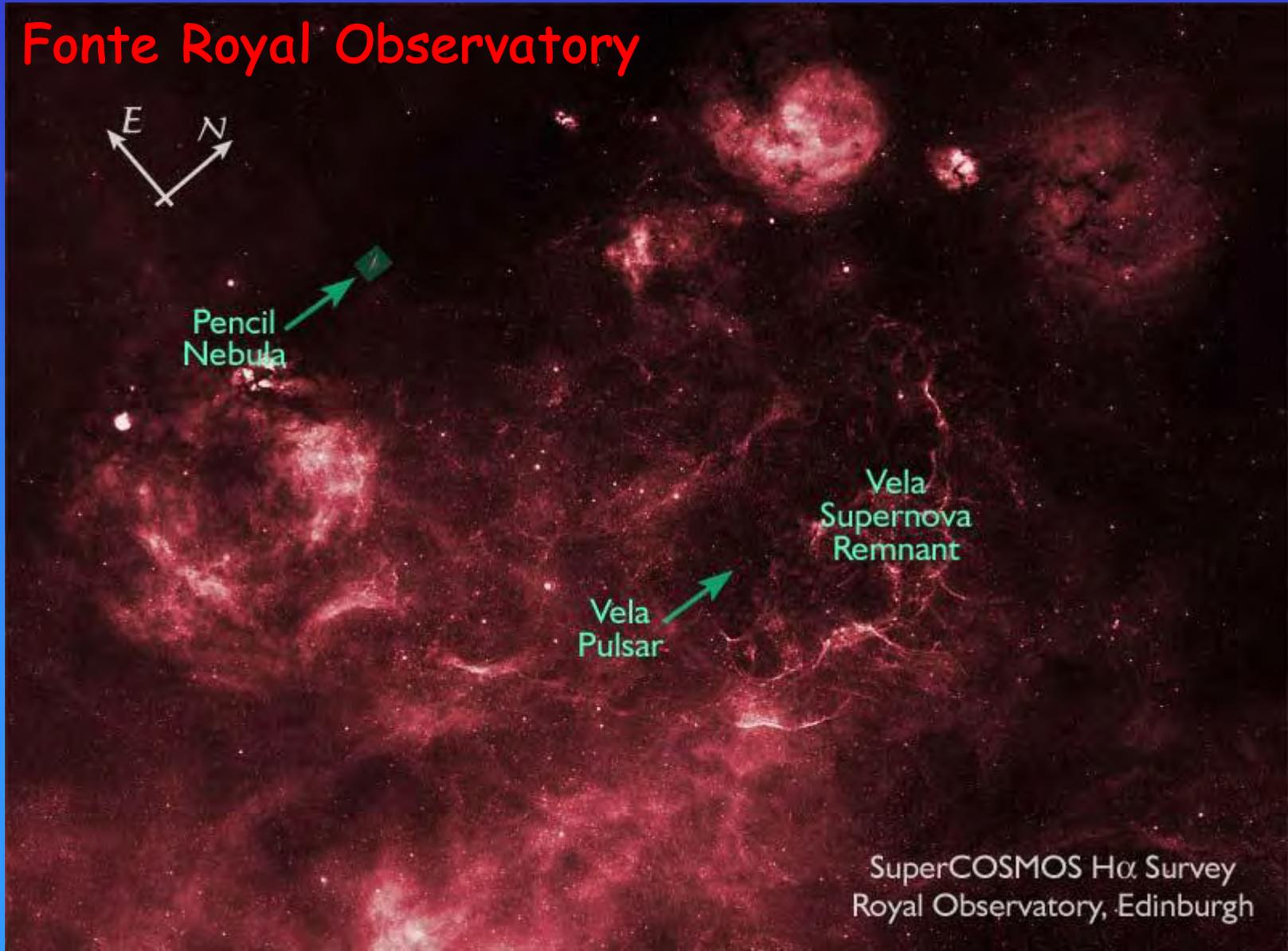
HST Image of a Gas and Dust Disk



17 Arc Seconds
400 LIGHT-YEARS

COME LA FENICE

Fonte Royal Observatory



COME LA FENICE

Supernova Remnant Cassiopeia A



Fonte HST - NASA

Hubble
Heritage



TAVOLA PERIODICA

H																	He
Li	Be											B	C	N	O	F	Ne
Na	Mg											Al	Si	P	S	Cl	Ar
K	Ca	Sc	Ti	V	Cr	Mn	Fe	Co	Ni	Cu	Zn	Ga	Ge	As	Se	Br	Kr
Rb	Sr	Y	Zr	Nb	Mo	Tc	Ru	Rh	Pd	Ag	Cd	In	Sn	Sb	Te	In	Xe
Cs	Ba	La	Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra	Ac	Unq	Unp	Unh												
Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu				
Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lw				

NUCLEOSINTESI PRIMORDIALE

NUCLEOSINT. POST SEQUENZA

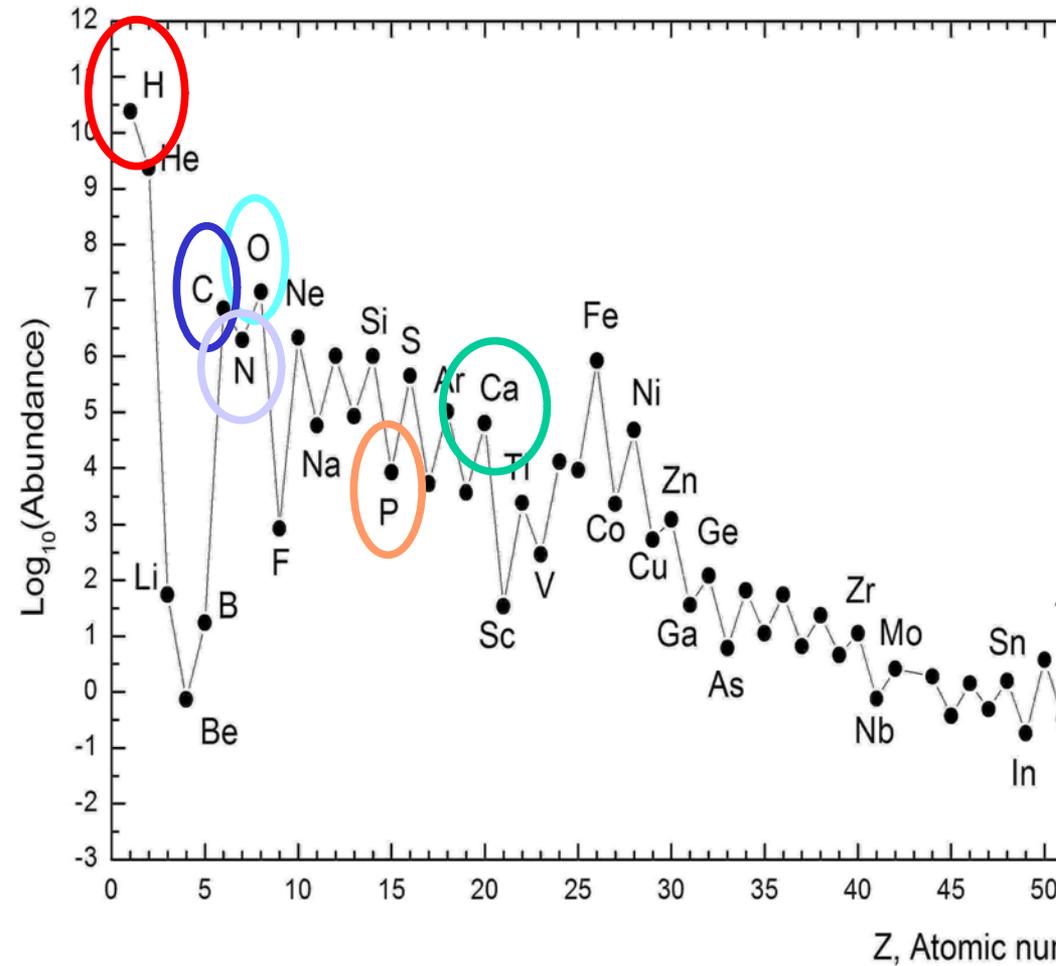
NUCLEOSINT. PROCESSI s E r

NUCLEOSINT. PROCESSI r



ABBONDANZE COSMICHE

ABBONDANZE CORPO UMANO



ELEMENTO	% MASSA
Ossigeno	65
Carbonio	18
Idrogeno	10
Azoto	3
Calcio	1,5
Fosforo	1,2
K, S, Cl	0,2
Sodio	0,1
Magnesio	0,05
Fe, Co, Cu, Zn	< 0,05

ABBONDANZE COSMICHE NEL SISTEMA SOLARE
 Fonte K. Lodders Ap. J n° 591



FATTI DI POLVERE DI STELLE

GRAZIE PER
L'ATTENZIONE
DOMANDE?