

Seeking God in Einstein's Universe The Substance of the World

Aileen A. O'Donoghue

Evening Came ...

**"As the universe expanded
and cooled, darkness
descended,**



...And Morning Followed

"Then light dawned anew with the formation of the first stars.

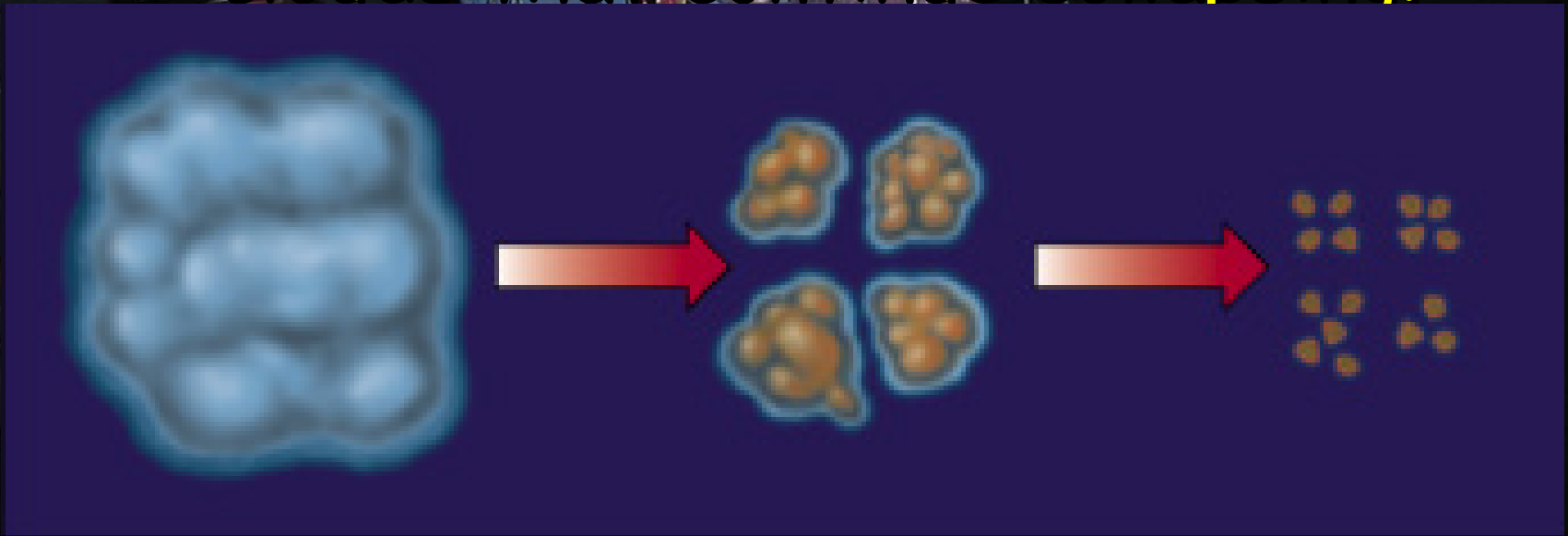
Each star is a nuclear furnace where matter is coaxed into releasing a little of the energy it inherited from the primordial fireball."

Timothy Ferris

The Creation of the Universe

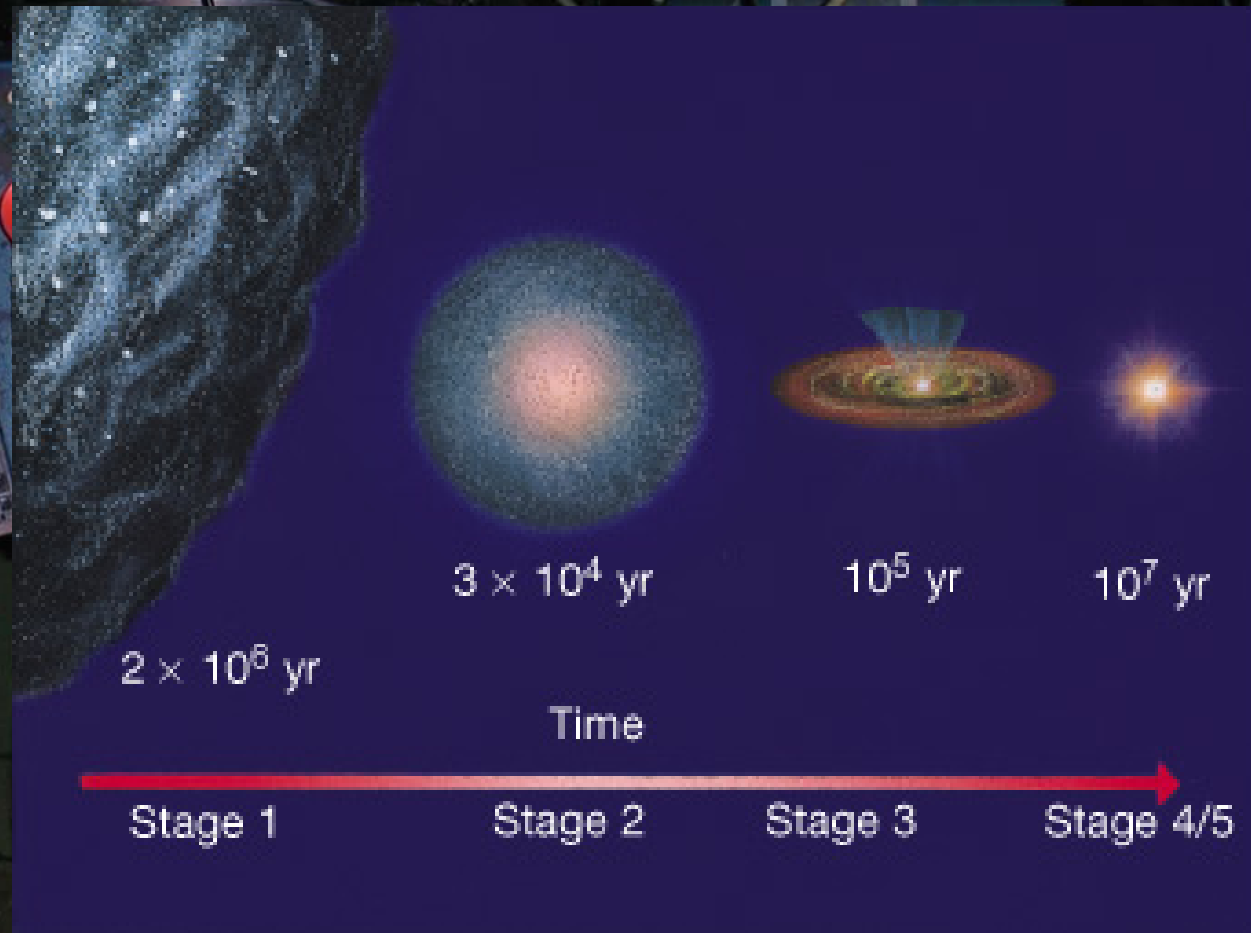
Starbirth

Interstellar clouds collapse under gravity and fragment into a cluster of denser clouds that continue collapsing.



Starbirth

Interstellar
cloud
fragments
collapse
under
gravity to
form
stars.



Star Birth Region

Giant, hot, young stars
illuminate nebula

Great
Nebula

Thick, dusty disks
protect forming stars &
planetary systems

Forming Solar Systems

Disks of
gas and dust
surrounding
forming
stars form
planets,
moons, etc.



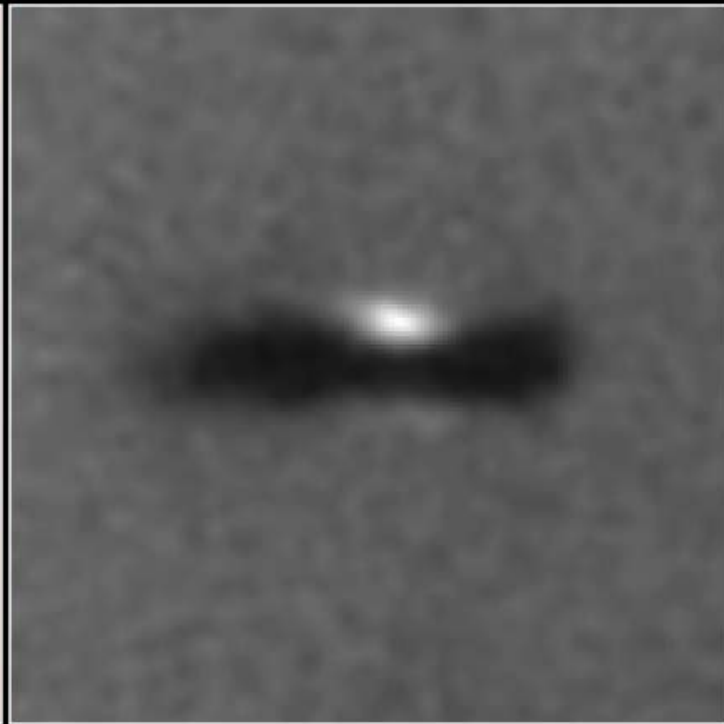
**Protoplanetary Disks
Orion Nebula**

HST · WFPC2

PRC95-45b · ST Sci OPO · November 20, 1995

M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA

Forming Solar Systems



**Edge-On Protoplanetary Disk
Orion Nebula**

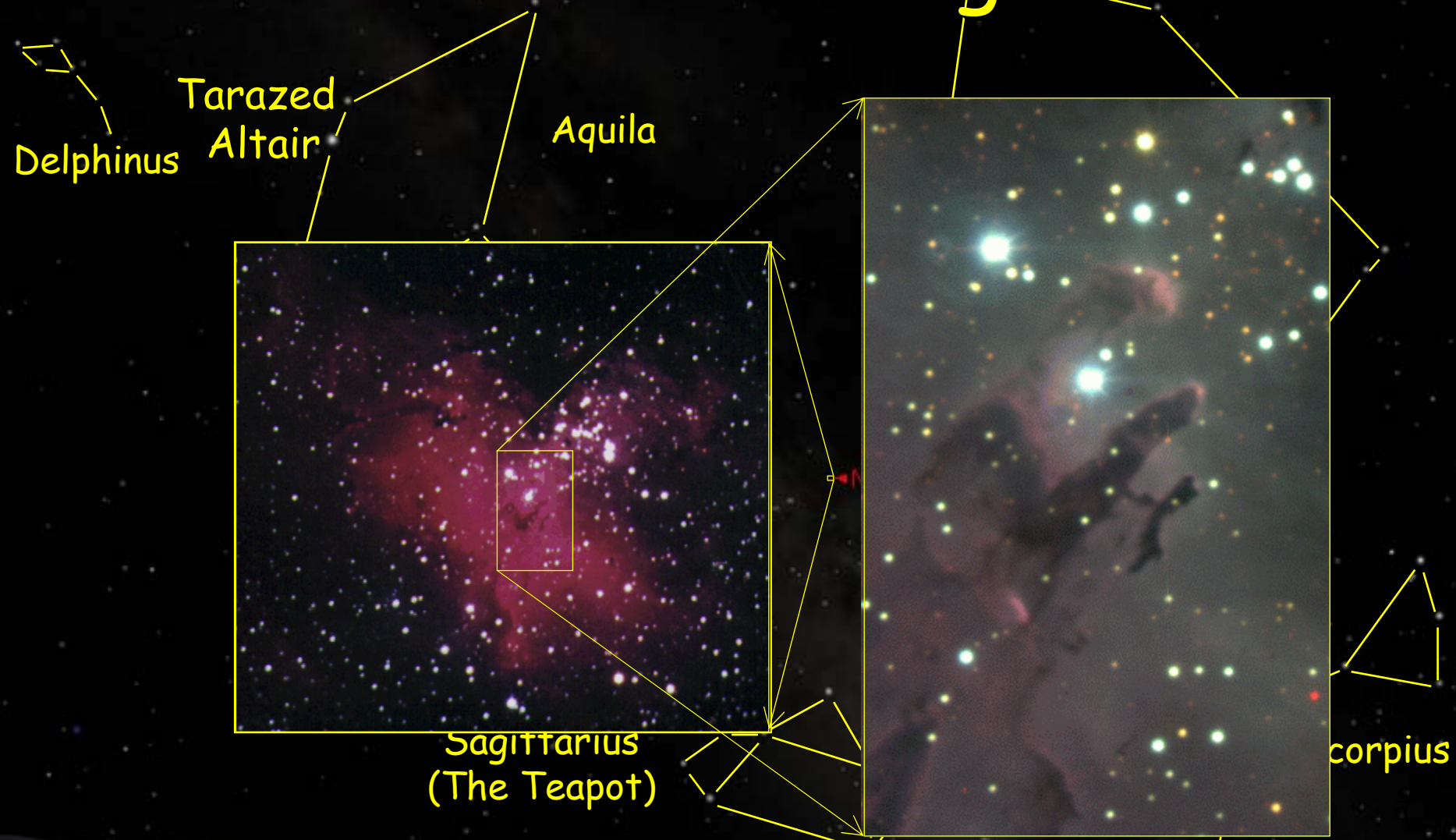
HST · WFPC2

PRC95-45c · ST ScI OPO · November 20, 1995

M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA

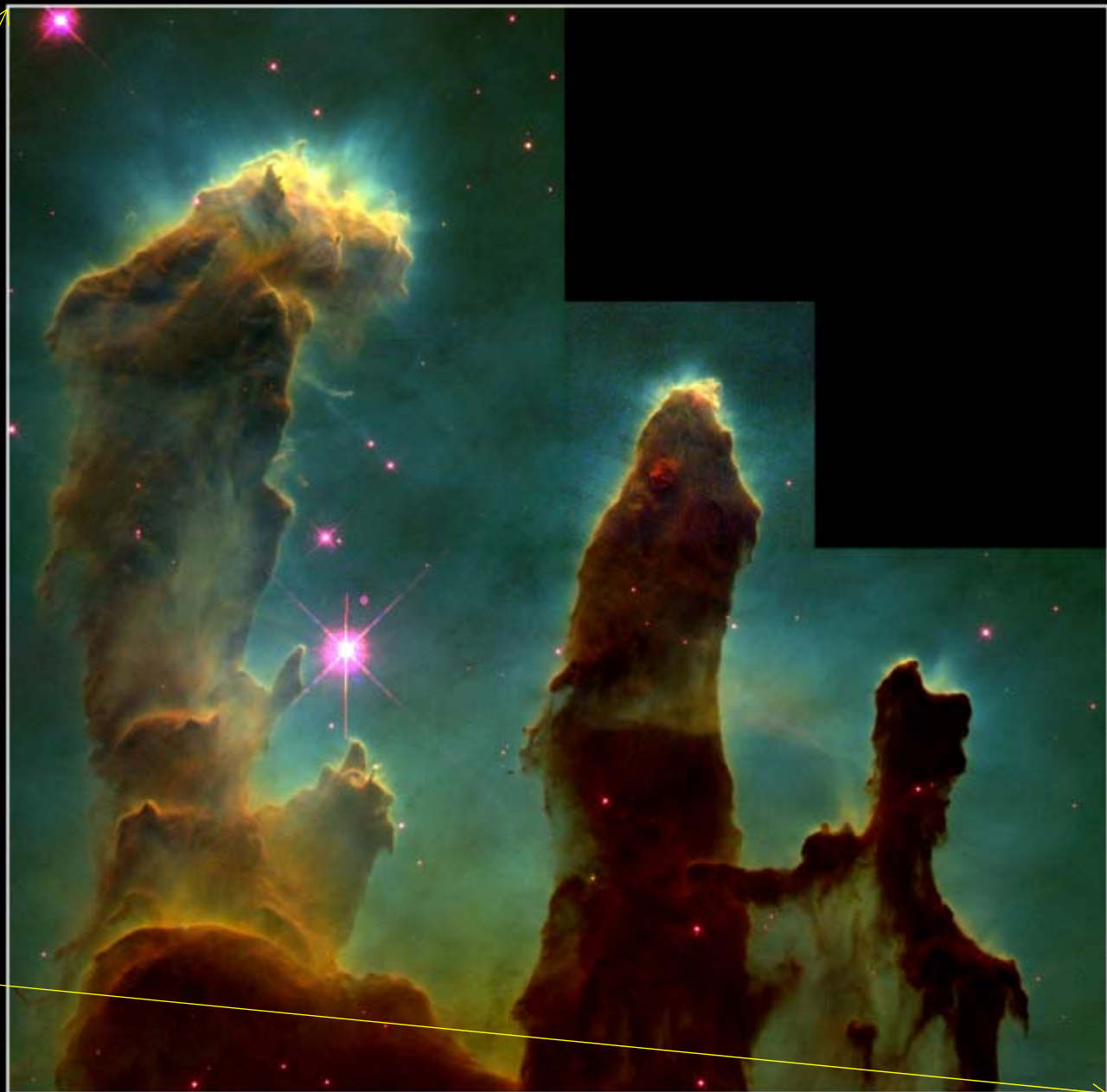
Disks of gas and dust surrounding forming stars seen edge-on in Orion

Starbirth In The Eagle Nebula



Canton's southern sky at 9 pm, September 15 or 7 pm, October 15

Starbirth In The Eagle

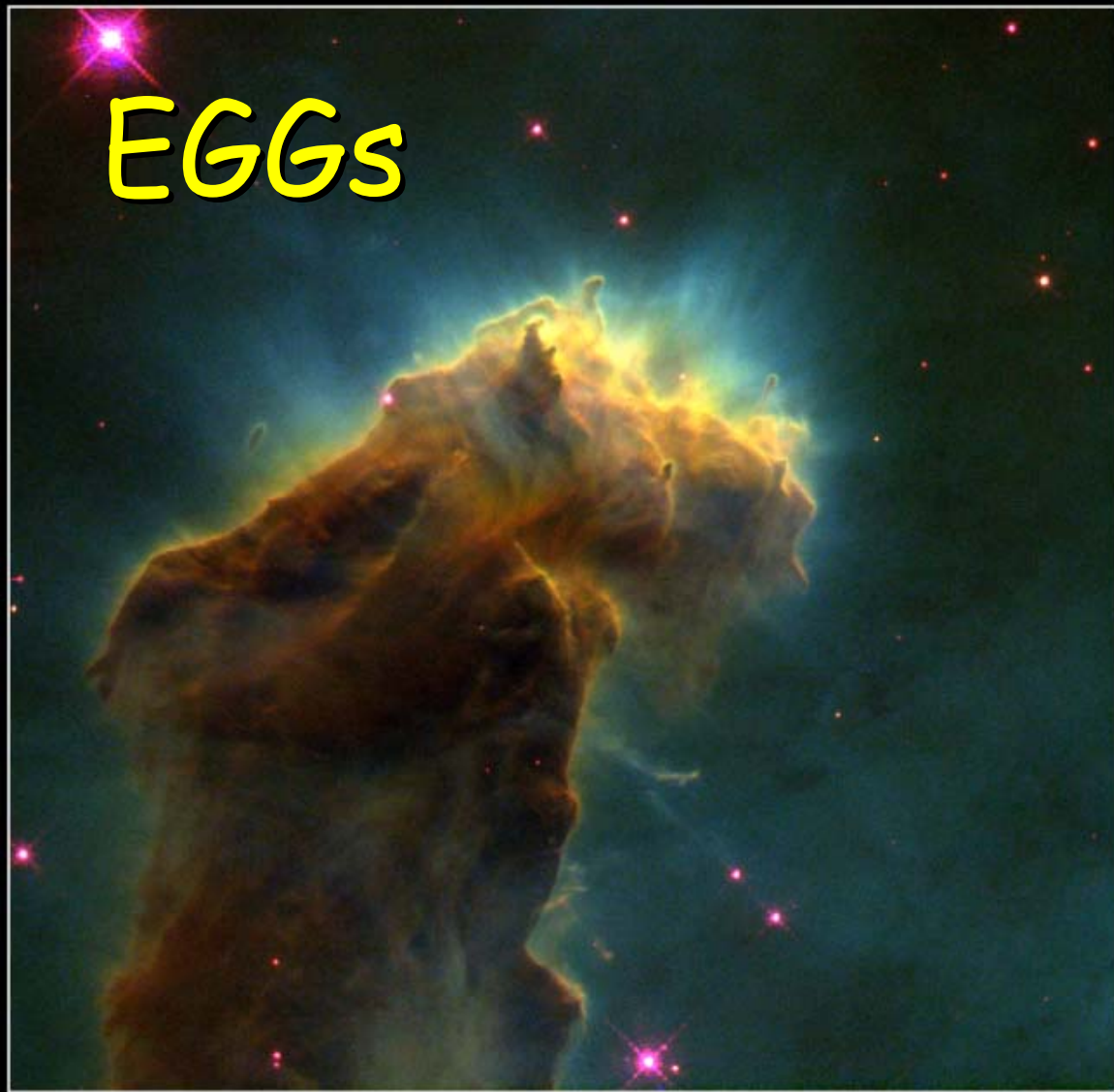


Gaseous Pillars · M16

HST · WFPC2

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

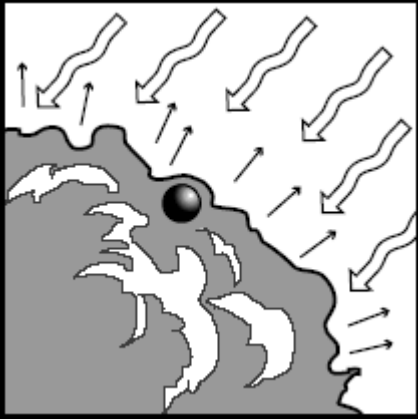
Light and stellar winds from above evaporate gas leaving dense, star-forming regions ...
Evaporating Gaseous Globules.



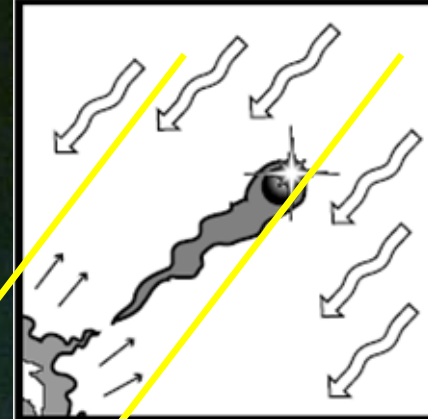
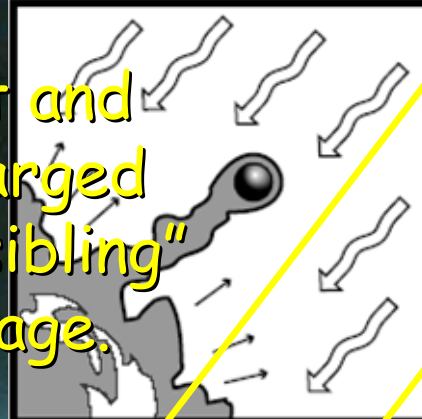
Star-Birth Clouds · M16

HST · WFPC2

PRC95-44b · ST Sci OPO · November 2, 1995
J. Hester and P. Scowen (AZ State Univ.), NASA



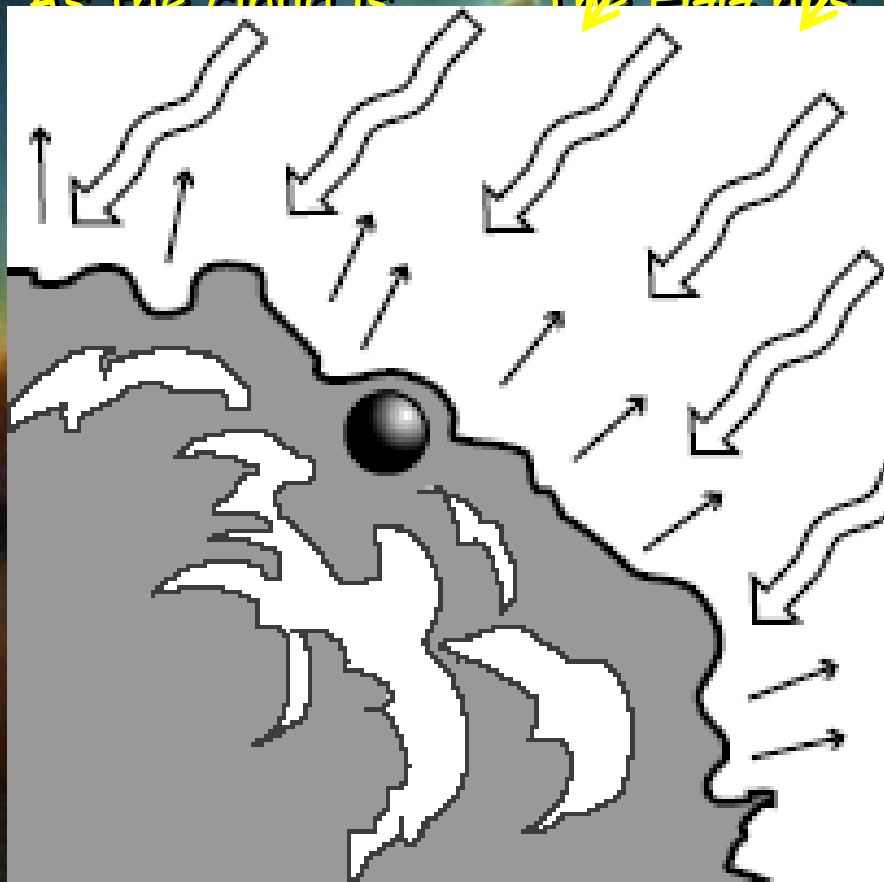
Ultraviolet light and stellar wind (charged particles) from "sibling" star beyond image.



The surface of a molecular cloud is illuminated by intense ultraviolet radiation from nearby hot stars. The radiation evaporates material off of the surface of the cloud.

As the cloud is

The EGG has

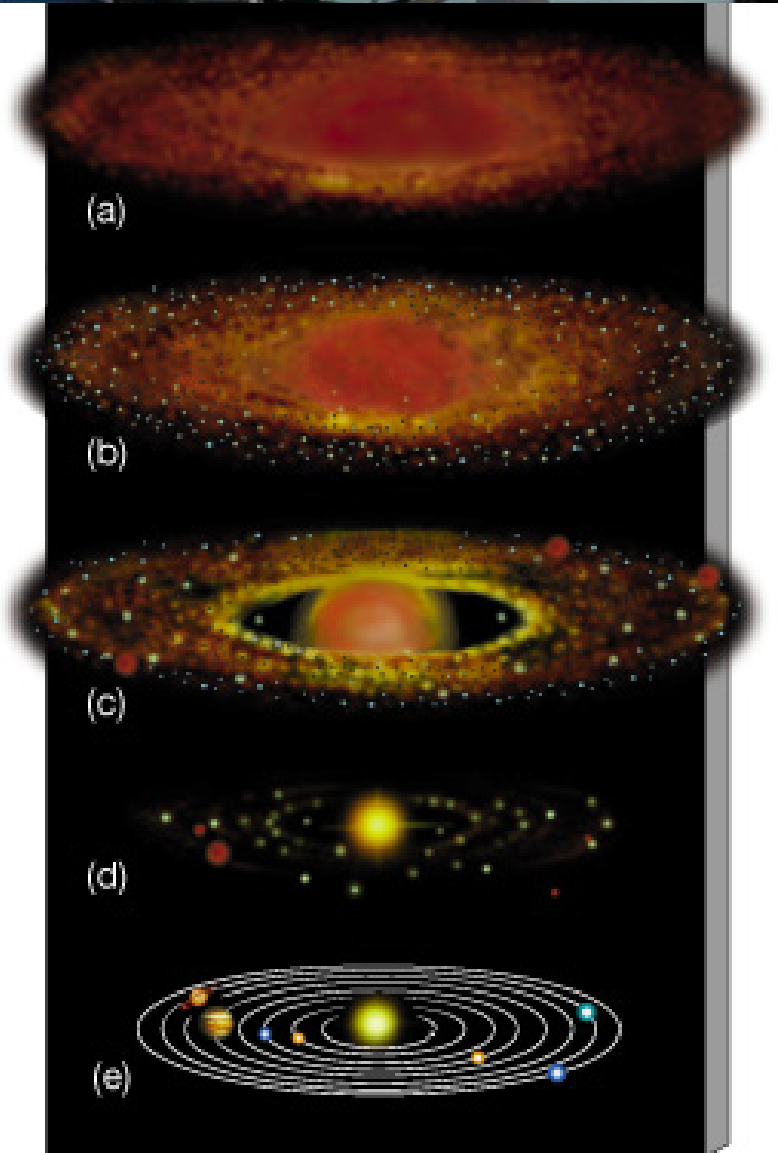
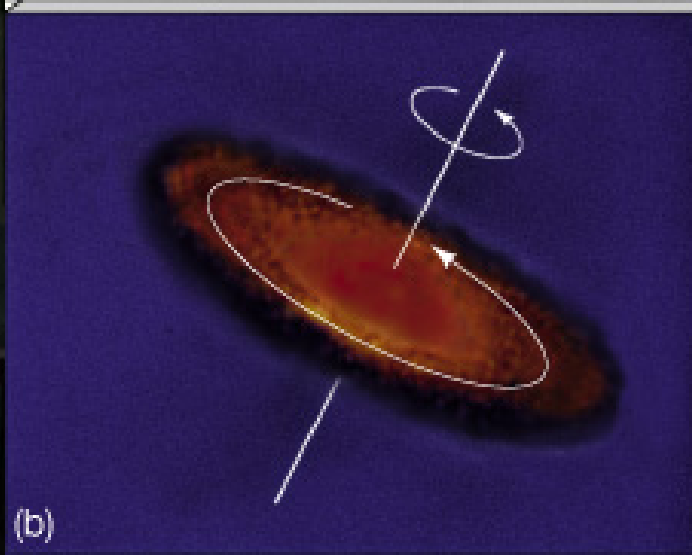
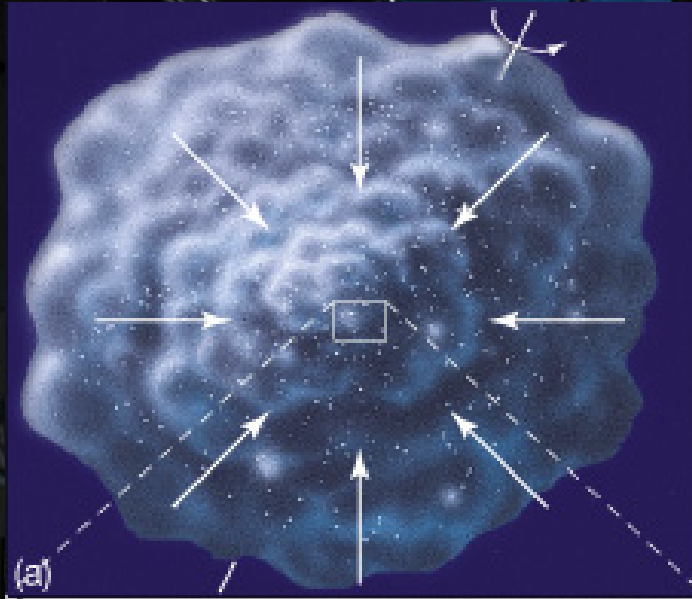


Eventually the EGG may become totally separated from the molecular cloud in which it formed. As the EGG itself slowly evaporates, the star within is uncovered and may appear sitting on the front surface of the EGG.

EGG = Evaporating Gaseous Globule

Solar System Formation

Planets form from debris around star.

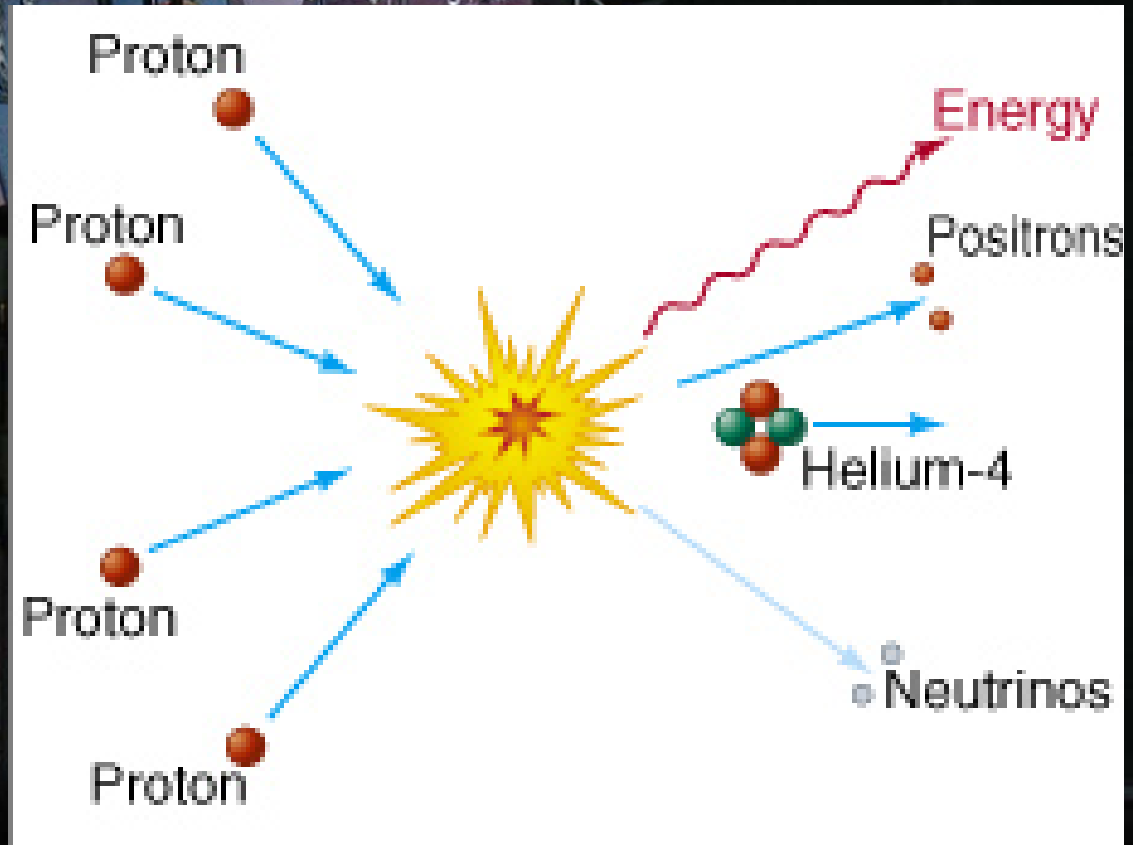


What Makes A Star?

Nuclear Fusion

✘ Light elements combine to make heavier elements.

Hydrogen
fuses to
Helium

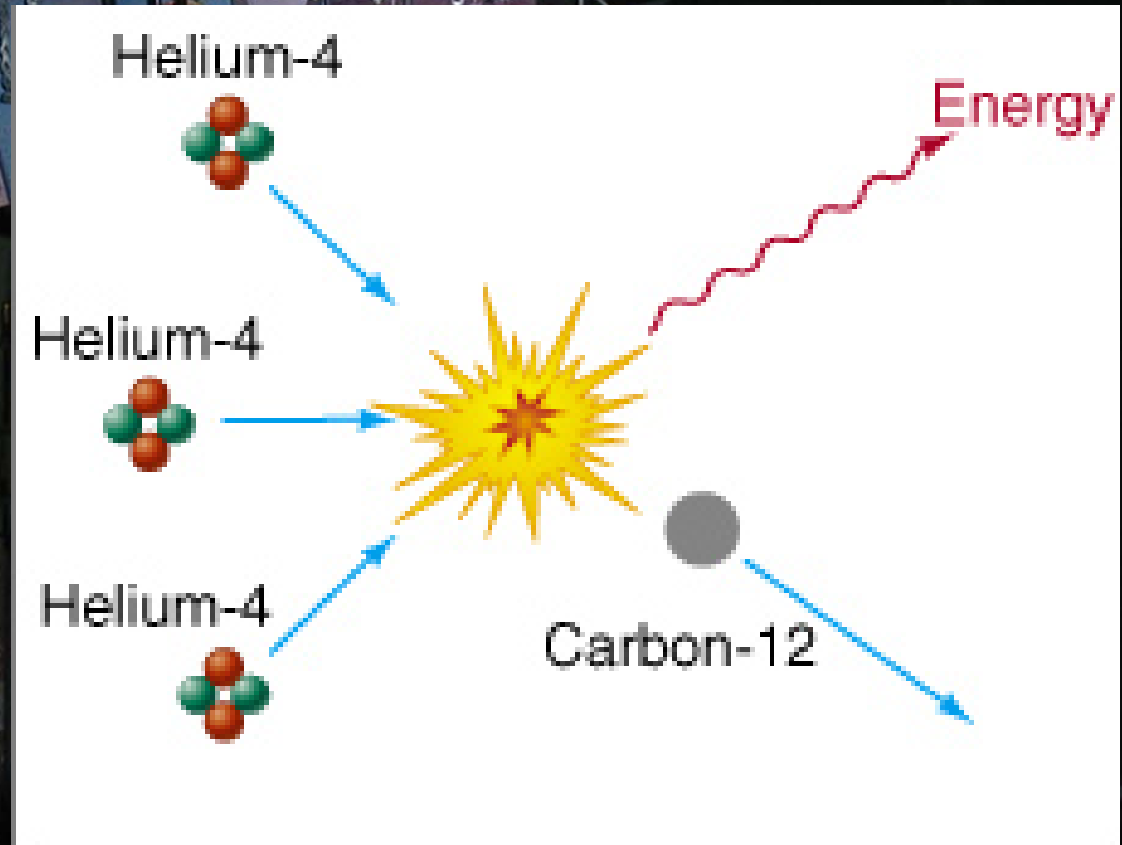


What Makes A Star?

Nuclear Fusion

✂ Light elements combine to make heavier elements.

Helium fuses to Carbon, Oxygen, Nitrogen ...



Fusion Releases Energy

Mass of 4 H atoms

$$4 \times (1.007940 \text{ amu}) = 4.031760 \text{ amu}$$

Mass of 1 He atom

$$= 4.002602 \text{ amu}$$

Difference (loss)

$$= 0.029158 \text{ amu}$$

$$= 0.7 \% \text{ of H}$$

Where does it go?

$$E = mc^2 \longrightarrow \text{Energy!}$$

Energy Of Fusion: Solar Power

Convert 1 kg of H to He:

0.7% (= 7 grams) becomes energy

by $E = mc^2$,

$(0.007 \text{ kg}) \times (3.0 \times 10^8 \text{ m/s})^2 = 630 \text{ trillion joules}$

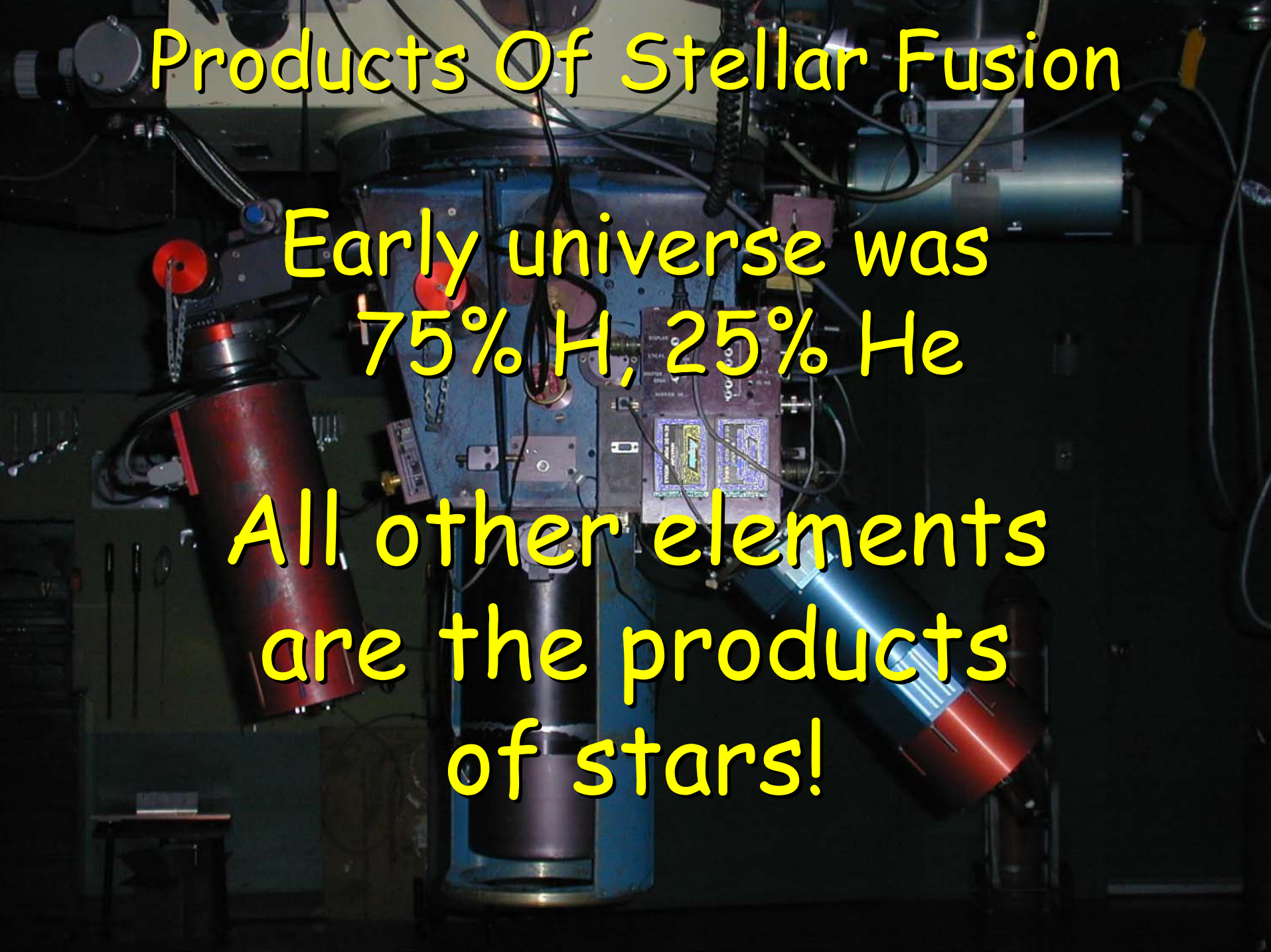
= 175 million kWhr

= 175 GWhr

US Annual Electrical Use = 3700 GWhr

Converting 22 kg of H to He would power the entire US for one year!

Products Of Stellar Fusion

The background image shows a complex scientific instrument, likely a particle detector or a component of a fusion reactor. It features a central blue cylindrical chamber, various tubes, wires, and electronic components. A prominent red cylindrical component is visible on the left side, and another red and blue component is on the right. The overall scene is dimly lit, with some components glowing.

Early universe was
75% H, 25% He

All other elements
are the products
of stars!

Substance Of Life

Life requires H, C, O, & N

✘ All elements of life came from stars that lived AND DIED before the sun formed.

✘ Sun is a 2nd or 3rd generation star

🚲 1st stars were pure hydrogen and helium)

"We are the matter of the cosmos contemplating itself."

- Carl Sagan

Interstellar Medium

Ancient stars enriched the ISM with the products of their fusion by

⚡ Stellar Winds

🚲 Stars constantly blow particles into space

🚲 Solar wind & storms cause aurorae

⚡ Deaths as Planetary Nebulae

Planetary Nebulae

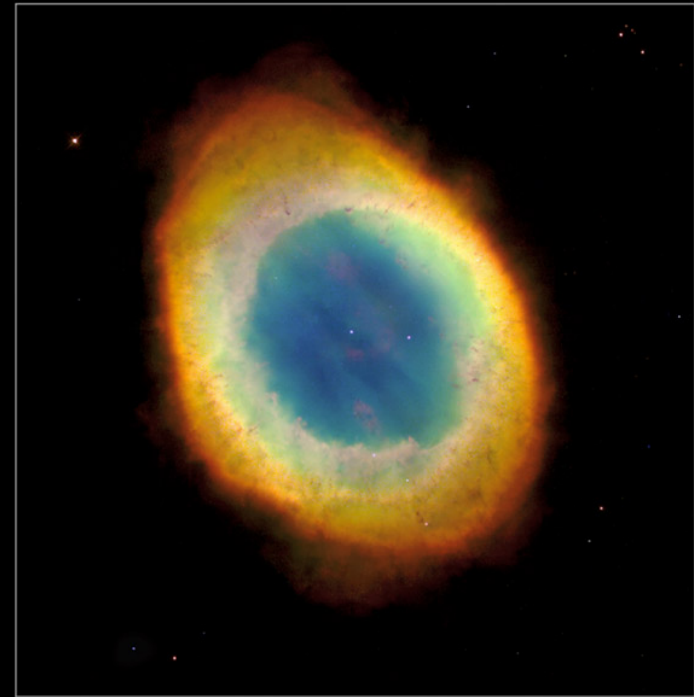
The source of common heavy elements
(lighter than iron) ... C, O, N, Ca, K, P,
etc.



Henize 1357 • Stingray Nebula
PRC98-15 • ST ScI OPO • April 2, 1998
M. Bobrowsky (Orbital Sciences Corp.) and NASA

HST • WFPC2

Ring Nebula



Hubble
Heritage

PRC99-01 • Space Telescope Science Institute • Hubble Heritage Team (AURA/STScI/NASA)

Planetary Nebulae



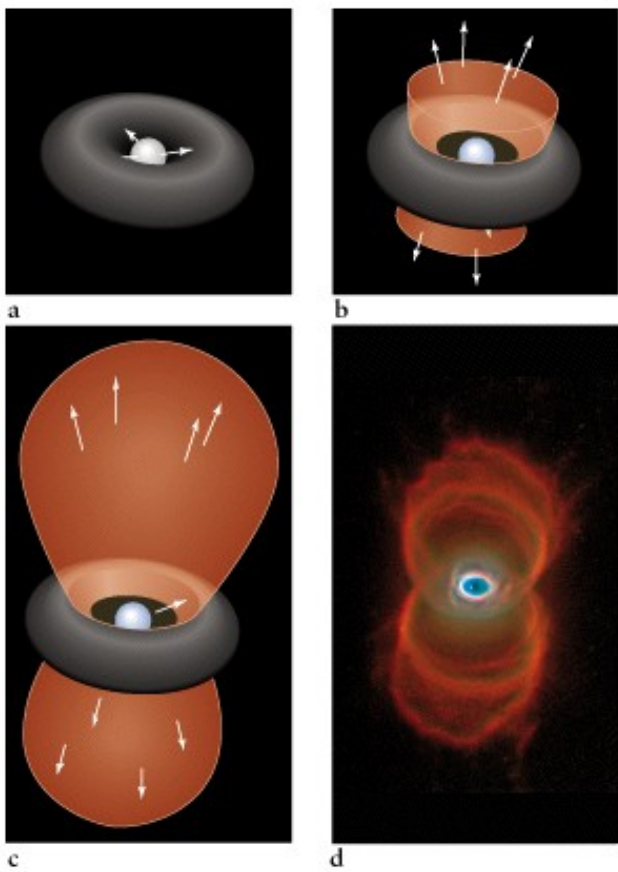
Ring Nebula in Lyra

Planetary Nebulae

Planetary Nebula Mz 3



The Hourglass Nebula



Hourglass Nebula • MyCn18

HST • WFPC2

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

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



Planets And Moons

The sun and all the planets formed from the same cloud



of "used" star stuff enriched with heavy elements by previous generations of stars.



There is a Time For Every Purpose Under Heaven ..

"Lift up your eyes to the heavens,
and look at the Earth down below
for the heavens
will vanish like smoke,
and the earth will wear out
like a garment."

Isaiah 51:6



There is a Time For Every
Purpose Under Heaven ..

Stars use up their nuclear fuel and die

Death of a sun-sized star:

Core fusion stops

Star swells to Red Giant

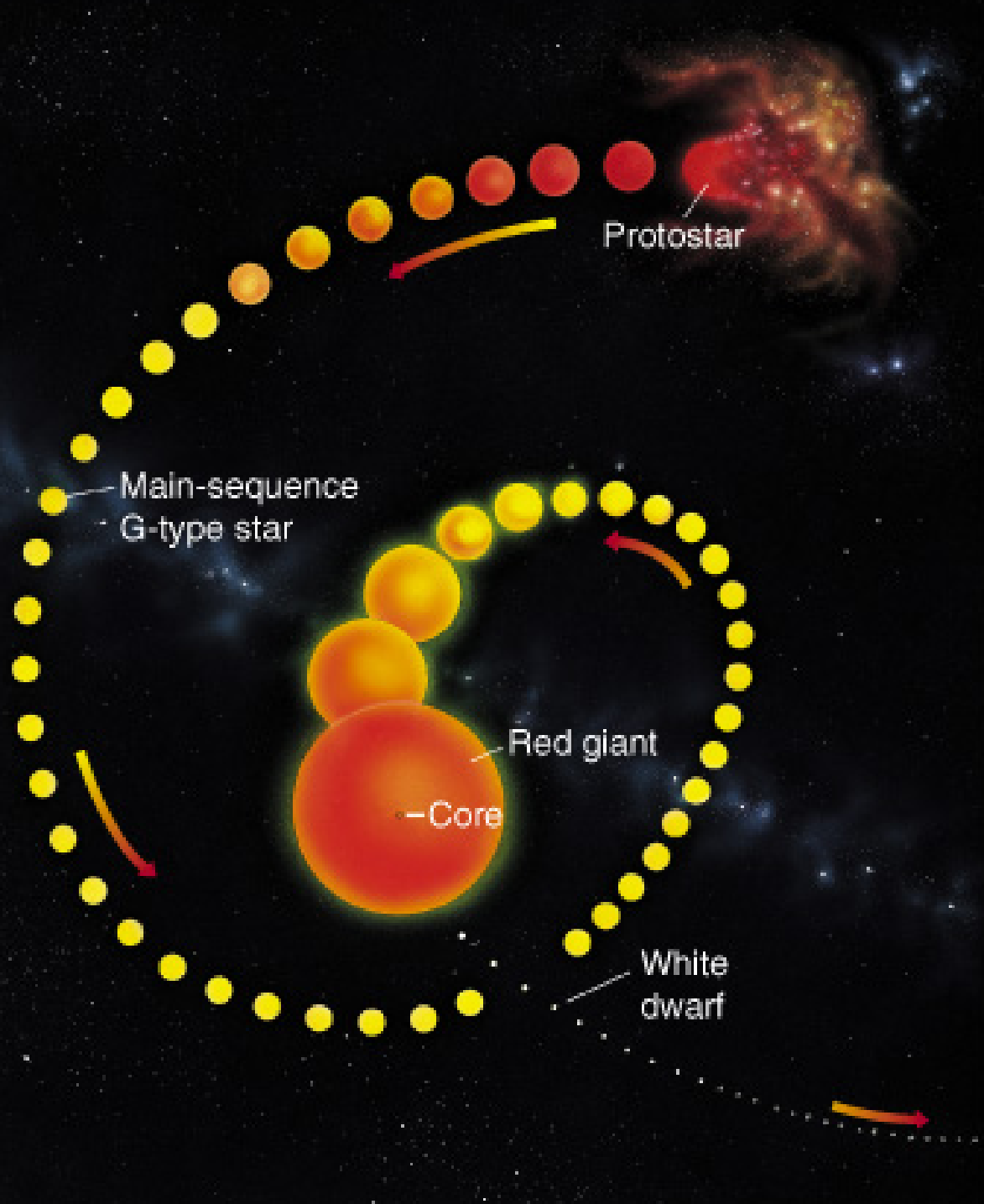
(Betelgeuse, Antares)

Becomes a Planetary Nebula

Ends as a White Dwarf

Star Death

The sun will become a Red Giant in about 5 By, a White Dwarf in about 7 By



Europa 6 Billion AD

The ice of Europa will melt when the sun becomes a red giant and swells beyond the size of Earth's orbit.



And all the elements we are made
of will return to the stars ...

Planetary Nebulae

The elements
we're made
of were once
part of a
planetary
nebula ...



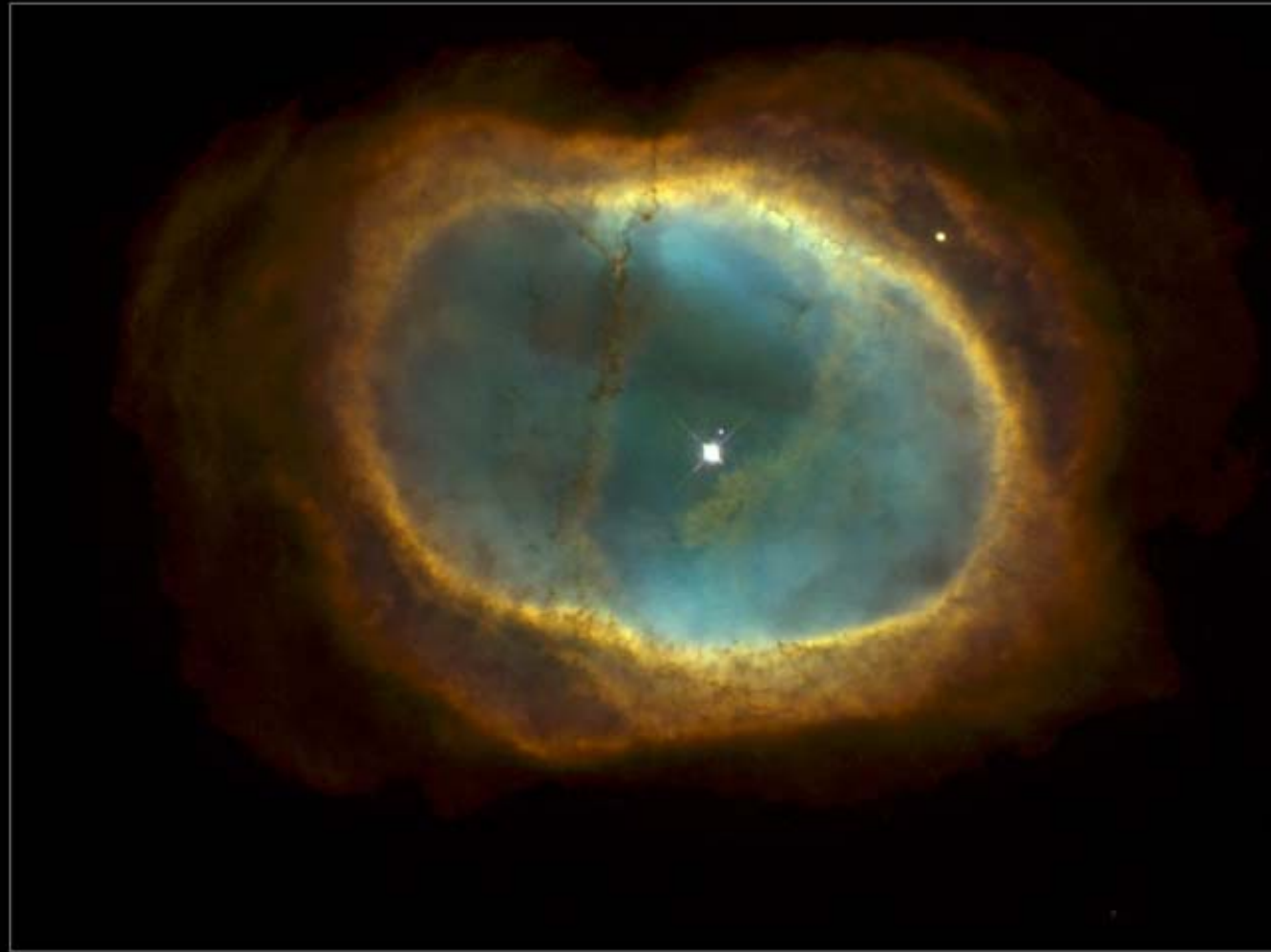
NGC 6543

HST • WFPC2

Planetary Nebulae

The elements we're made of will again be part of a planetary nebula.

Planetary Nebula NGC 3132



The Origin Of Metals

Only elements lighter than iron can be made in living stars.

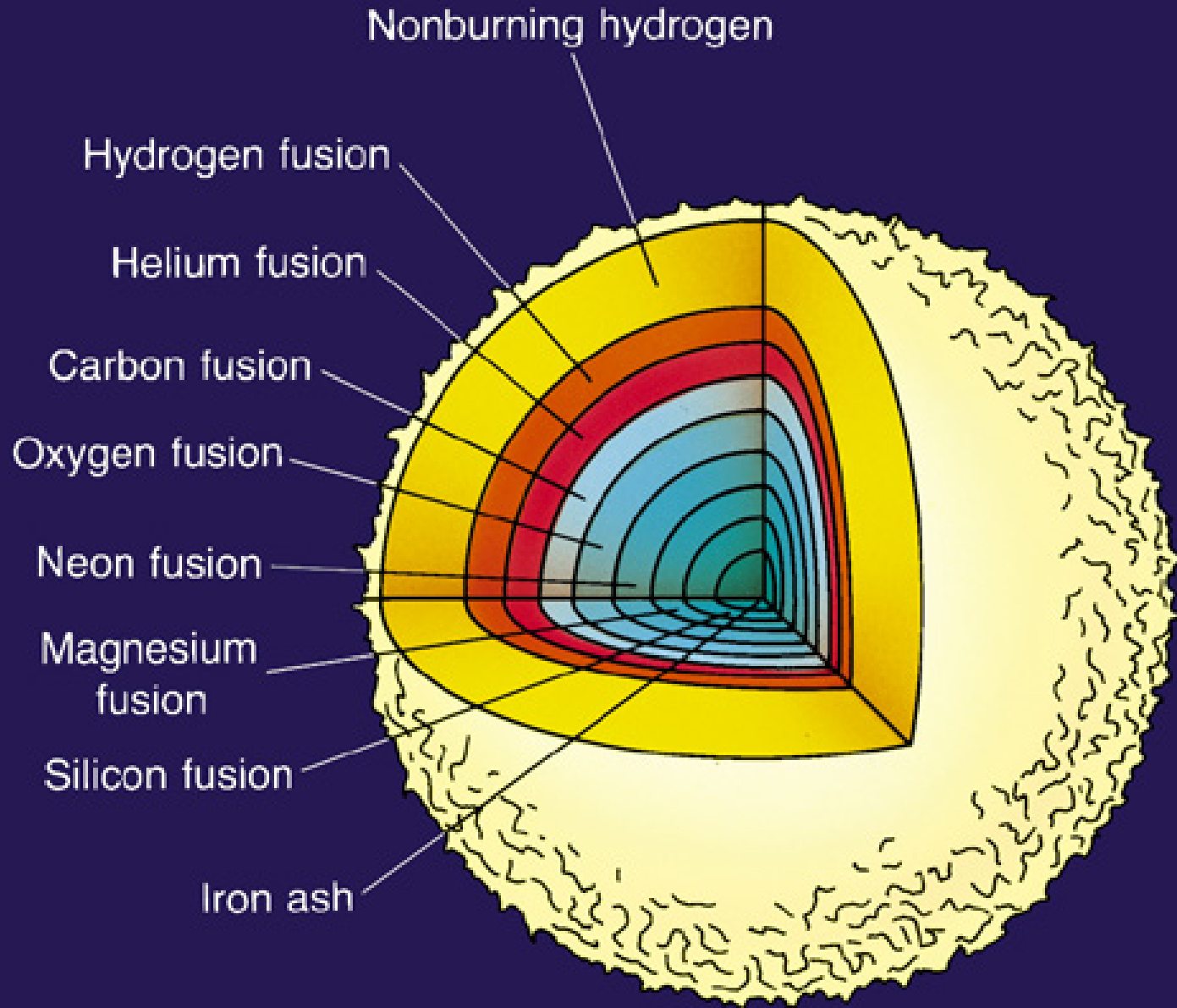
Light elements
from living stars

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	I	Xe
Cs	Ba		Hf	Ta	W	Re	Os	Ir	Pt	Au	Hg	Tl	Pb	Bi	Po	At	Rn
Fr	Ra		Rf	Db	Sg	Bh	Hs	Mt	Uun	Uuu	Uub						
		La	Ce	Pr	Nd	Pm	Sm	Eu	Gd	Tb	Dy	Ho	Er	Tm	Yb	Lu	
		Ac	Th	Pa	U	Np	Pu	Am	Cm	Bk	Cf	Es	Fm	Md	No	Lr	

Heavy elements from ...

Giant Stars

Have layers fusing different elements



Iron

Iron is the most stable element

- ✘ ABSORBS energy in fusion

- ✘ ABSORBS energy in fission

When iron core begins to fuse

- ✘ energy is absorbed by reaction

- ✘ core cools ... contracts

- ✘ outer layers begin to fall in

- ✘ star implodes ...

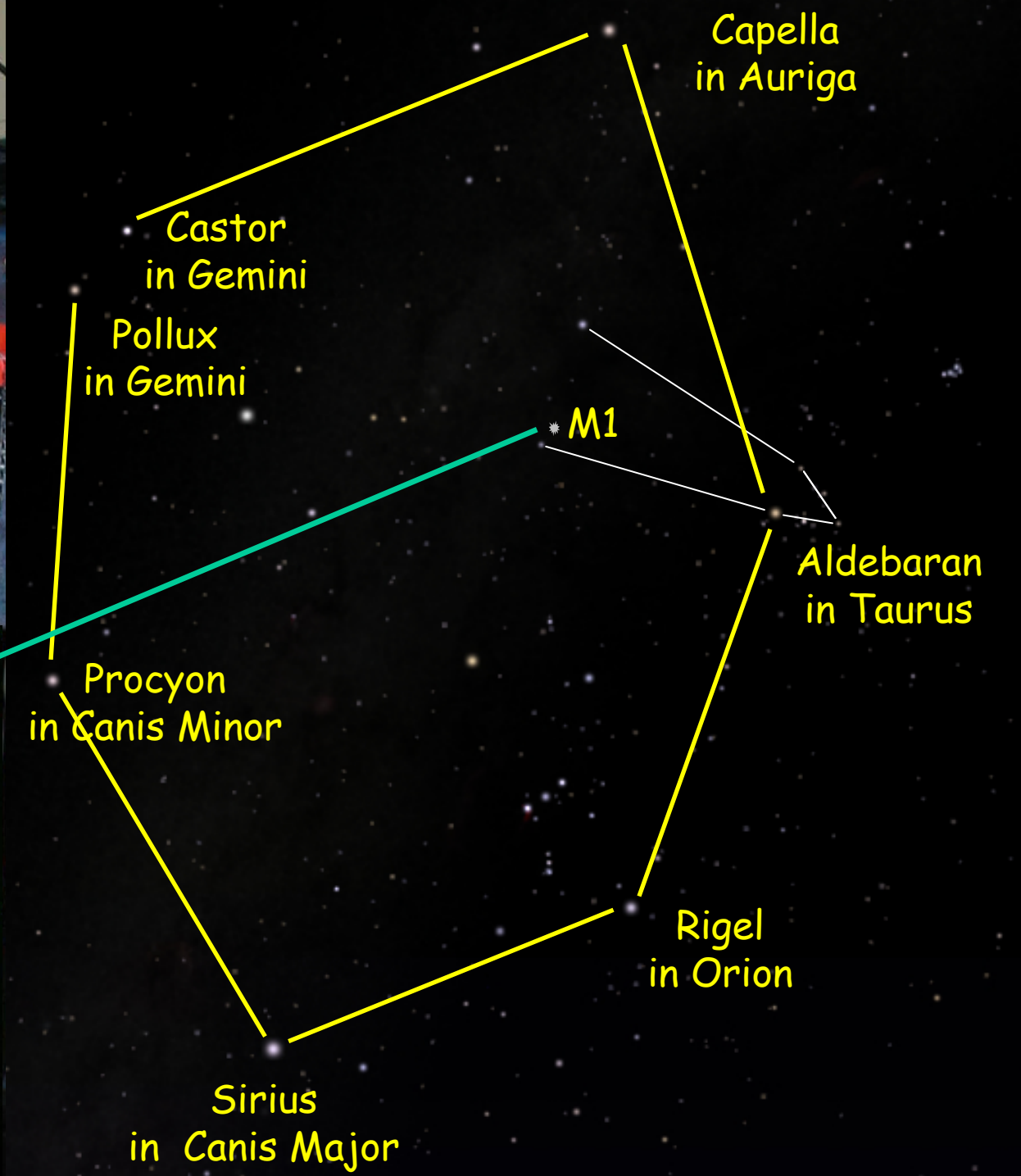
 - outer layers bounce off dense inner core

- ✘ star explodes ...

Supernova



Crab
Nebula
Supernova
Observed in
1054 by
Chinese &
Anazazi



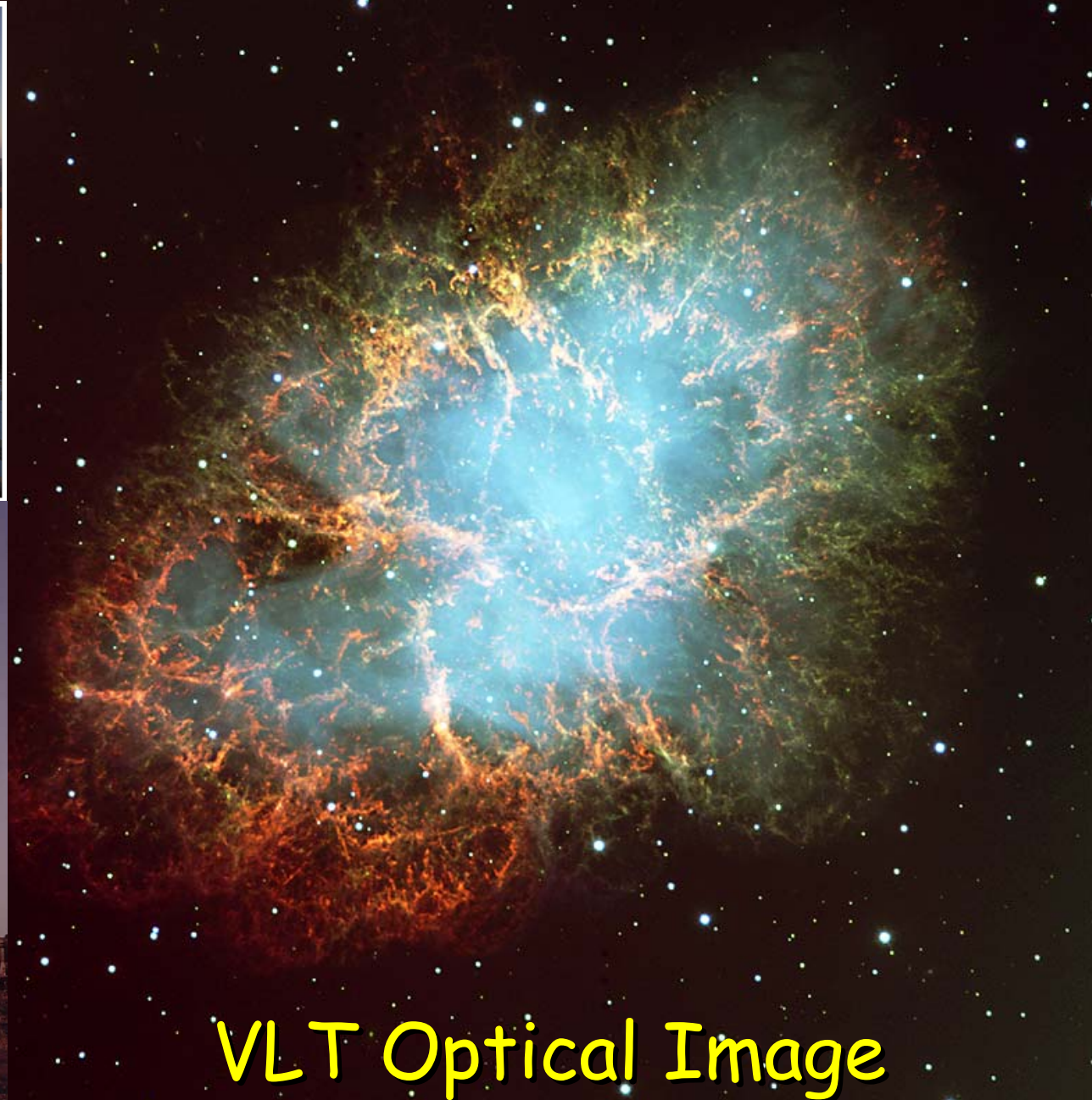
Supernova Remnant

Crab Nebula
"Guest Star" in,
Taurus noted in
Chinese records in
1054 and on rock
overhang in Chaco
Cañon, NM.

Is still expanding ...
still exploding!



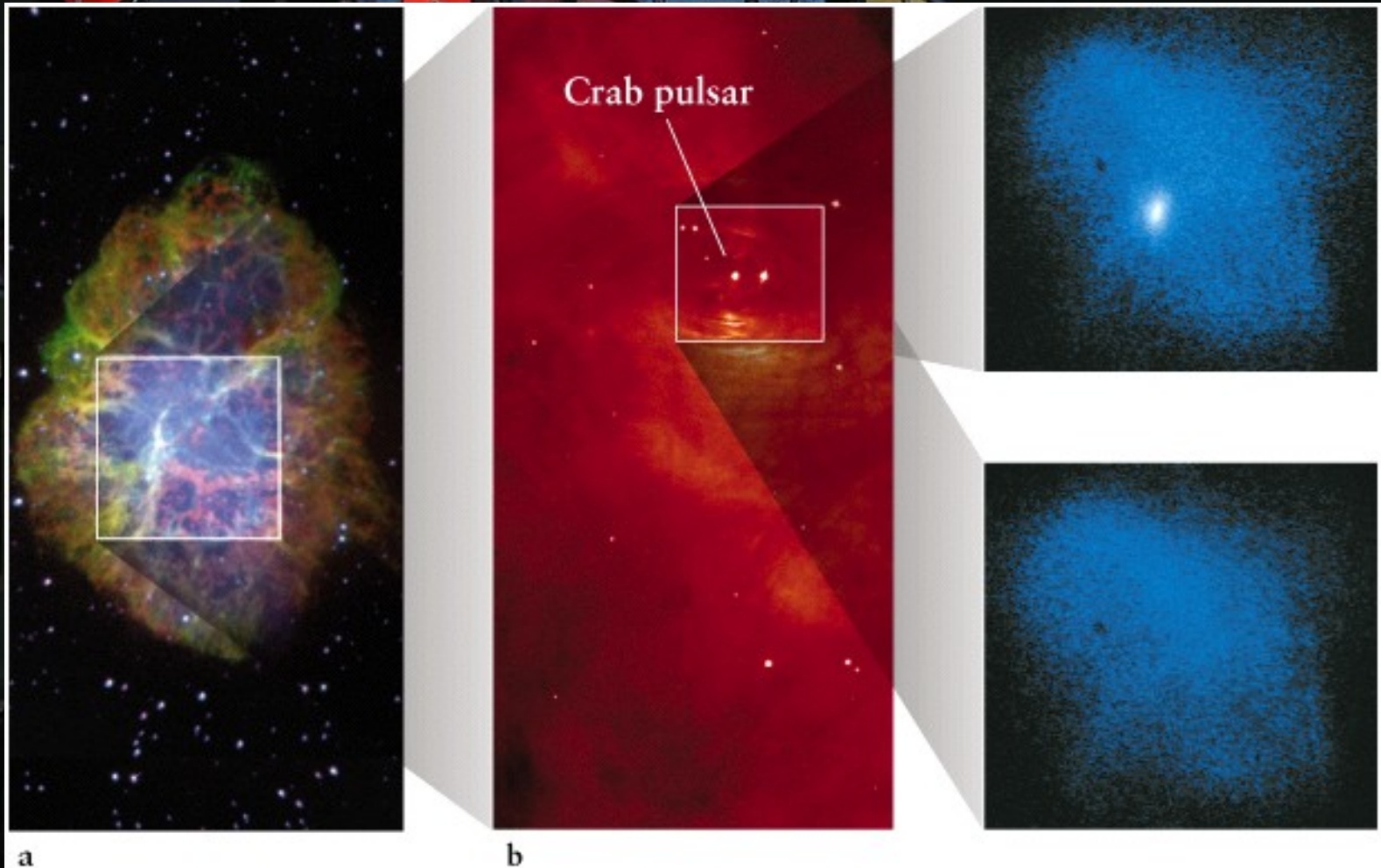
Crab Nebula



VLT Optical Image

Crab Pulsar

Neutron star pulses!
Called "LGM" at first for "little green men."

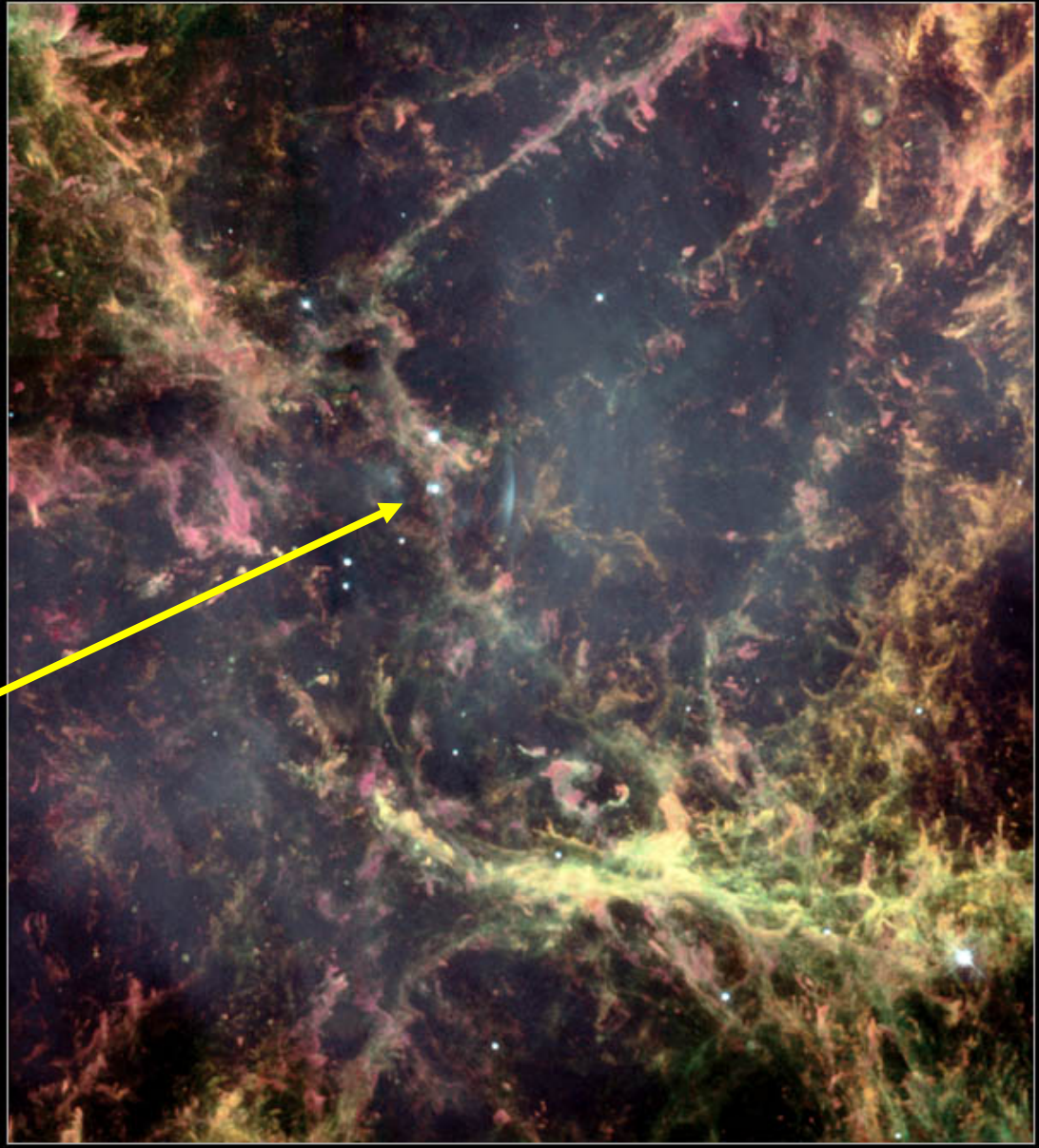


Crab Nebula

Core of
exploded
star is a
neutron
star



Crab Nebula



Hubble
Heritage

Neutron Stars



Dense

✘ all space squeezed out from within atoms

Enlarge an atom to size of St. Peter's Basilica

The nucleus is the size of a grain of salt

Rotate Very Quickly

✘ spun up as core collapsed

Strong Magnetic Fields

✘ increased as core collapsed

✘ Radiation strongly beamed along axis

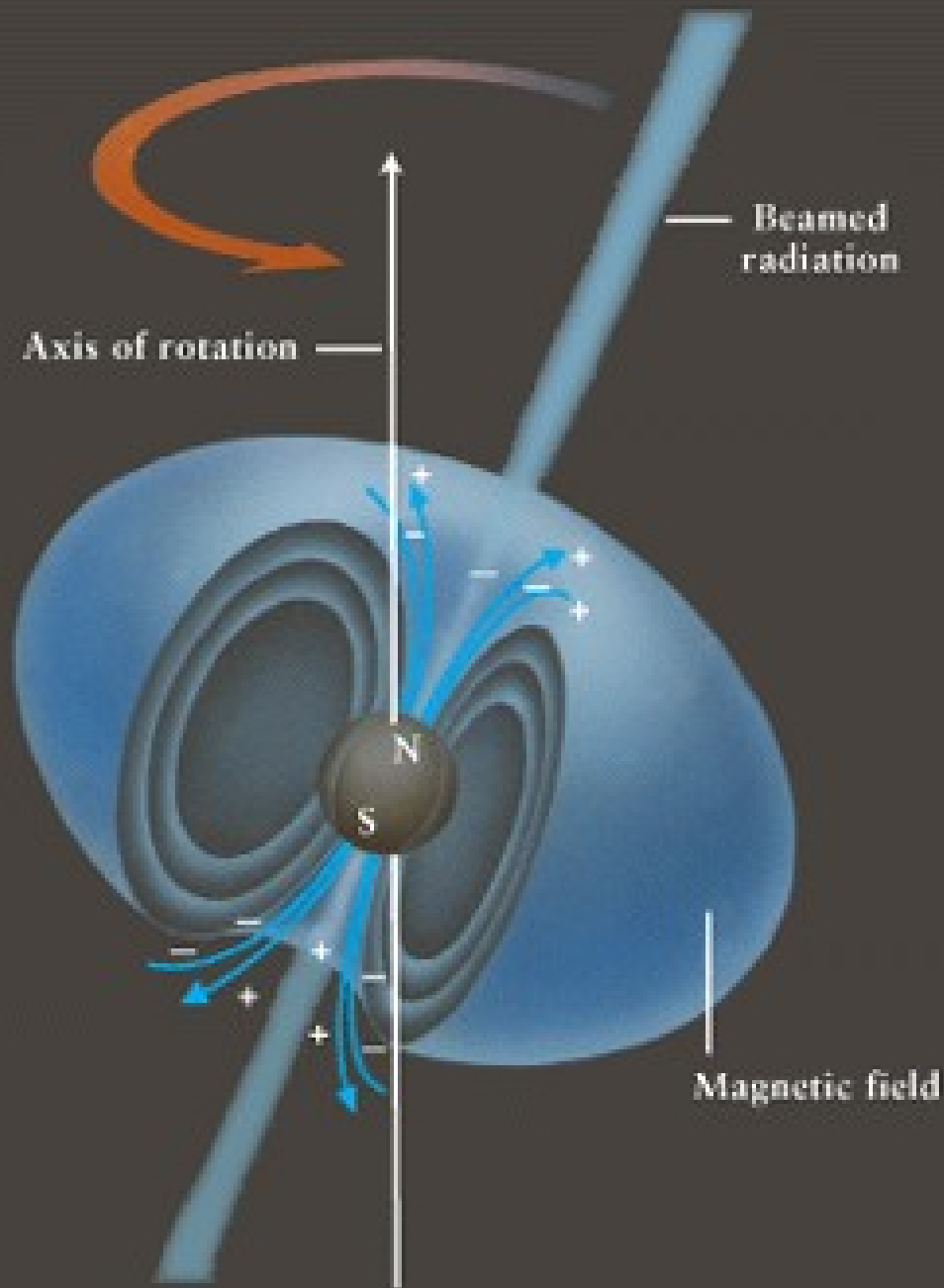
Pulsars

Rapidly Rotating Neutron Stars

✘ Emission
"beamed" by
magnetic fields

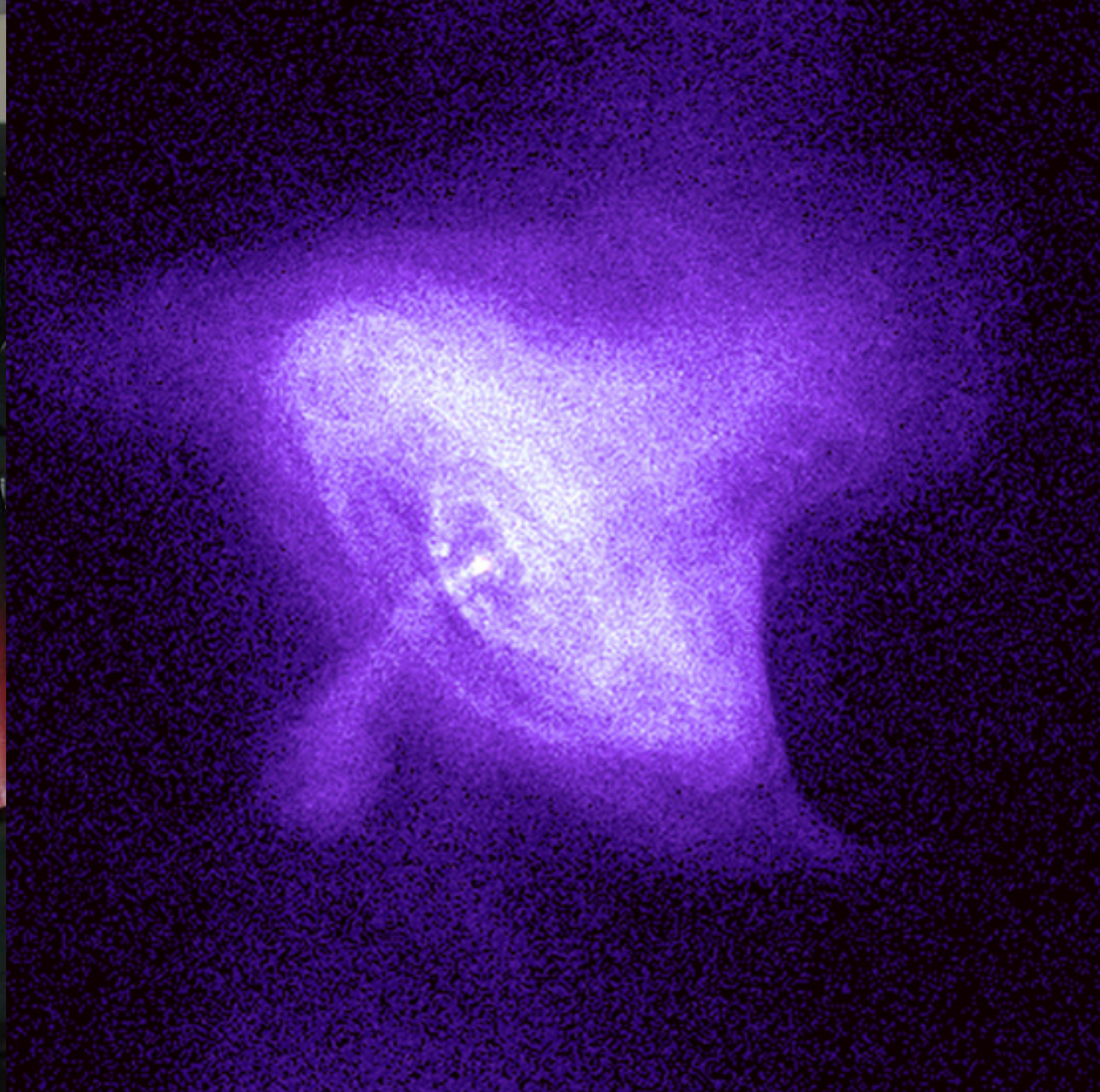
✘ Bright when
beam points at
Earth

✘ Stars "spin-up"
during collapse
like spinning
skater



Crab Nebula

Neutron
star
heats
nebula to
glow in X-
rays



Supernovae

Can outshine entire galaxies ...



Super-
nova
1987 A
First SN
observable
with
unaided
eye in
400 yr!



© Anglo-Australian Observatory

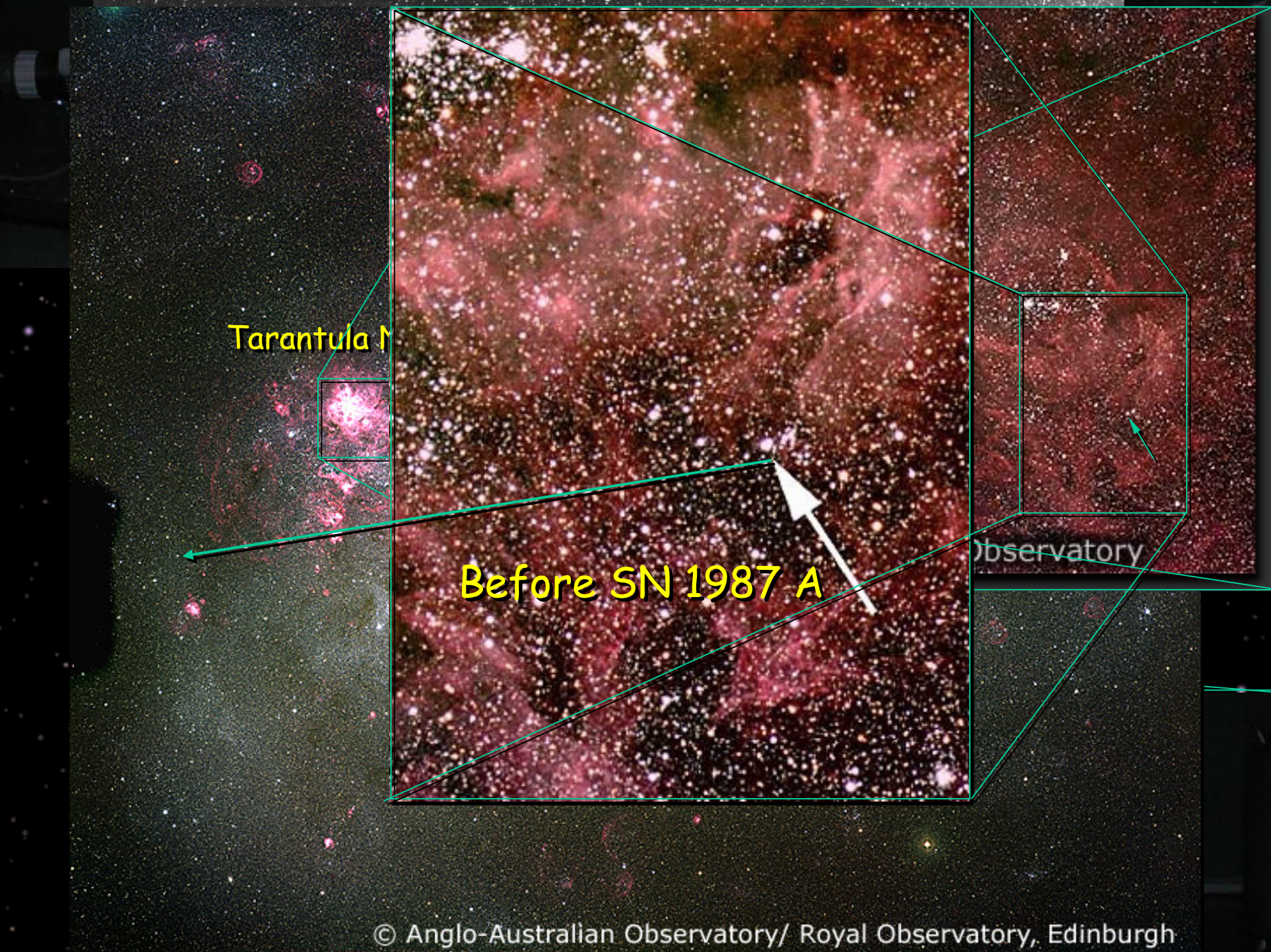
After
SN 1987a

Before
Sanduleak -69 202a
indicated by arrow
(before 1987!)

Tarantula M

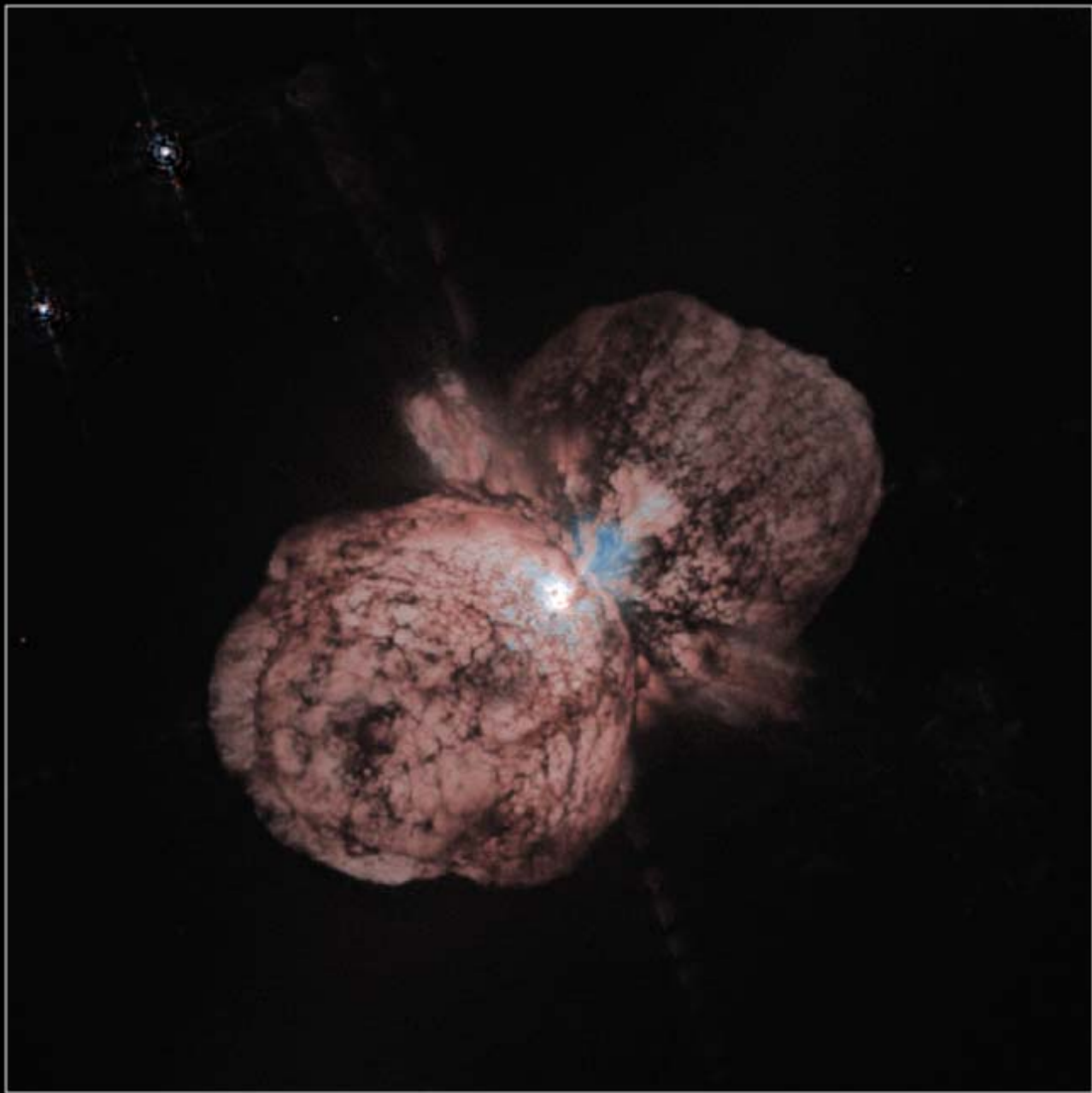
Before SN 1987 A

Observatory



Eta Carinae

A star 100
times the
mass of Sol
...in death
throes



Eta Carinae

HST · WFPC2

PRC96-23a · ST ScI OPO · June 10, 1996

J. Morse (U. CO), K. Davidson, (U. MN), NASA

η Car

A star surrounded by a torus of x-ray emitting gas



2 light years
3000 x Pluto's orbit

Southern Sky from CTIO

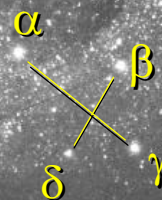
SMC

LMC

α Cen

1.5 m

β Cen telescope

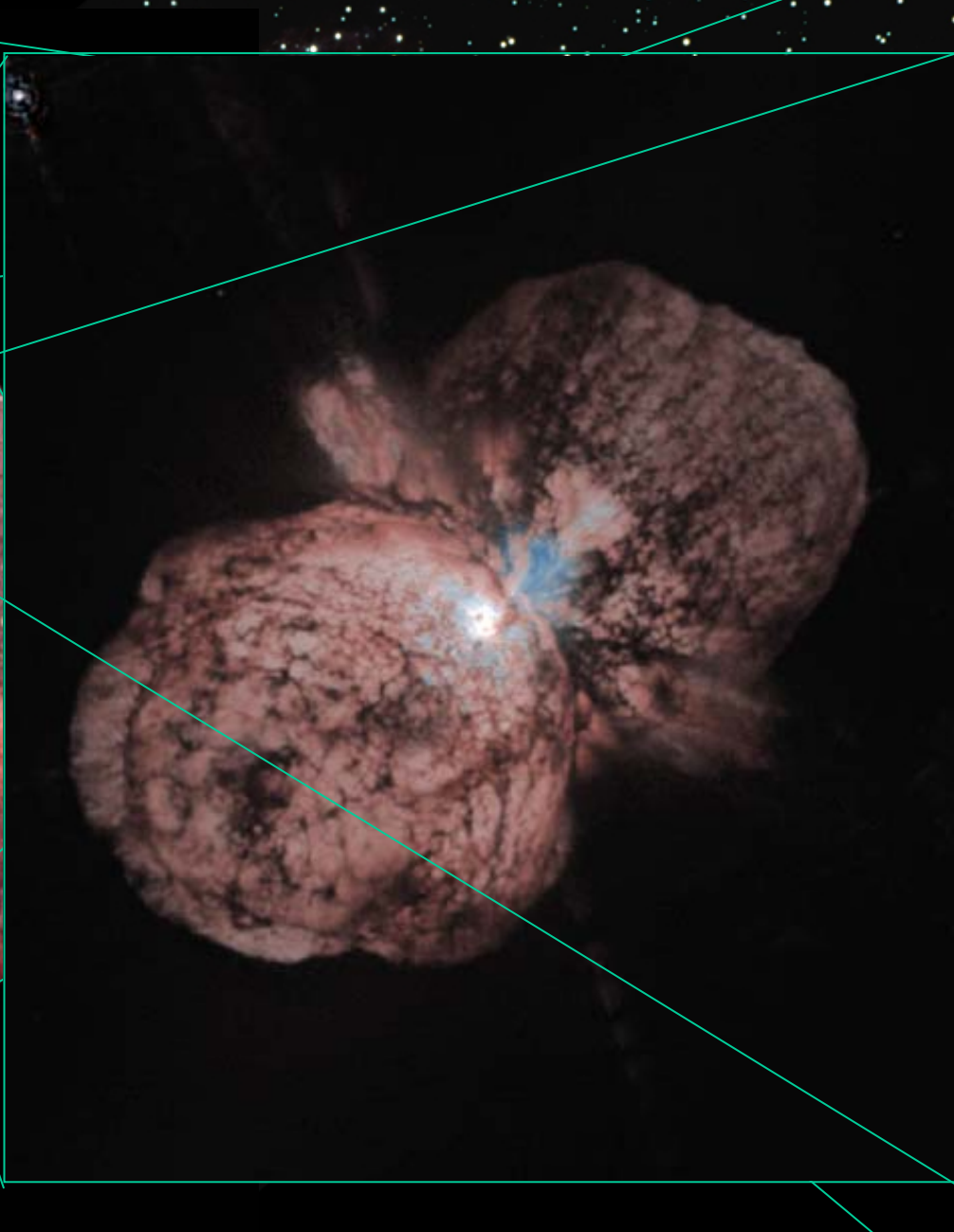
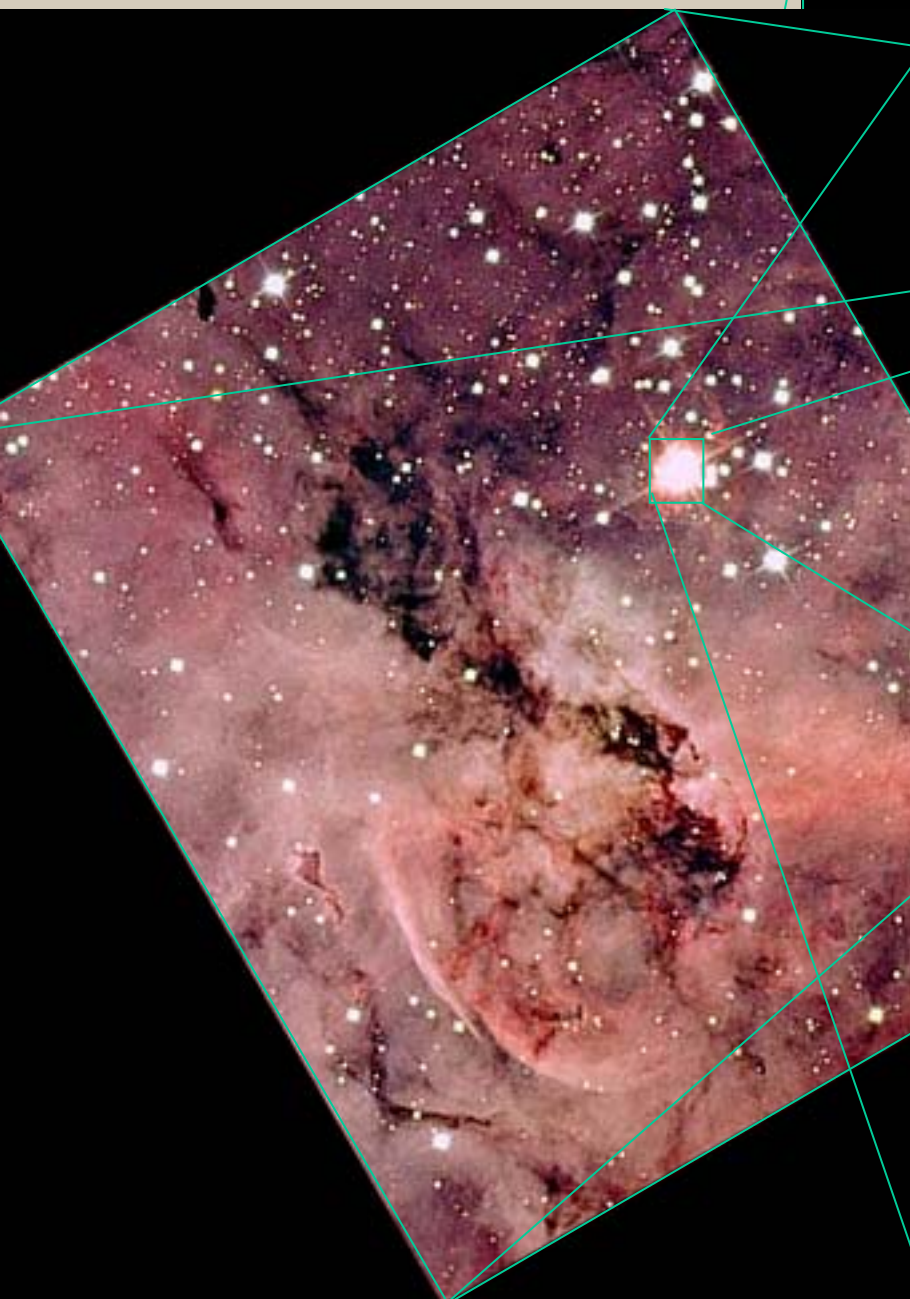


Southern
Cross
(Crux)

4 m telescope

AOD observes here!

Cerro Tololo Interamerican
Observatory La Serena, Chile

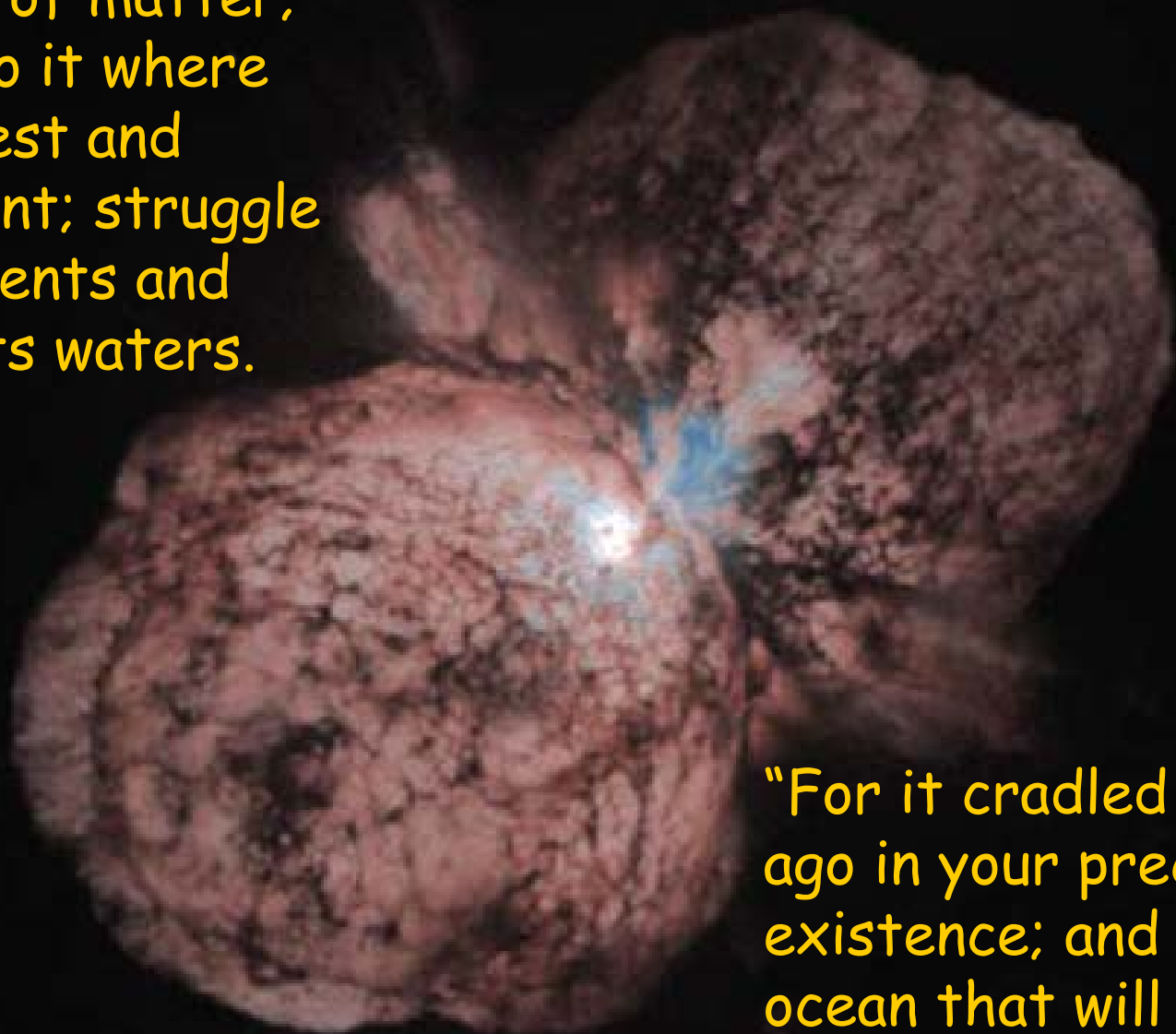


VIEW

0

0:11

"... Bathe yourself in
the ocean of matter;
plunge into it where
it is deepest and
most violent; struggle
in its currents and
drink of its waters.



"For it cradled you long
ago in your preconscious
existence; and it is that
ocean that will raise you
up to God."

Teilhard de Chardin

Supernovae

ONLY way to fuse heavy elements ...

Source of all the

✘ iron, zinc, copper, iodine, etc.

in our bloodstreams,

✘ gold, silver, bronze, tin, etc.

in our jewelry (and teeth!),

✘ mercury, lead, molybdenum, etc.

in our machines.

God's Blessings

"For the LORD your God is bringing you into a good land, a land with flowing streams... a land whose stones are iron and from whose hills you may mine copper. You shall eat your fill and bless the LORD your God for the good land that he has given you."

Deuteronomy 8:7,9,10

Machines

- ✘ Made of elements from supernovae
 - 🚲 ashes of giant stars that died before the sun was born
 - 🚲 one may have initiated the sun's formation with shock waves
- ✘ Created by human minds,
- ✘ Created by human vision
- ✘ Created by human toil ...

Machines are not foreign to the universe!



Machines
Show Us
The
Universe:
HST
2002



VLA Radio Telescope



Where “Ellie” heard
the signal of another
civilization ...

Contact, The Movie





Vatican Advanced Technology Telescope

"Our scientific knowledge of the physical evolution of the universe, and our very limited knowledge of the origin of humans within it, might provide an opportunity to enrich our relationship to God as creator, if only we get loose of our idolatries."

Dr. George Coyne, S. J., Director

Machines

Bless our lives

✂ science

✂ healthcare

🚲 I am alive because of machines
testing and refrigerating blood

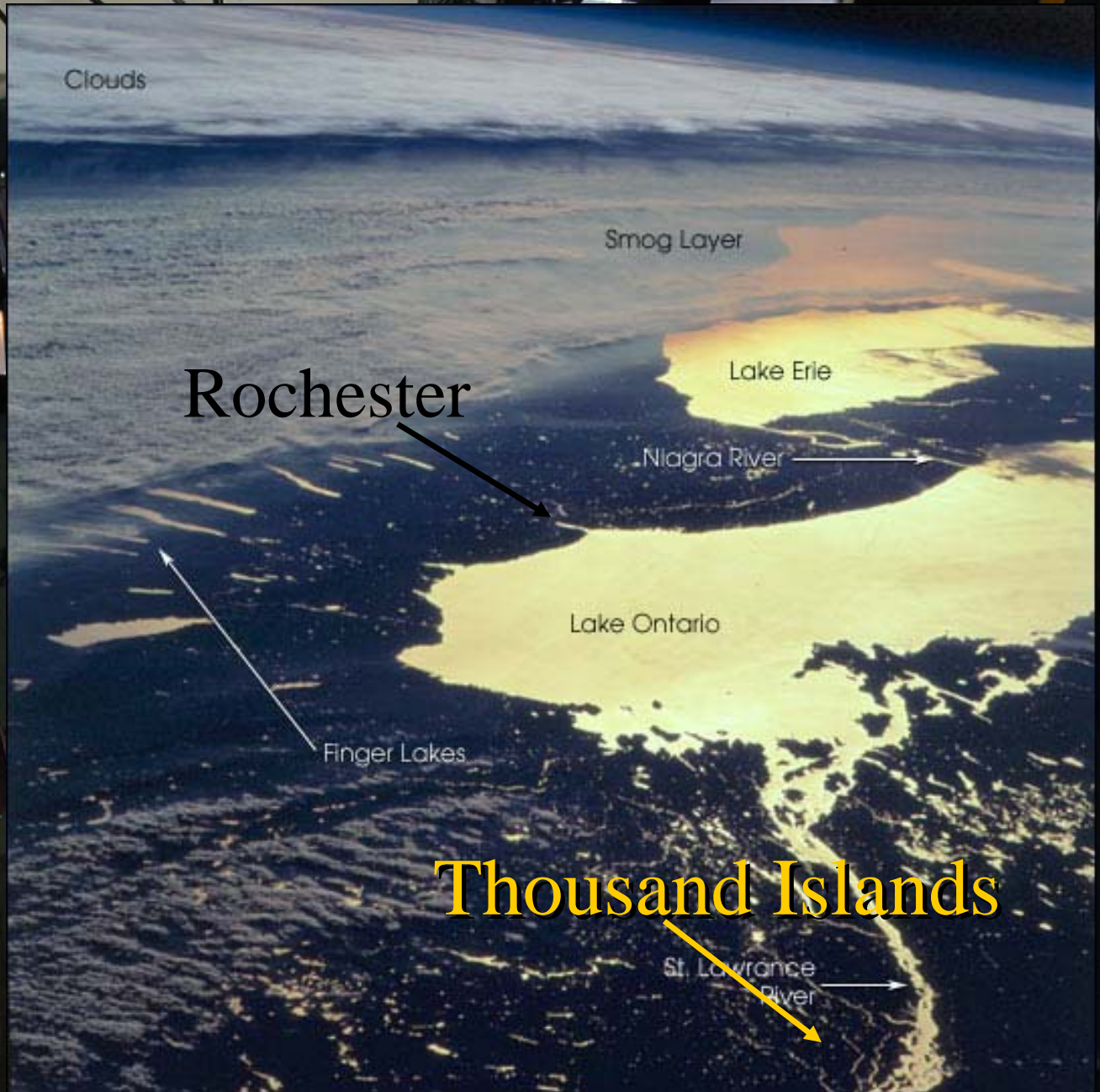
✂ transportation

✂ sanitation

✂ communication

But the blessings of machines can be hidden

Pollution Hides Blessings



Dumps Hide Blessings

Denver, Colorado

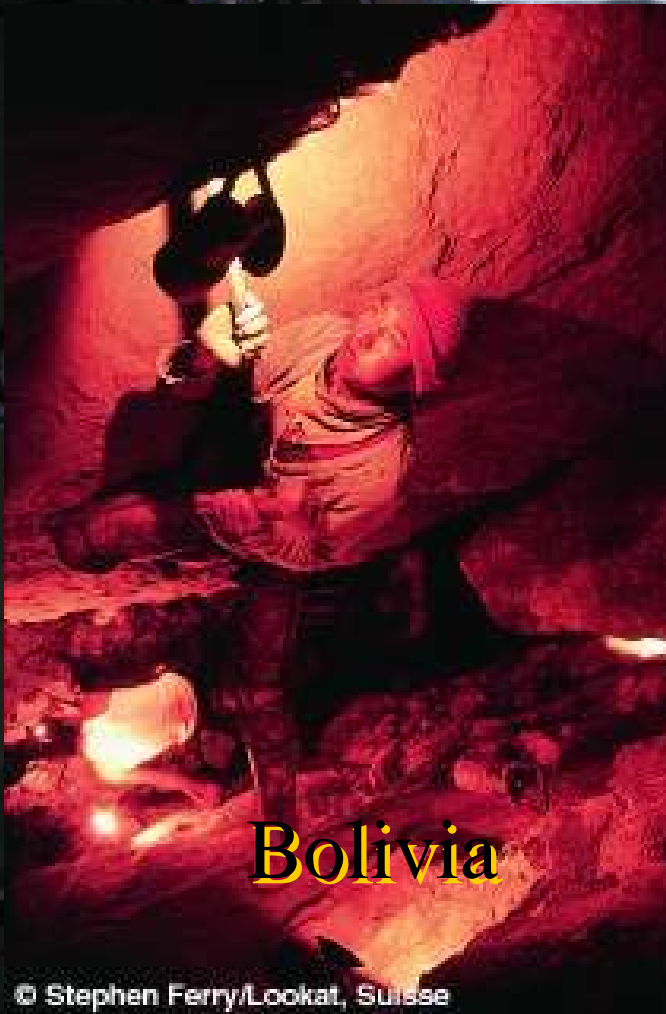


Mining Hide Blessings

Arizona



Bolivia



© Stephen Ferry/Lookat, Suisse

But Blessings Lurk

Behind the junk ...

Within the junk ...



Machines



Seen as evil ...

"Our intellectual journals are full of gloomy tracts that depict a society debased by technology. Our health is being ruined, ..., our landscape despoiled, and our social institutions laid waste"

Samuel Florman
Blaming Technology

Machines

Seen to reduce us ...

"Atomism, or the machine model, reduces all living things to their most basic chemical compounds, so that we and all other organisms are "nothing but" the chemicals in our bodies."

Sallie McFague
The Body of God

Seeing Junk Anew

... "Imagine God as the living awareness in the space between the atoms ... Is God immanent or transcendent, internal or external, composed or compassionate? Like the question of whether the atom is a wave or a particle, the answer is: yes."

Tom Mahon
The Spirit in Technology

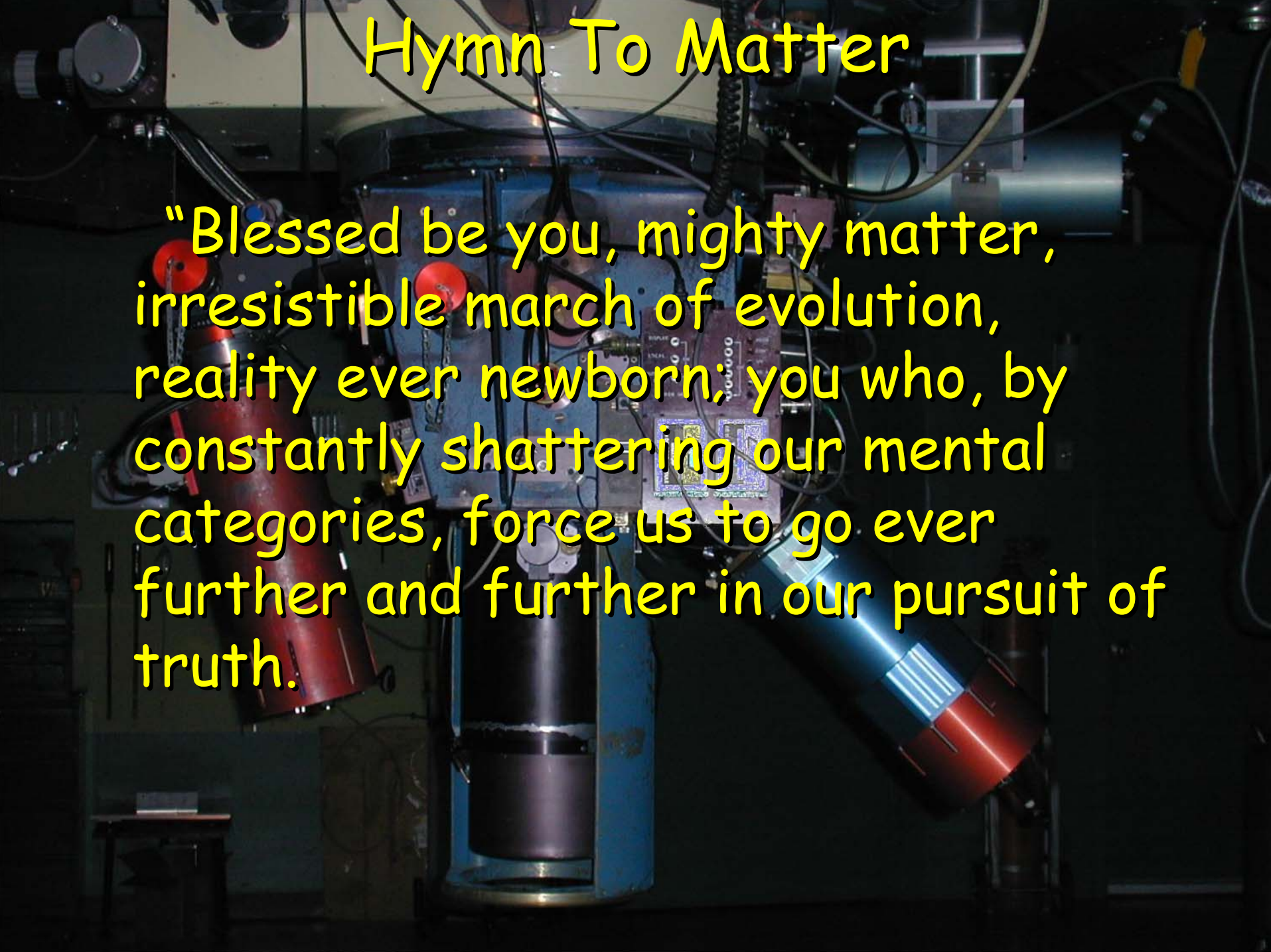
Seeing Machines Anew

Teilhard's Christ ...

"Glorious Lord Christ: The divine influence secretly diffused and active in the depths of matter..."

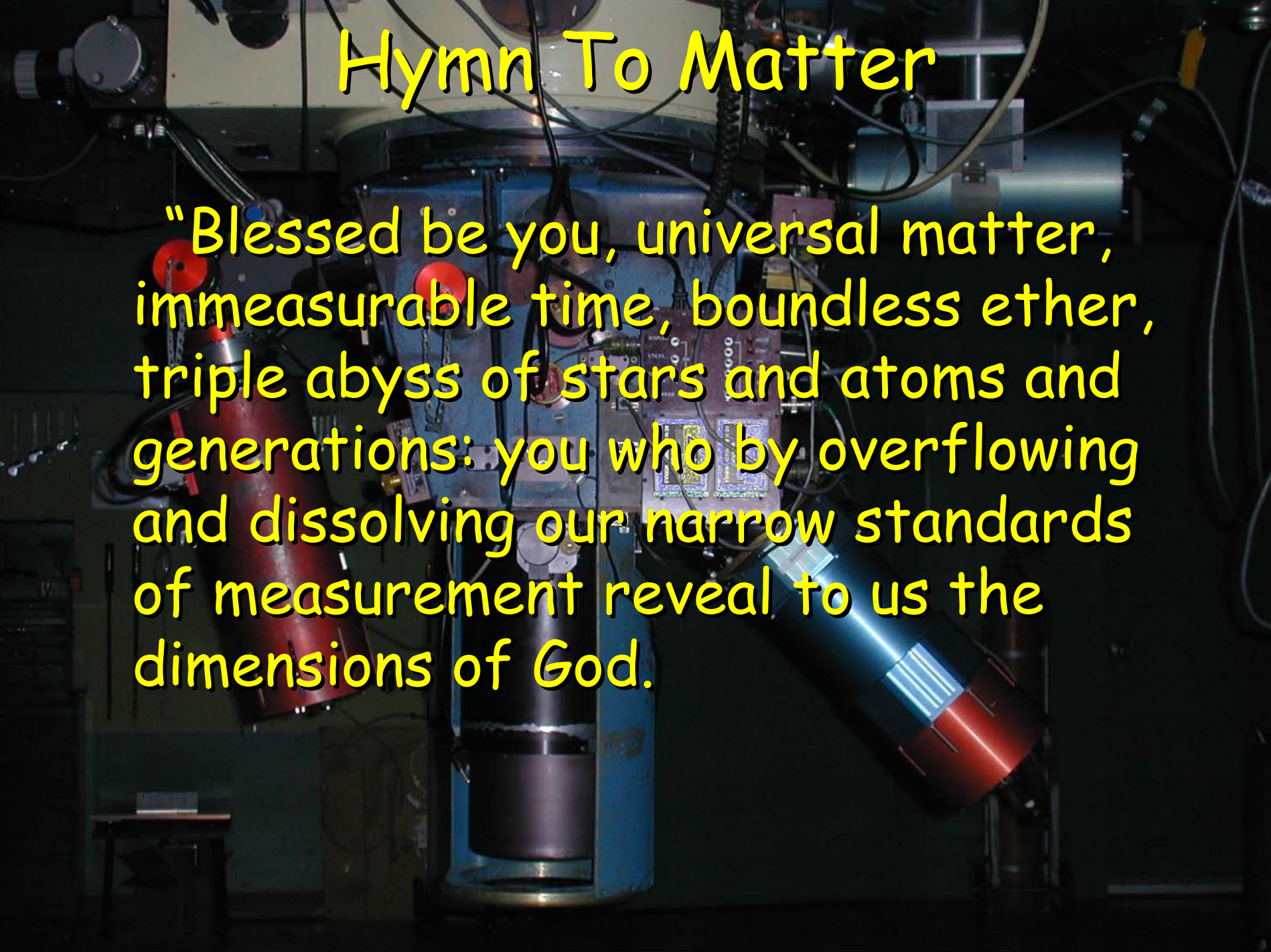
Is also diffused and active in machines!

Hymn To Matter

The background image shows a complex scientific apparatus, likely a particle detector or accelerator component. It features a central cylindrical chamber, various tubes, wires, and a control panel with a digital display. The lighting is dim, with some components illuminated by a blue light.

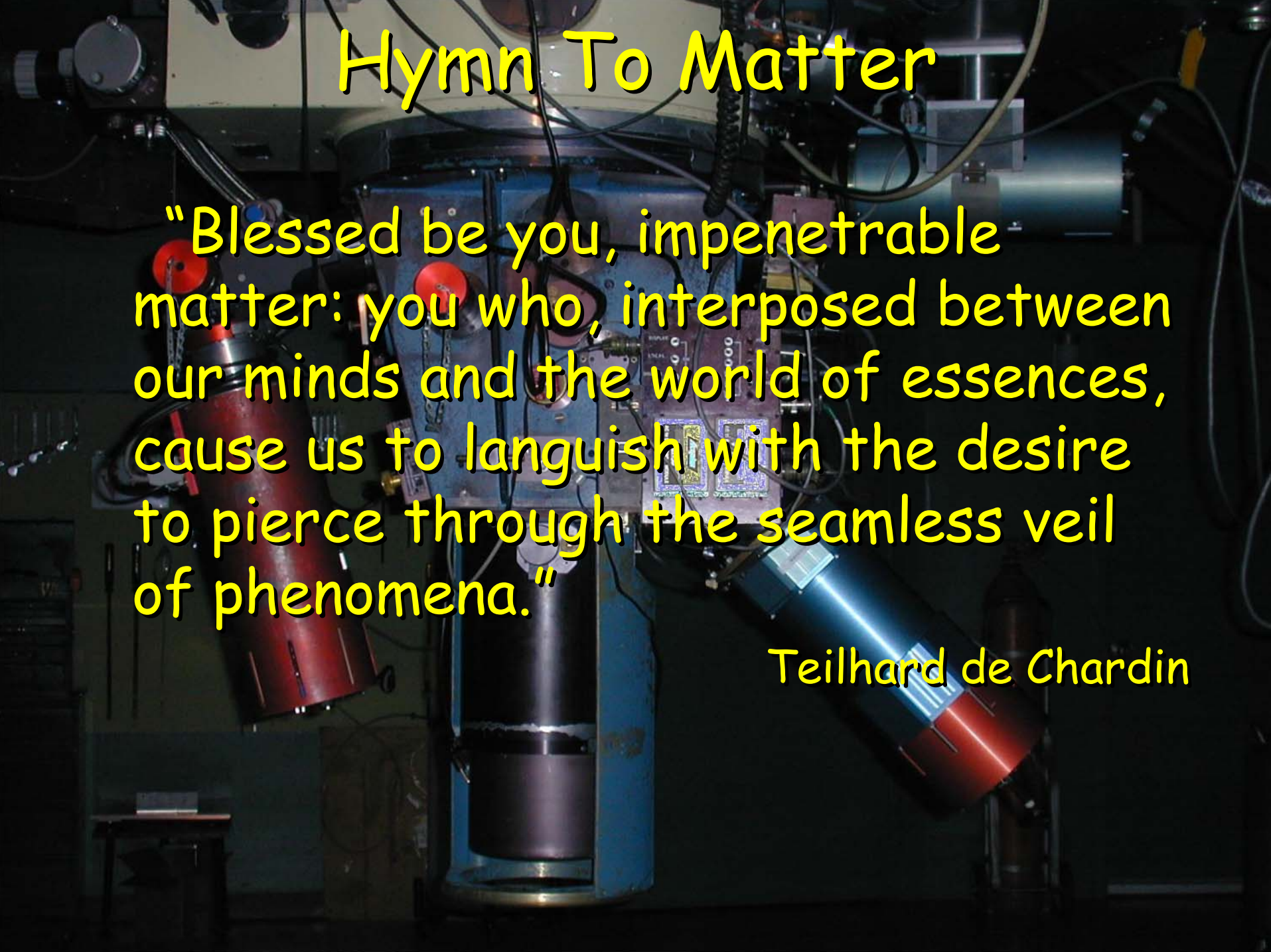
"Blessed be you, mighty matter,
irresistible march of evolution,
reality ever newborn; you who, by
constantly shattering our mental
categories, force us to go ever
further and further in our pursuit of
truth.

Hymn To Matter



"Blessed be you, universal matter,
immeasurable time, boundless ether,
triple abyss of stars and atoms and
generations: you who by overflowing
and dissolving our narrow standards
of measurement reveal to us the
dimensions of God.

Hymn To Matter



"Blessed be you, impenetrable matter: you who, interposed between our minds and the world of essences, cause us to languish with the desire to pierce through the seamless veil of phenomena."

Teilhard de Chardin

God's Grandeur

THE WORLD is charged with the grandeur of God.

It will flame out, like shining from shook foil;

It gathers to a greatness, like the ooze of oil

Crushed. Why do men then now not reck his rod?

Generations have trod, have trod, have trod;

And all is seared with trade; bleared, smeared
with toil;

And wears man's smudge and shares man's smell:
the soil

Is bare now, nor can foot feel, being shod.

God's Grandeur

And for all this, nature is never spent;

There lives the dearest freshness deep down
things;

And though the last lights off the black West went

Oh, morning, at the brown brink eastward,
springs—

Because the Holy Ghost over the bent

World broods with warm breast and with ah!
bright wings.

Gerard Manley Hopkins