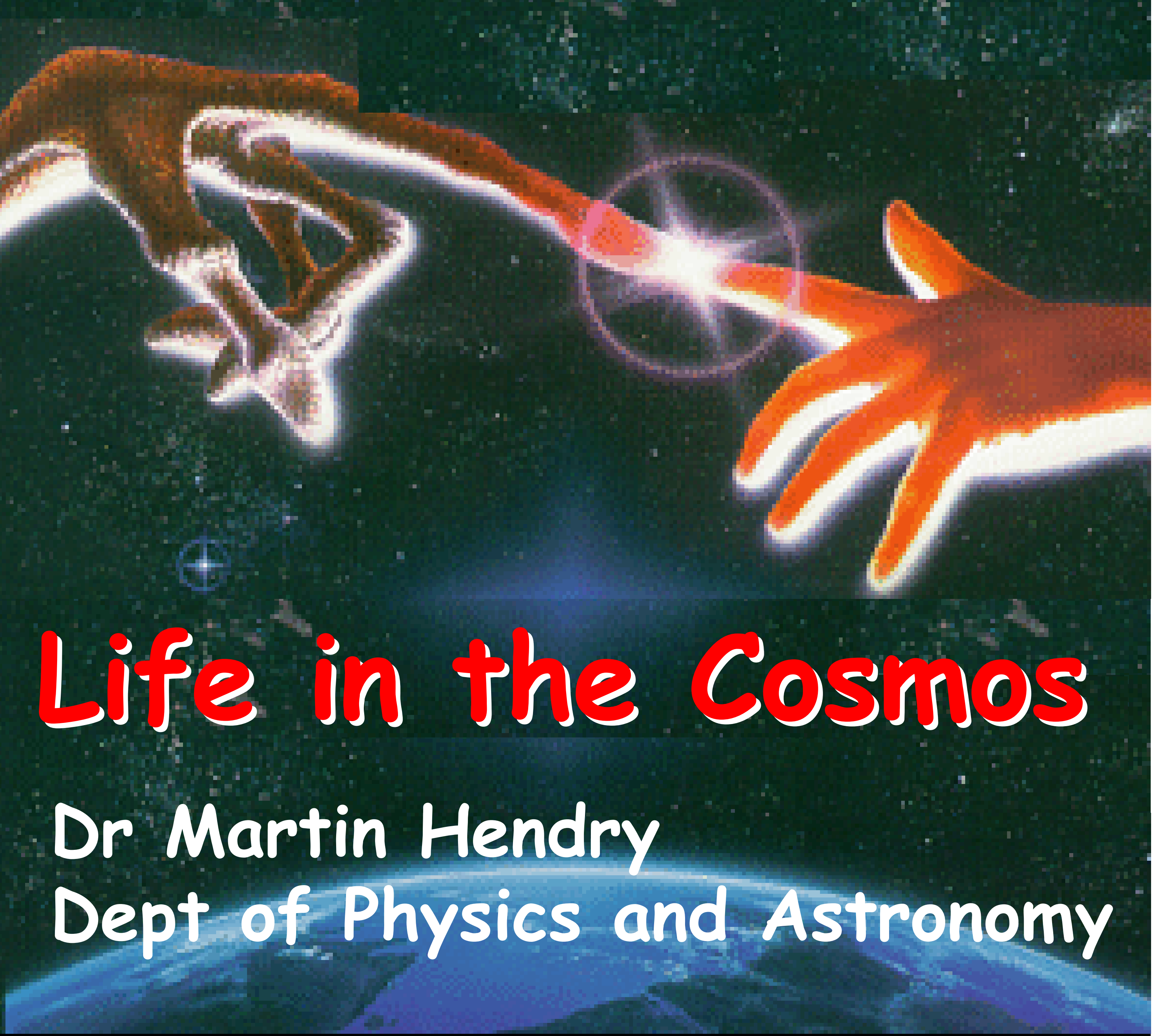


Life in the Cosmos

Dr Martin Hendry
Dept of Physics and Astronomy

UNIVERSITY of GLASGOW

ASTRONOMY ASTROPHYSICS

PPARC

Life in the Cosmos

10 meetings, beginning 16/01/06

Course Aims:

To review recent, and likely future, progress in astronomers' search for life in Universe. To understand some of the astrophysics which underpins this exciting research field-

- Forming Stars and Planets
- Life in the Solar System
- Searching for Extra-Solar planets
- Can we find Earth-like planets?
- Threats to life in the Cosmos
- The Search for Extra Terrestrial Intelligence
- The big questions: Why are We Here?
  Where is Everybody?

UNIVERSITY of GLASGOW

PPARC

Life in the Cosmos: Jan 2006

Life in the Cosmos

Course Lecturers:

Dr Martin Hendry

Dept of Physics and Astronomy
University of Glasgow
martin@astro.gla.ac.uk

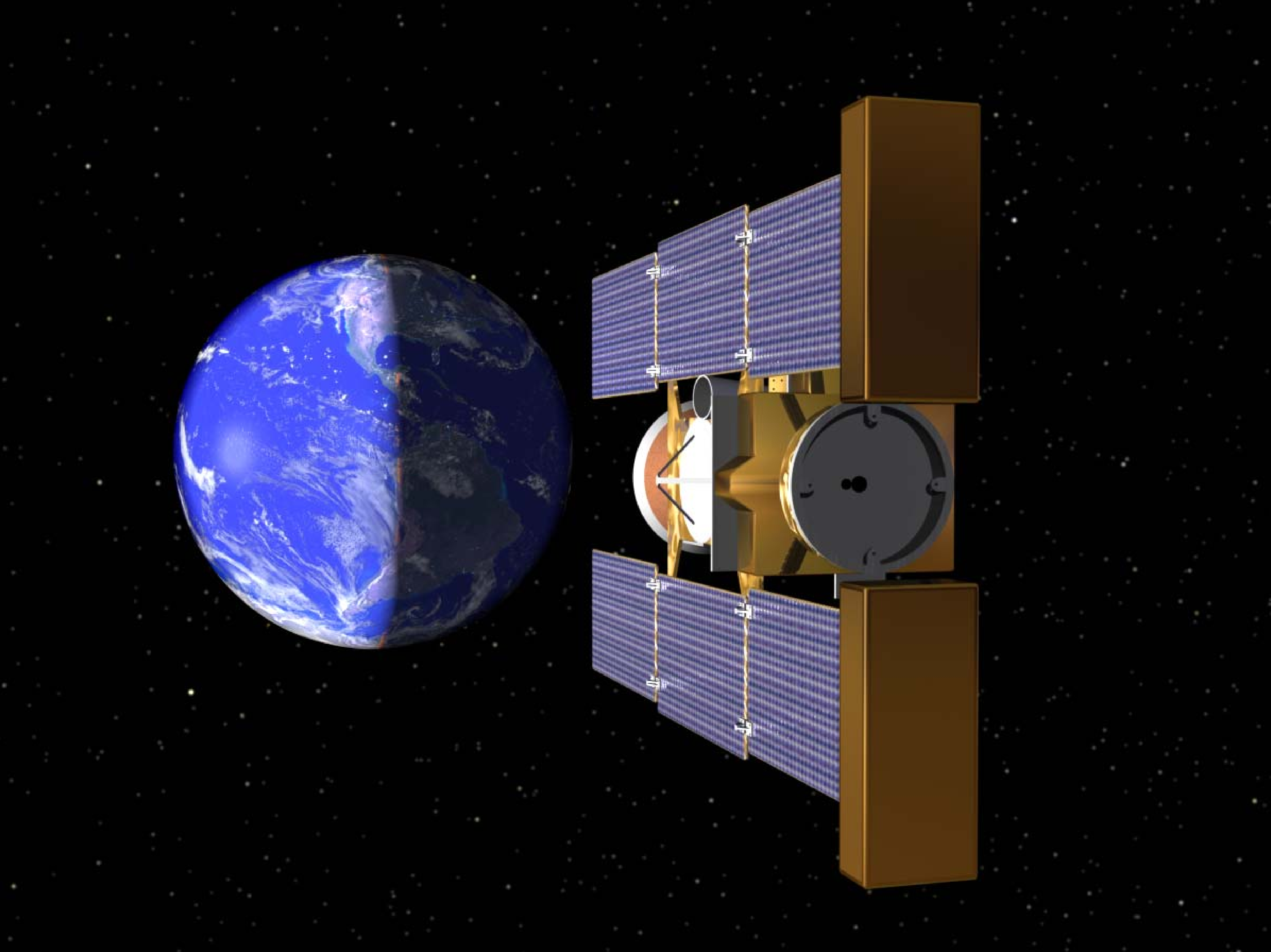
Dr Luis Teodoro

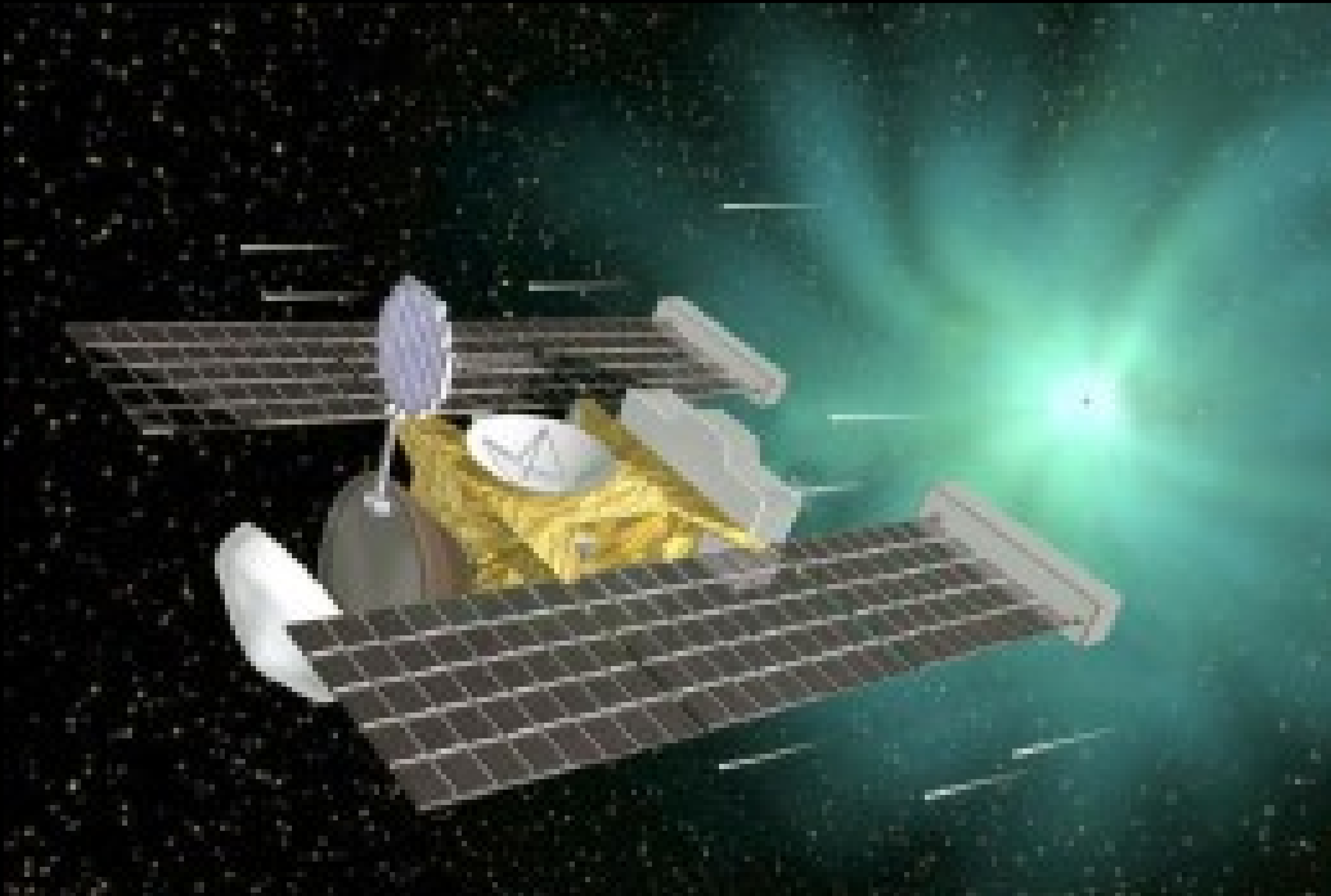
Dept of Physics and Astronomy
University of Glasgow
luis@astro.gla.ac.uk

Course Website:

http://www.astro.gla.ac.uk/users/martin/teaching/life/

username: life password: life





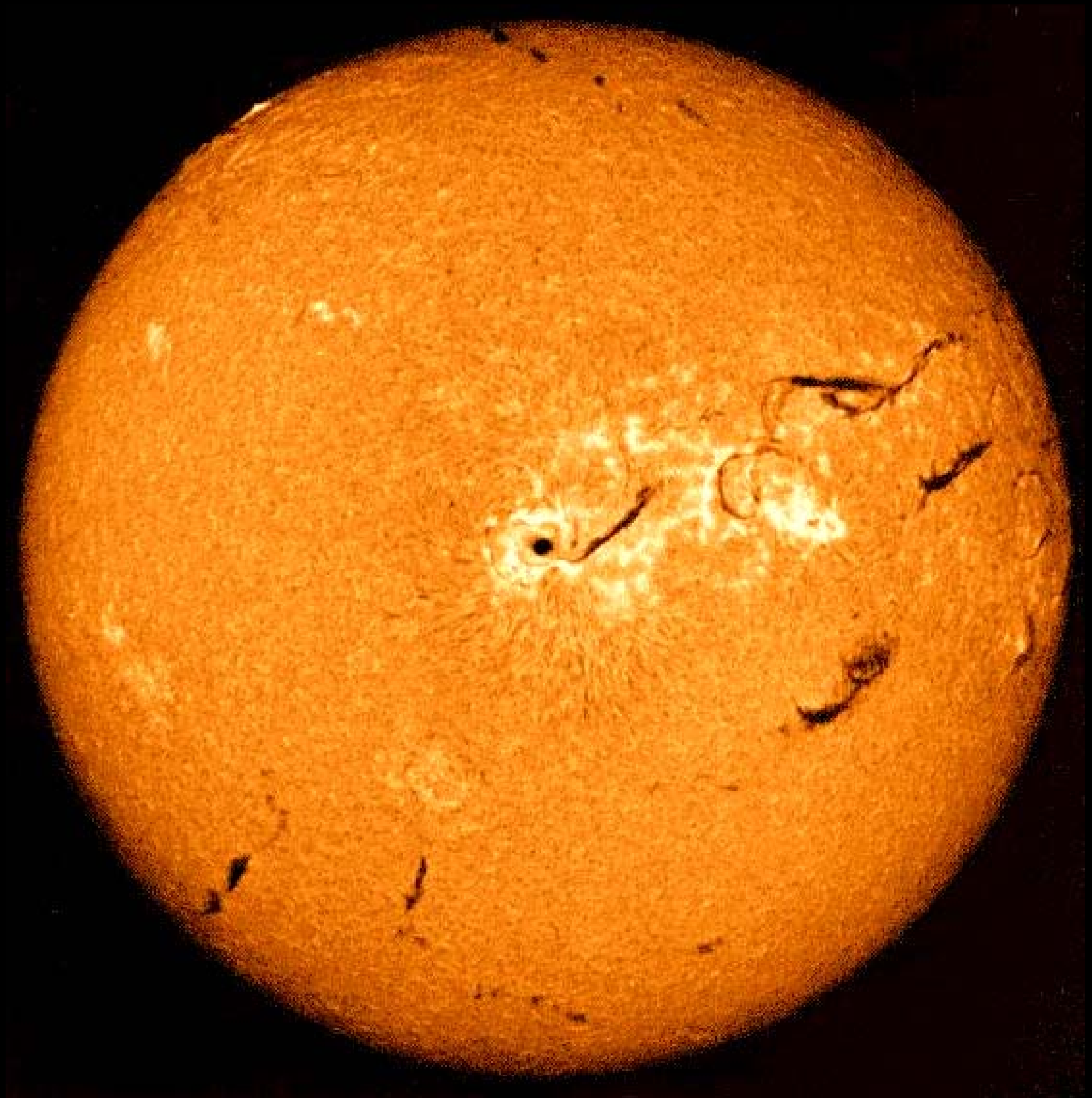
STARDUST: SCIENCE IN-DEPTH

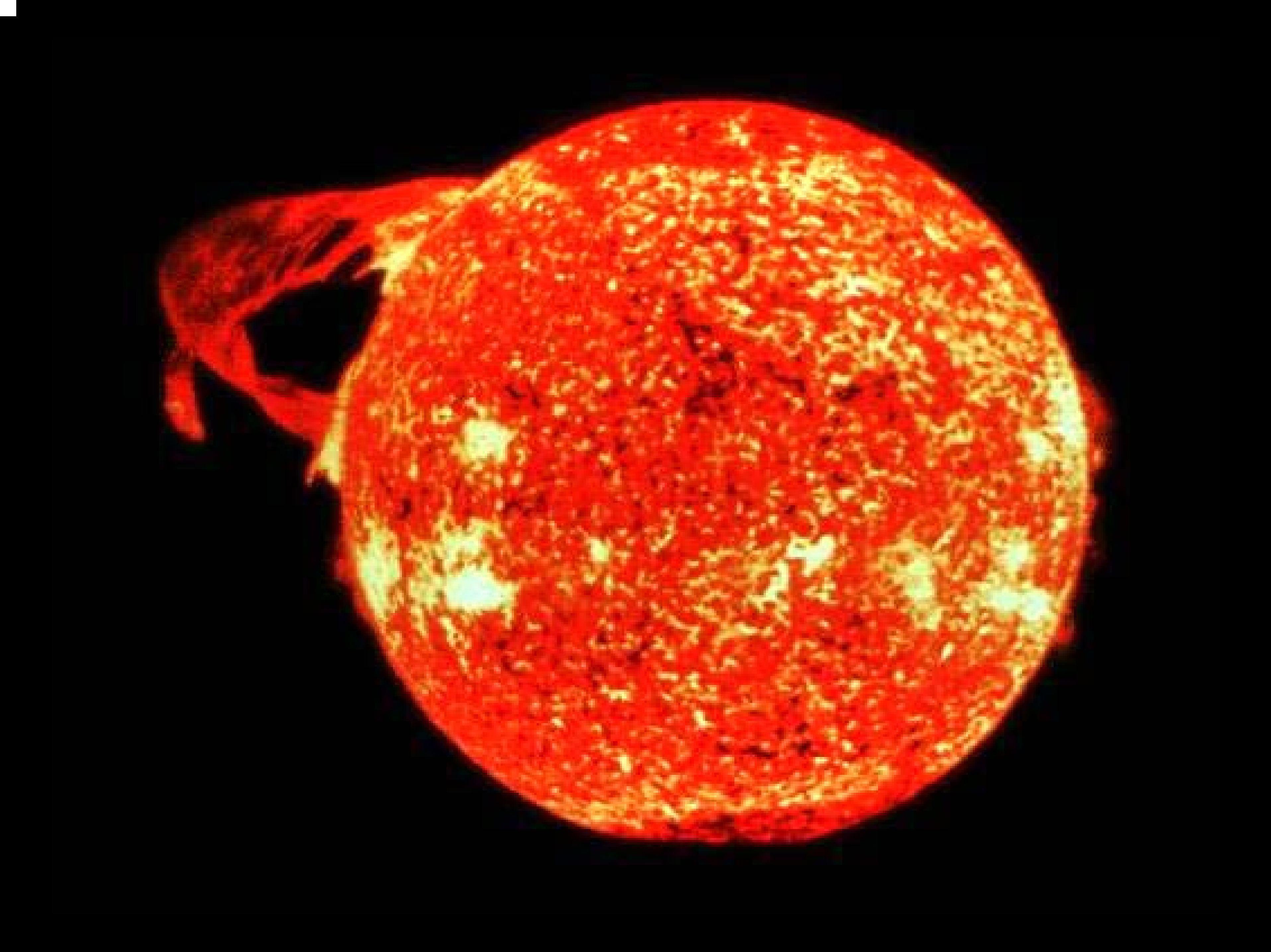
Comet Coma Sample Return Plus Interstellar Dust, Science and Technical Approach

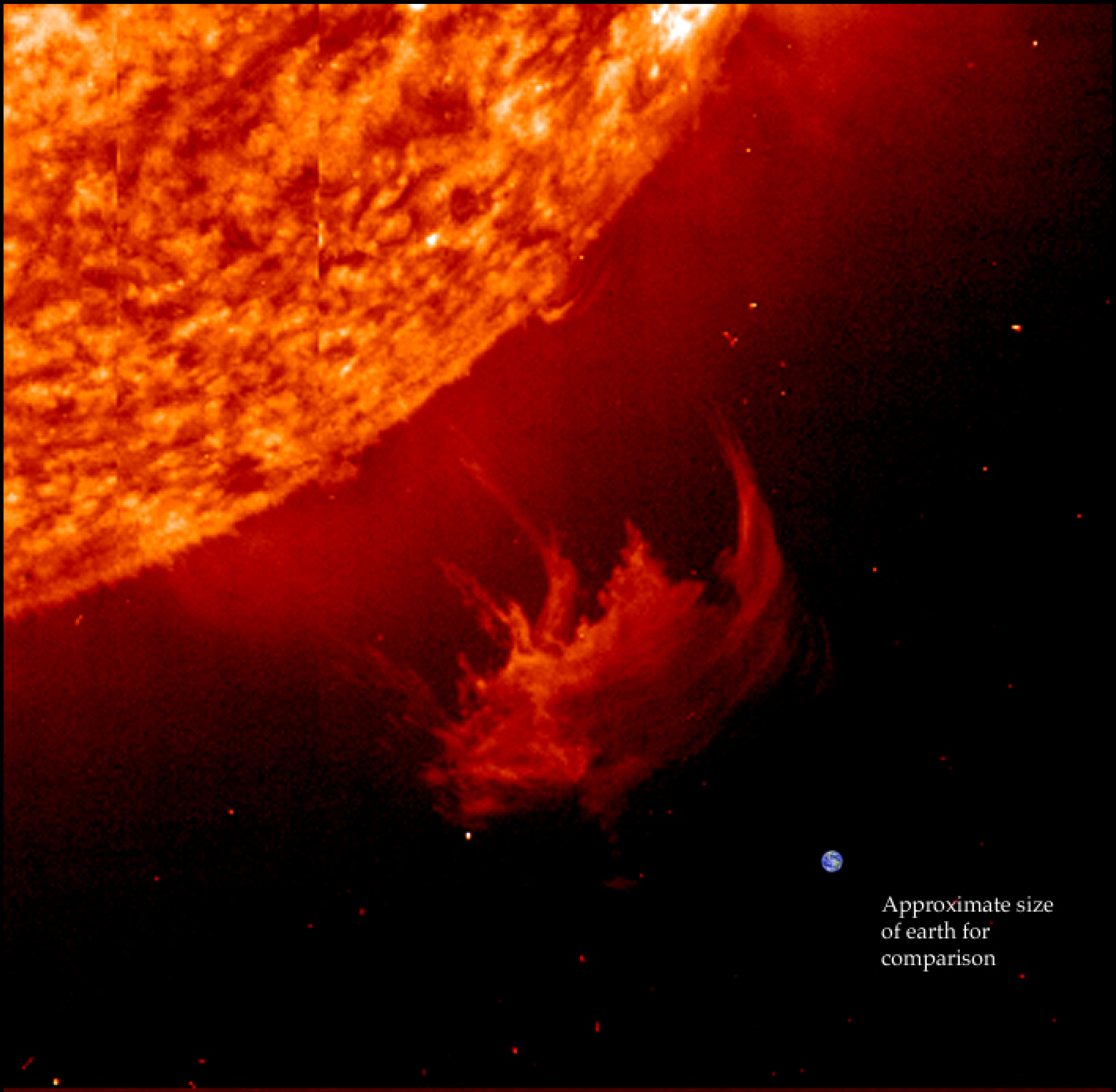
Oct 21, 1994

by Donald E. Brownlee, Principal Investigator, University of Washington, Peter Tsou, Benton C. Clark, Paul N. Swanson, and Joseph Vellinga.


How do stars and planets form?

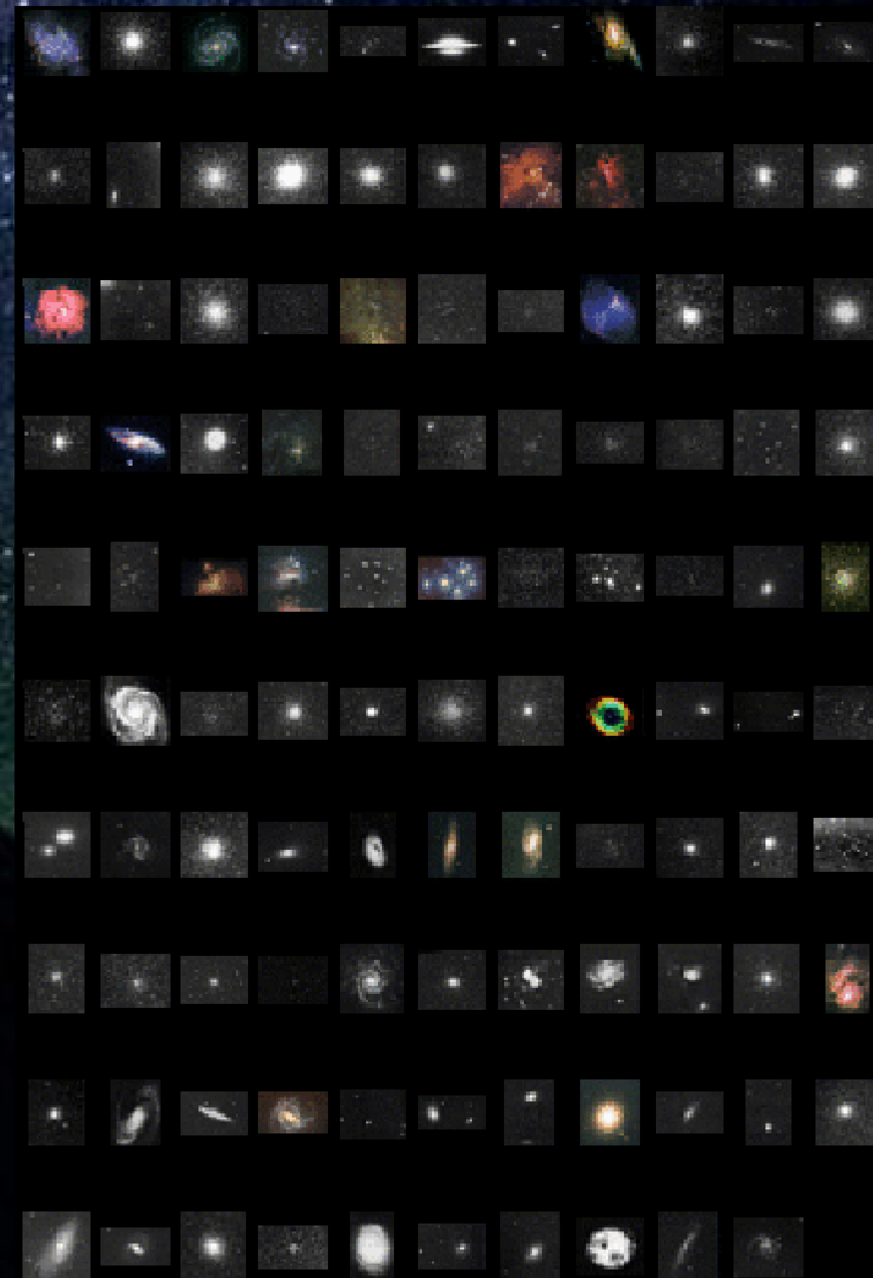





Approximate size
of earth for
comparison

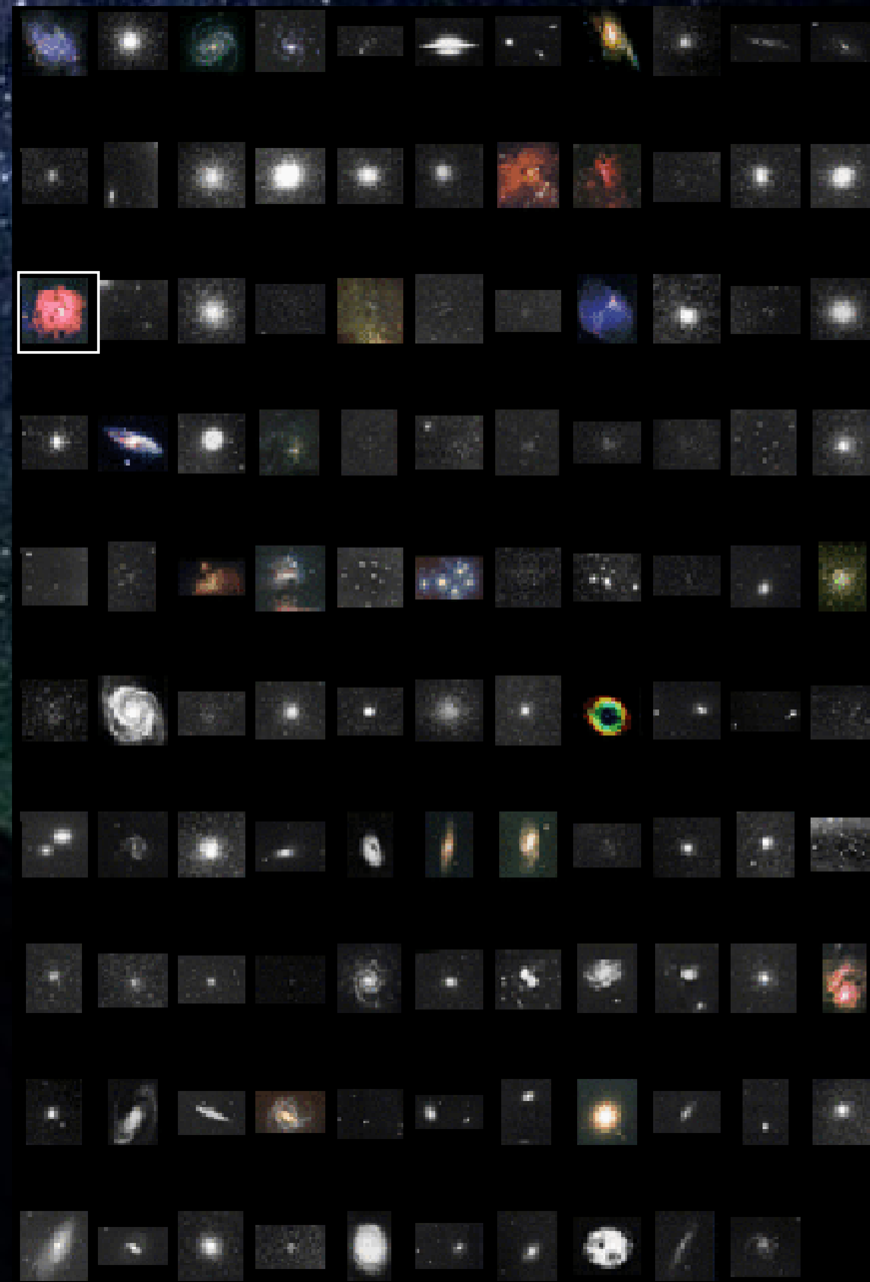
How do stars and planets form?

from Nebulae



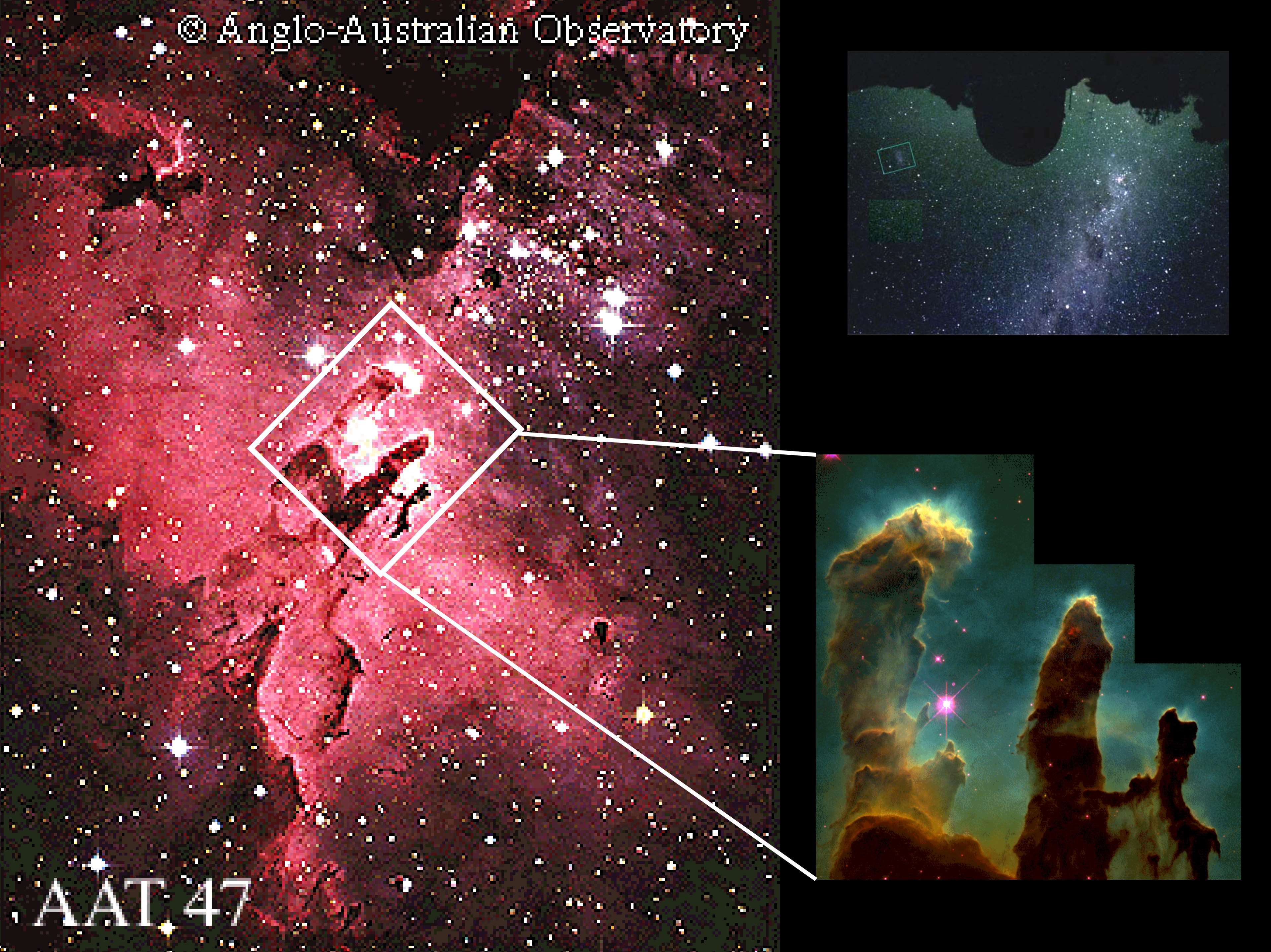
How do stars and planets form?

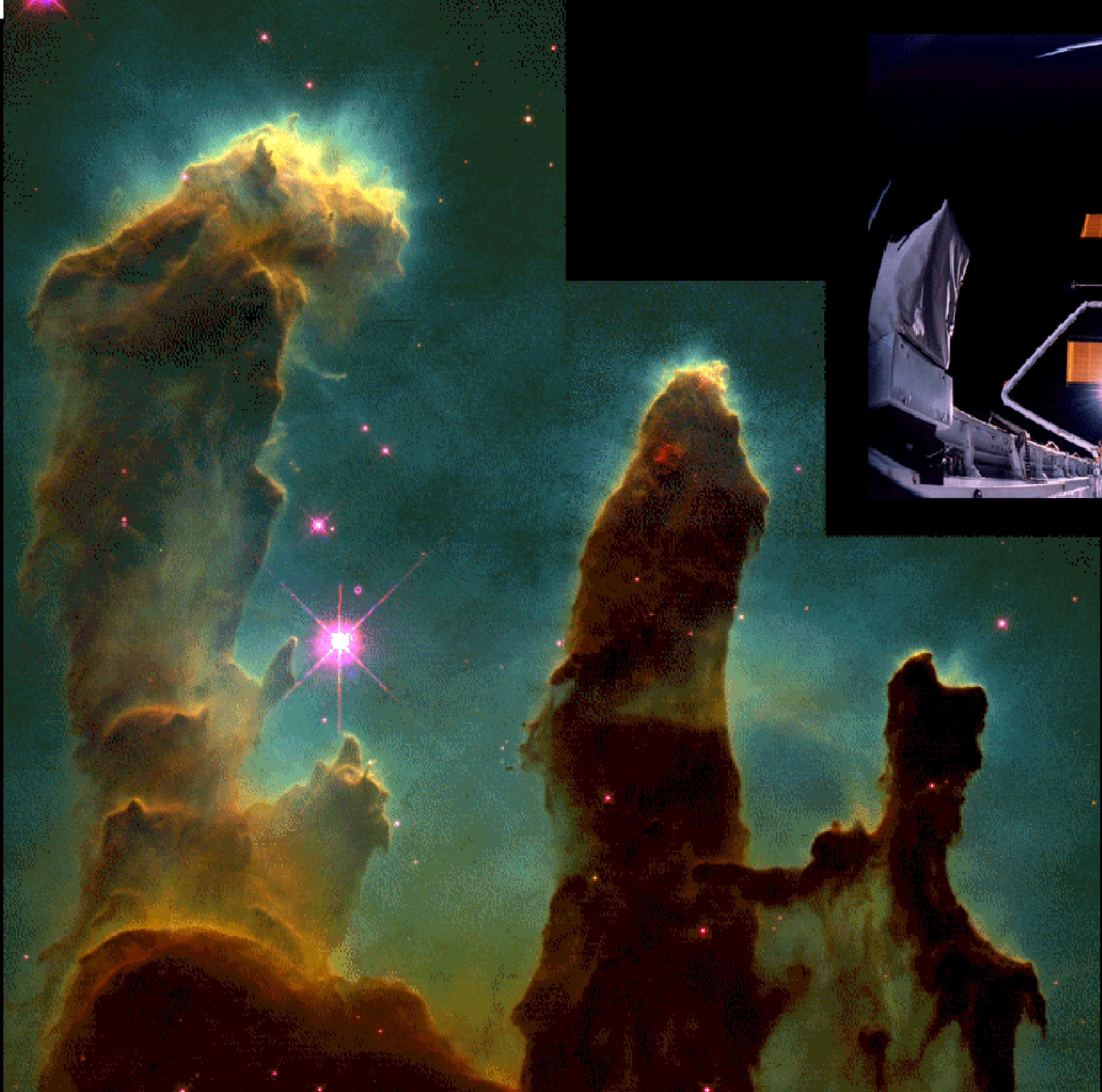
from Nebulae

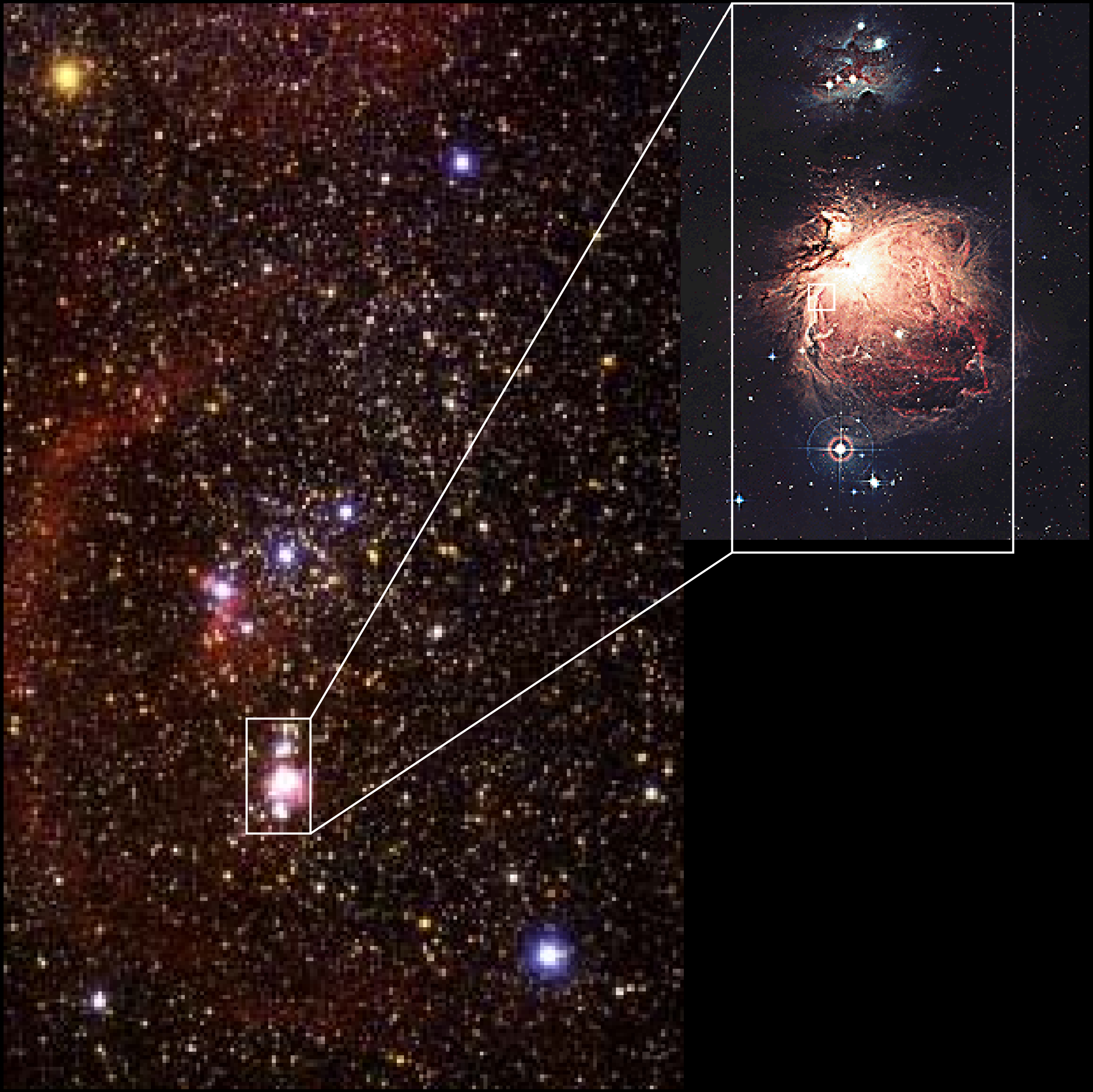


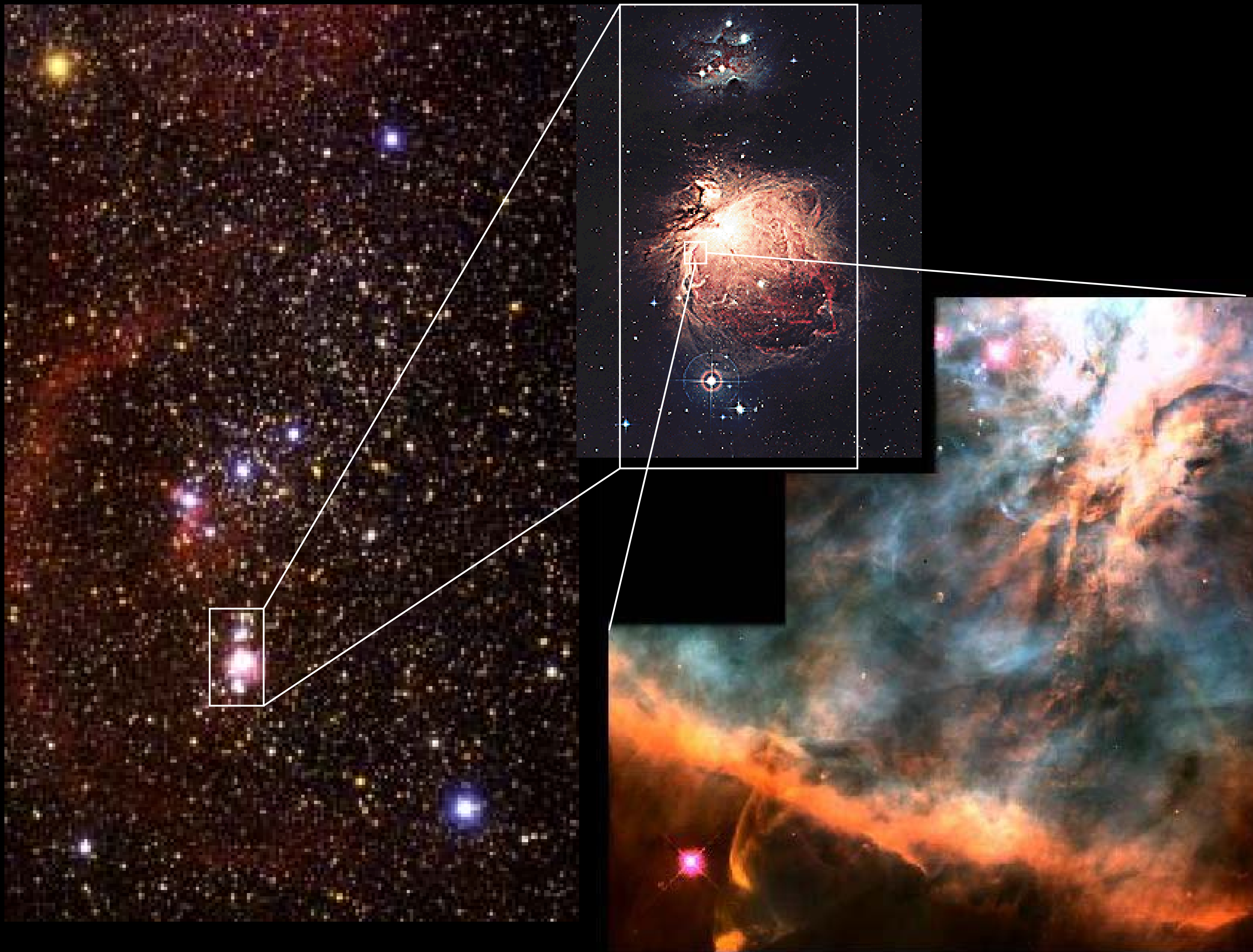

© Anglo-Australian Observatory
AAT 47


© Anglo-Australian Observatory
AAT 47


© Anglo-Australian Observatory
AAT 47







The Orion Nebula

Forming stars and planets….

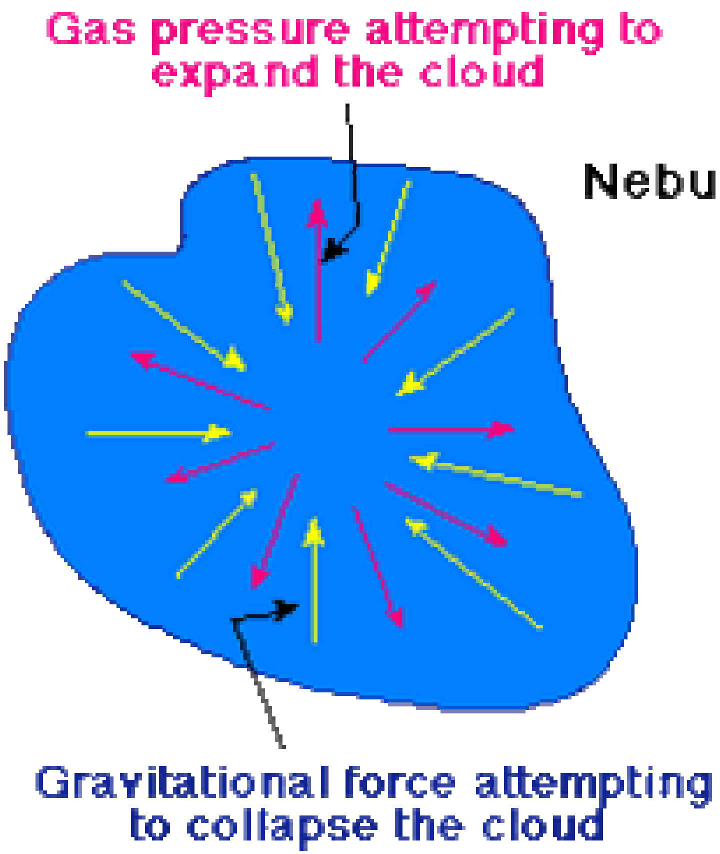
Forming stars and planets….

Pressure

versus

Gravity

Forming stars and planets….

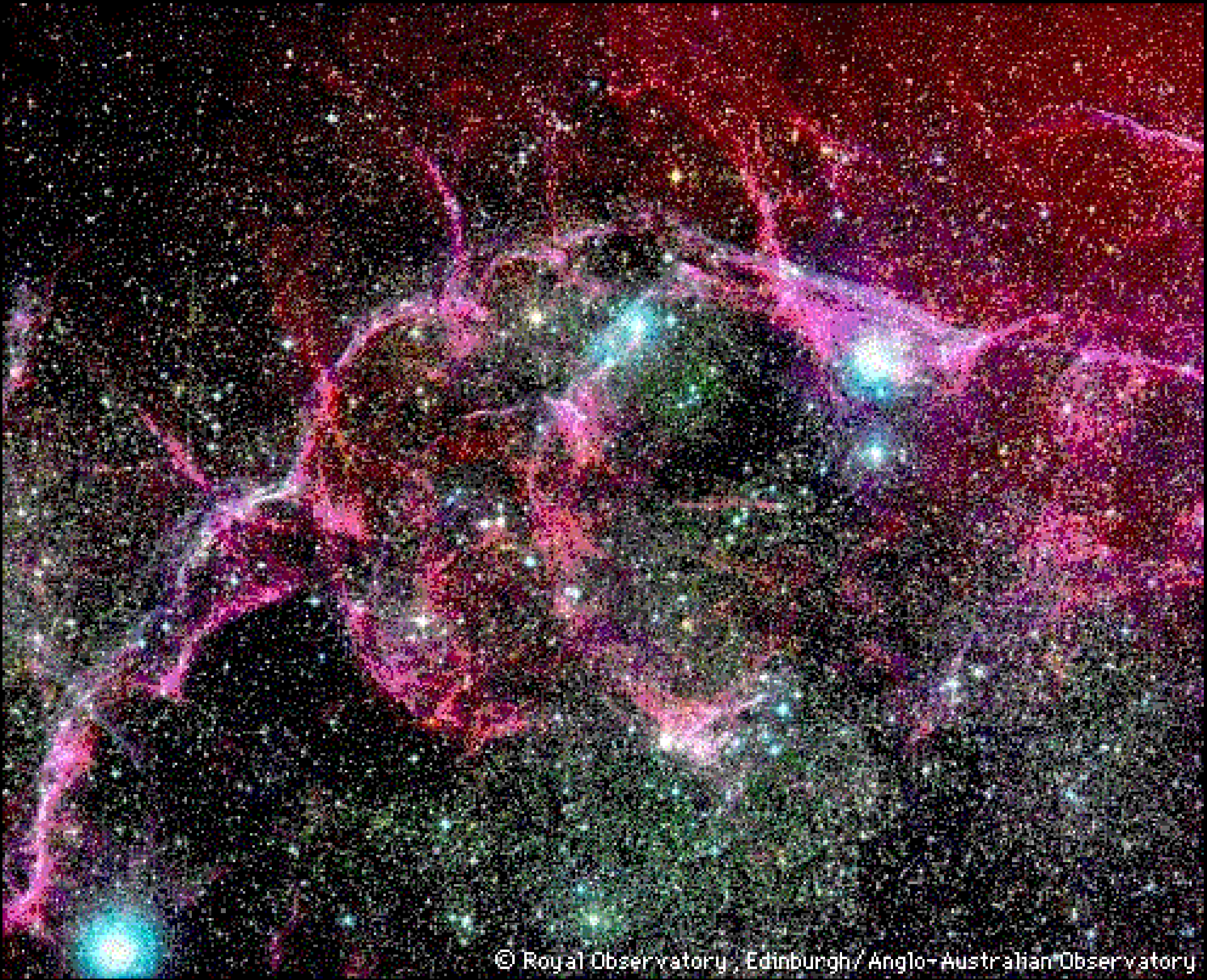


Pressure

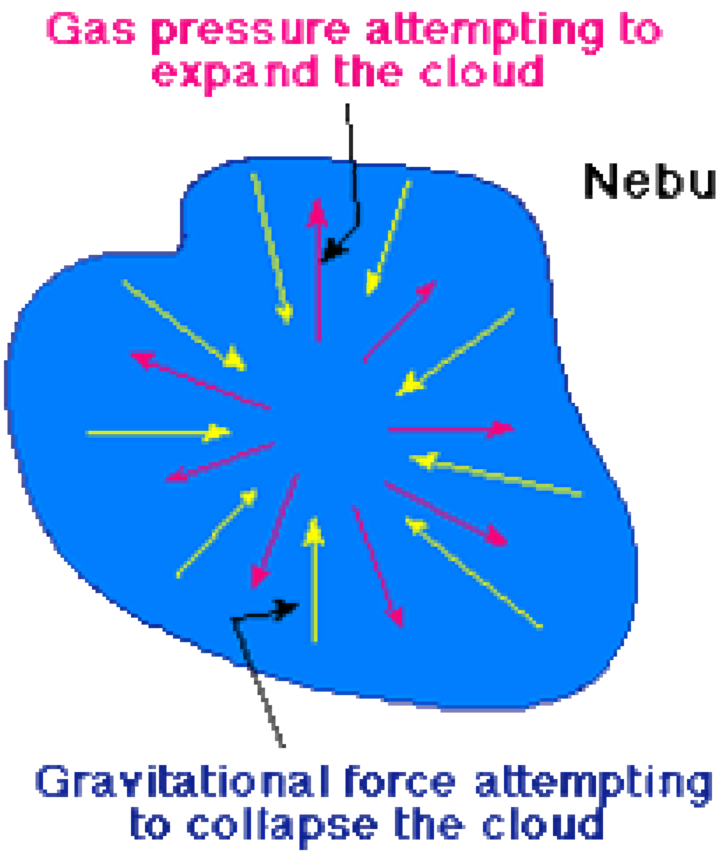
versus

Gravity

Collapse often caused by a supernova shock wave


© Royal Observatory, Edinburgh/ Anglo-Australian Observatory

Forming stars and planets….



Pressure

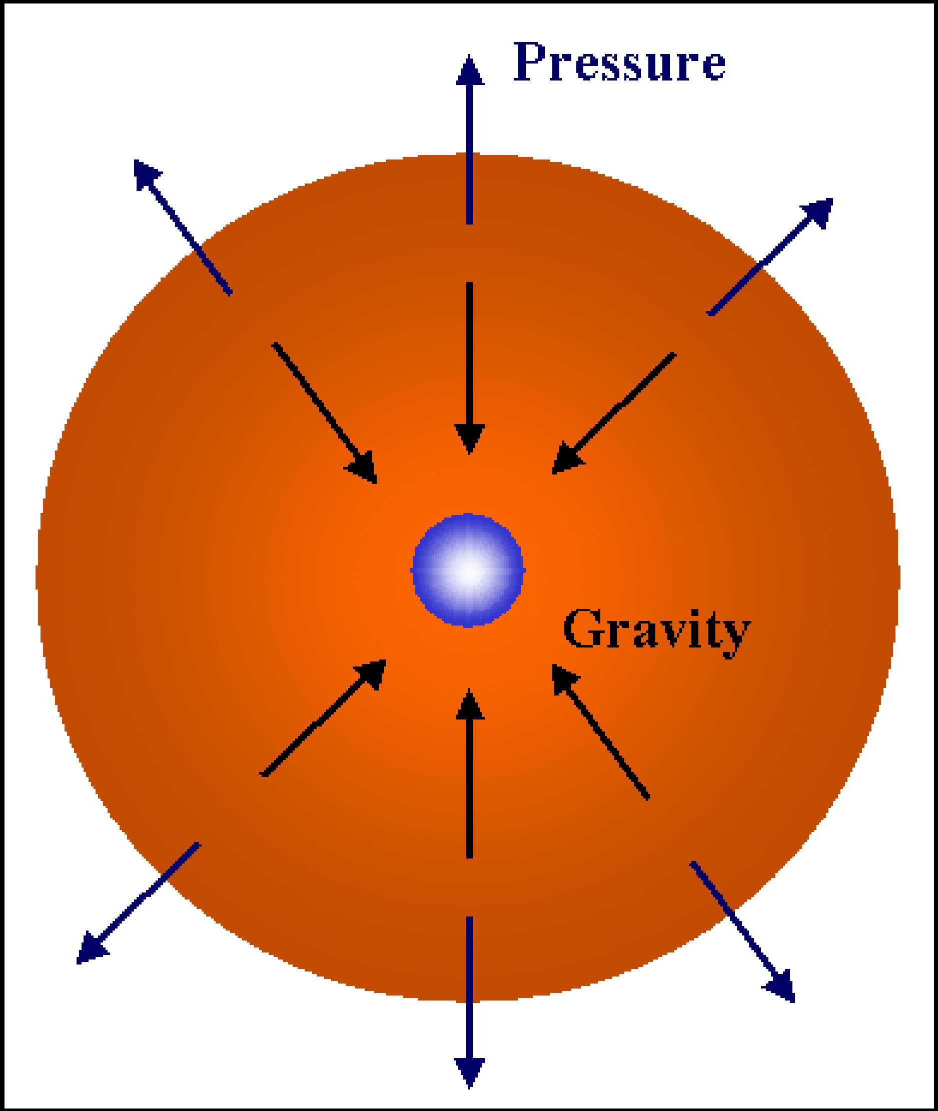
versus

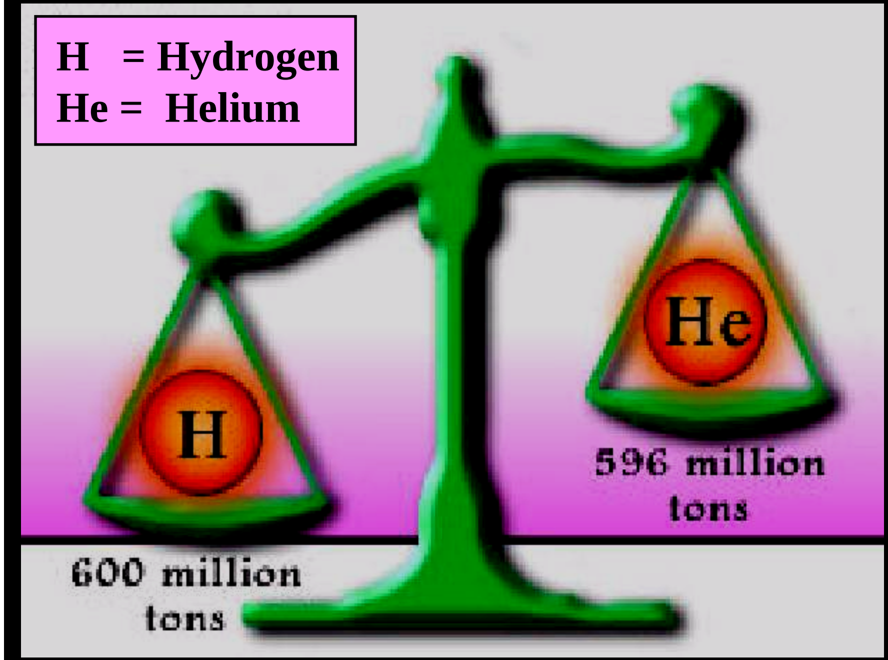
Gravity

Collapse often caused by a supernova shock wave

When one star dies another star is born

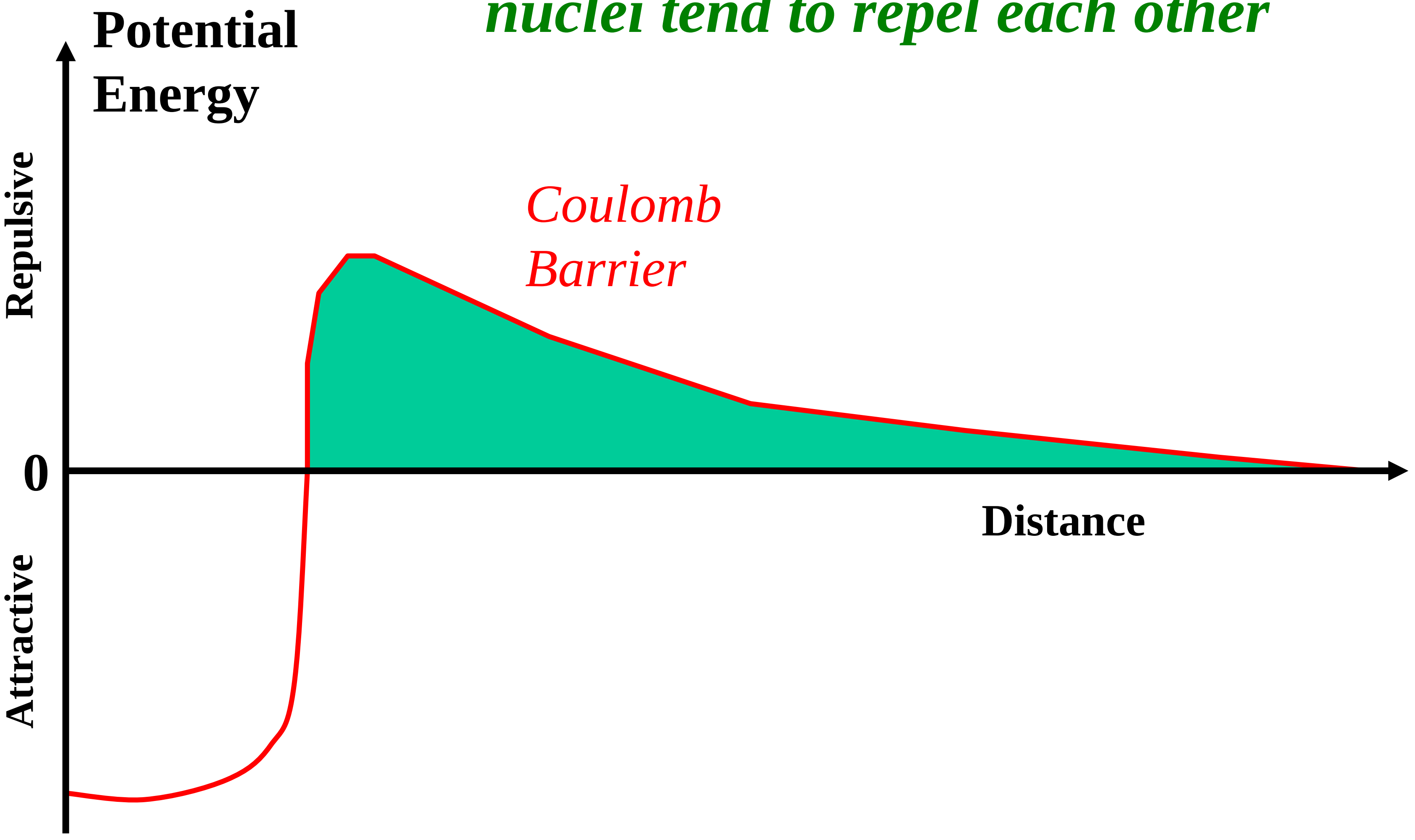
Hydrogen fusion – fuelling a star's nuclear furnace



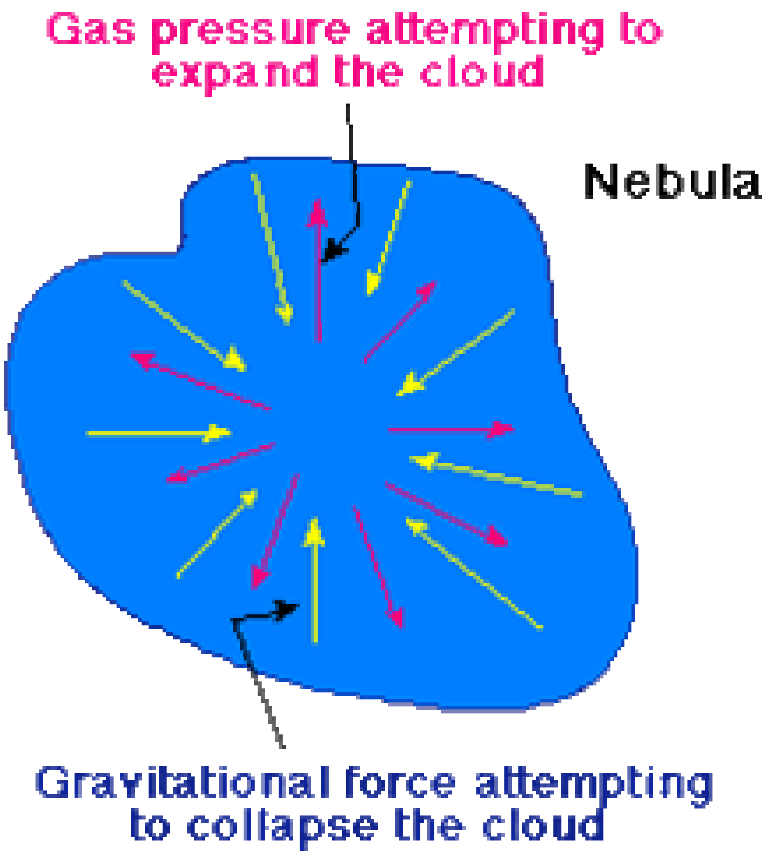


$$E = mc^2$$

Nuclear fusion only occurs at very high temperatures, because atomic nuclei tend to repel each other

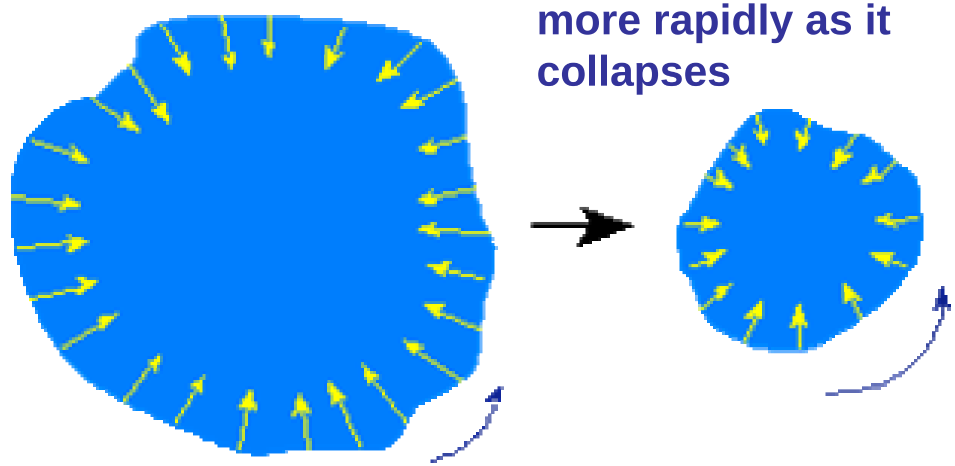


Forming stars and planets….



Pressure versus Gravity

The nebula spins more rapidly as it collapses



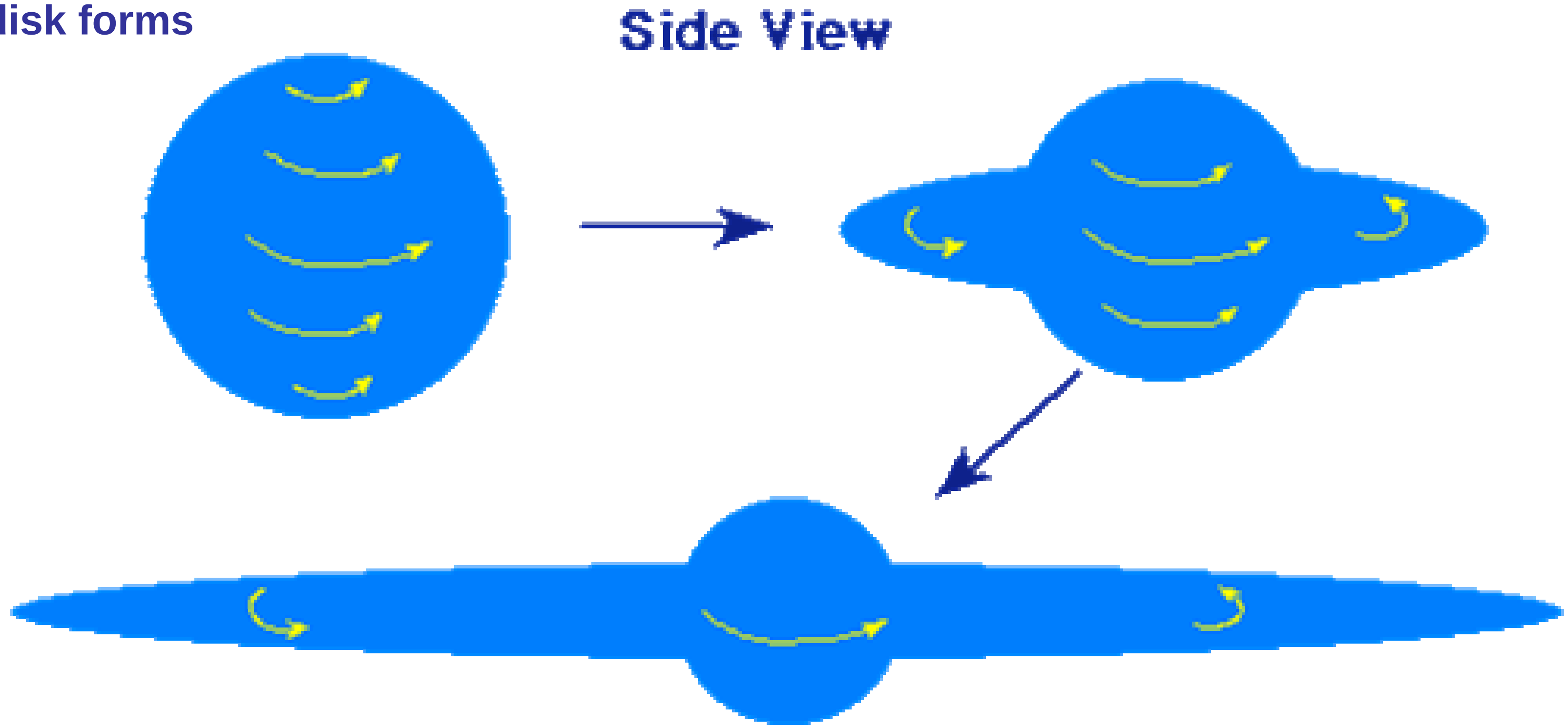
Forming stars and planets….

Pressure

versus

Gravity

As the nebula collapses
a disk forms



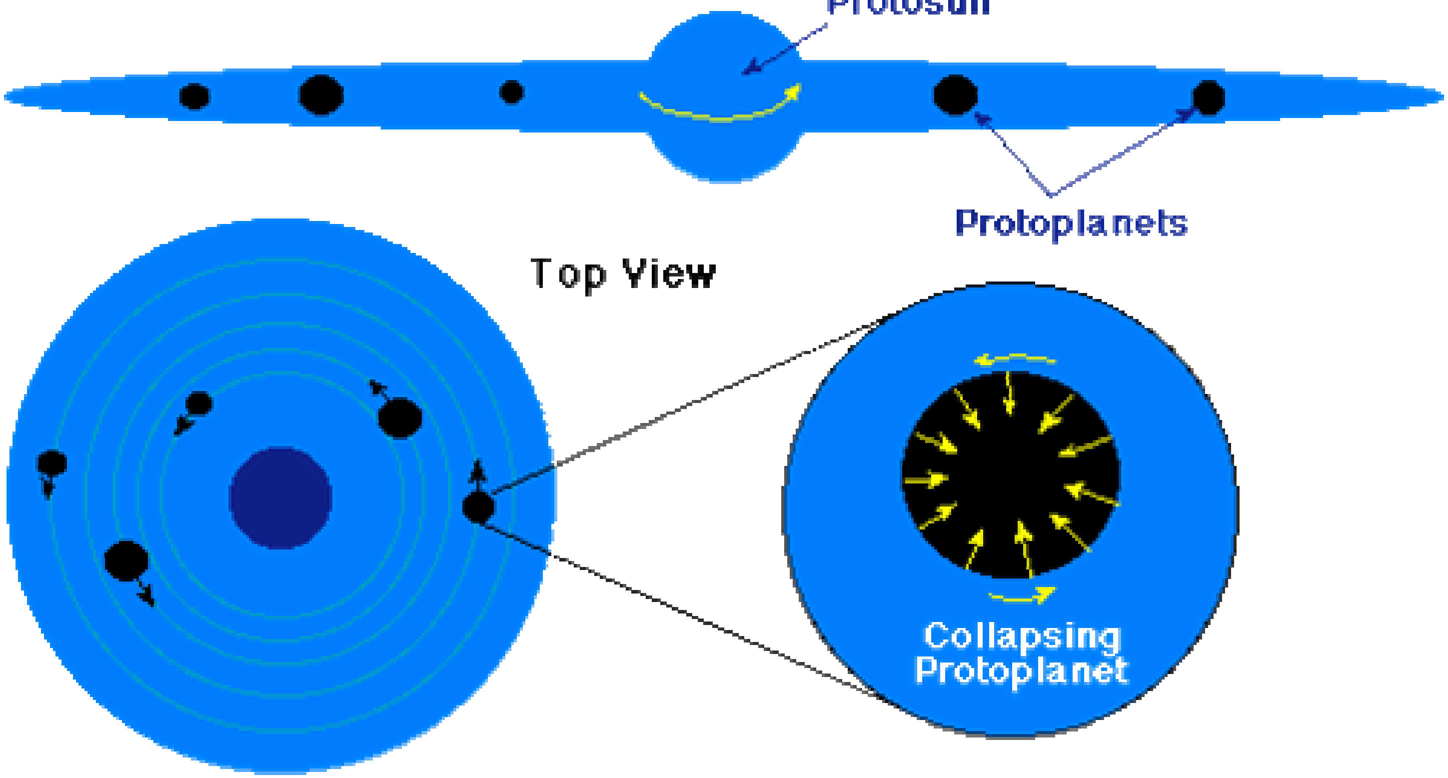
Forming stars and planets….

Pressure

versus

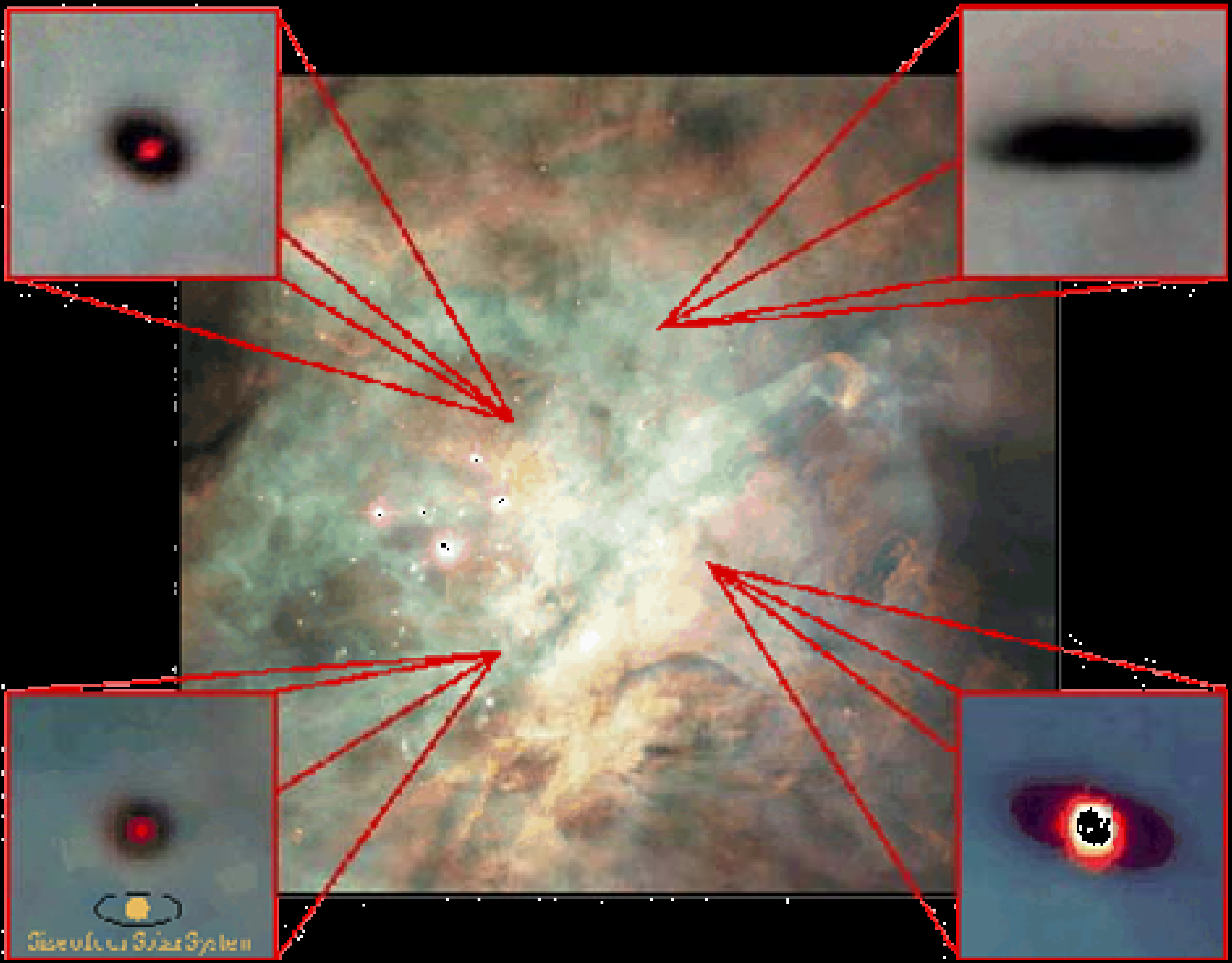
Gravity

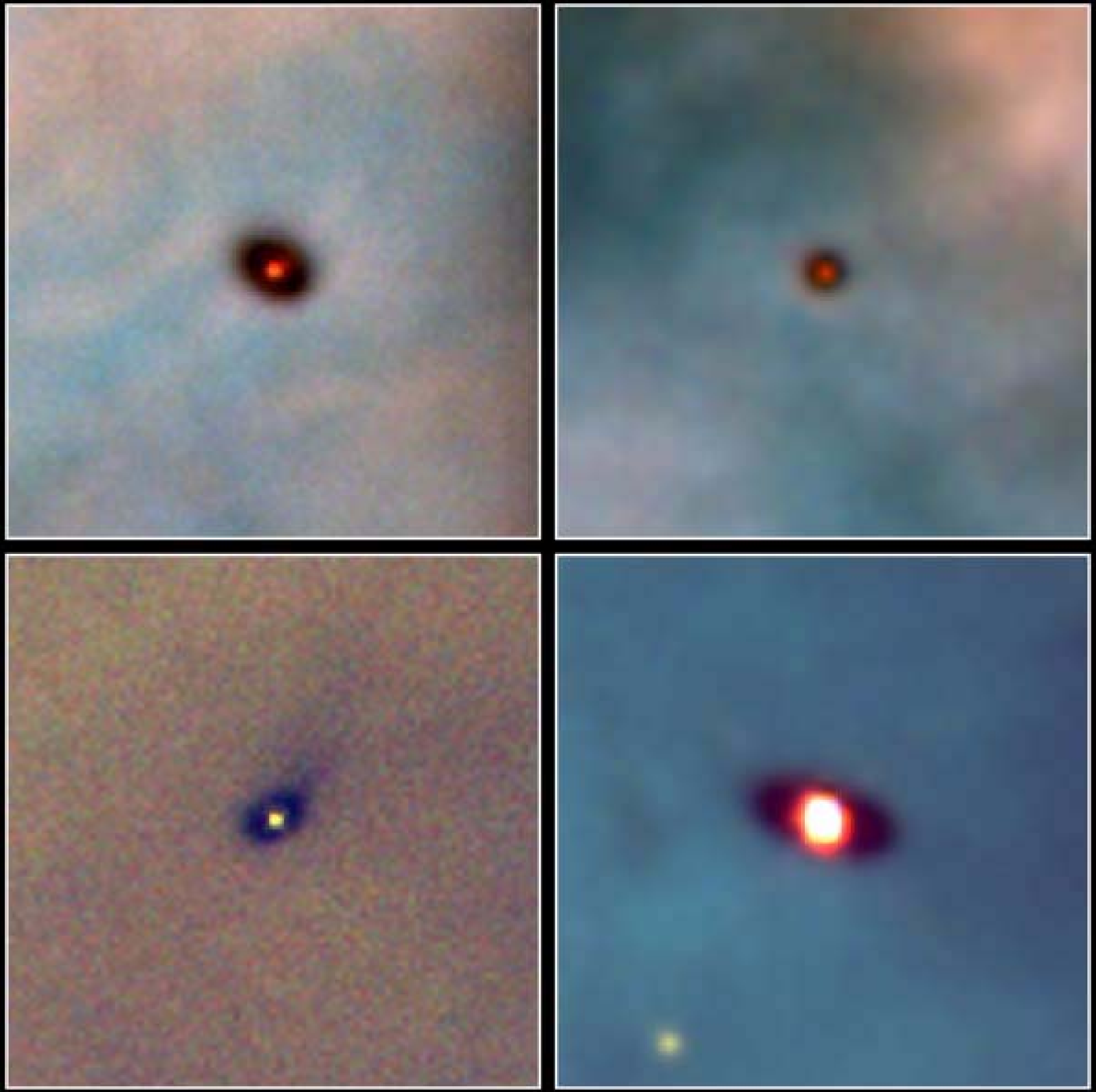
Lumps in the disk form planets



The Orion Nebula

The Orion Nebula

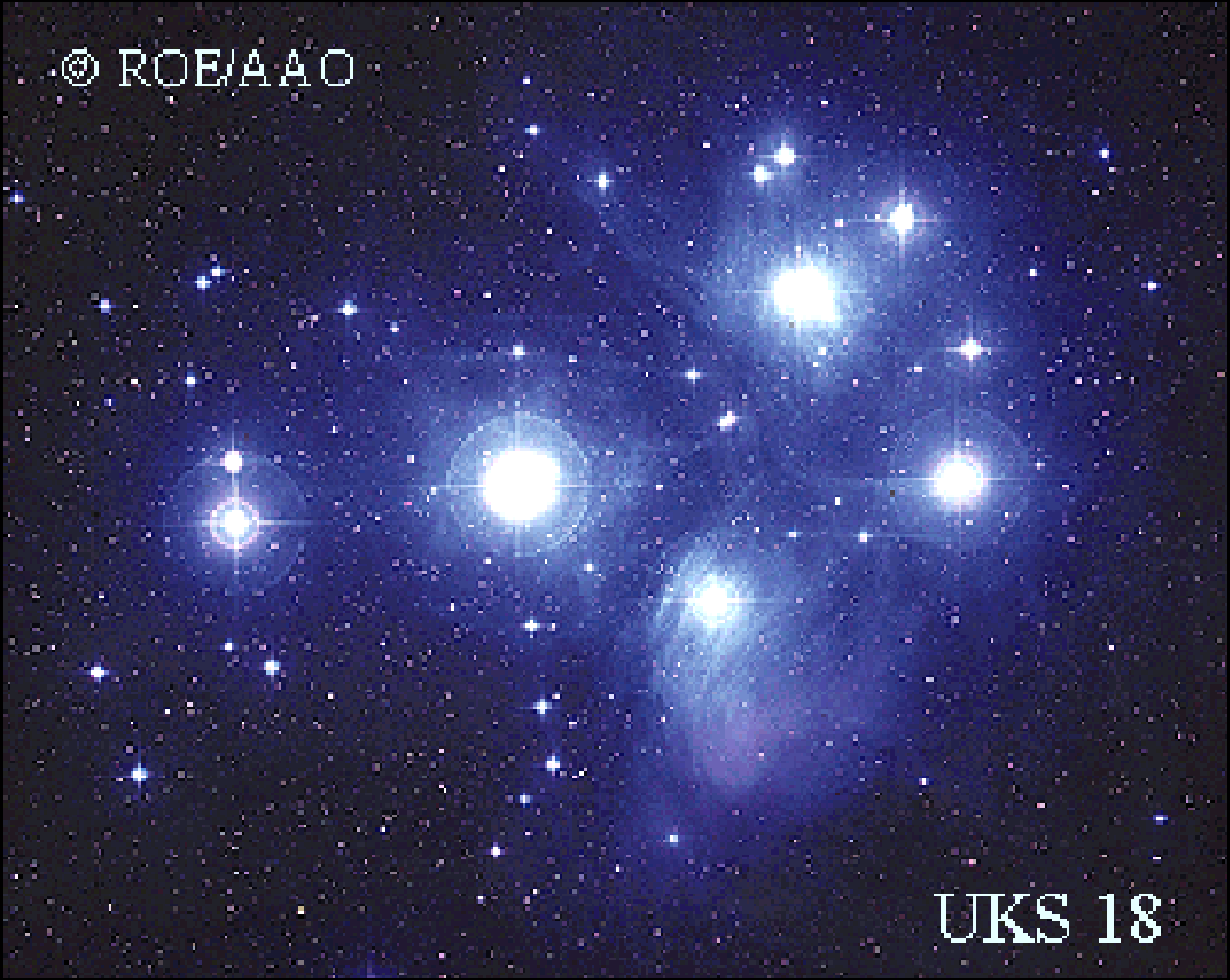




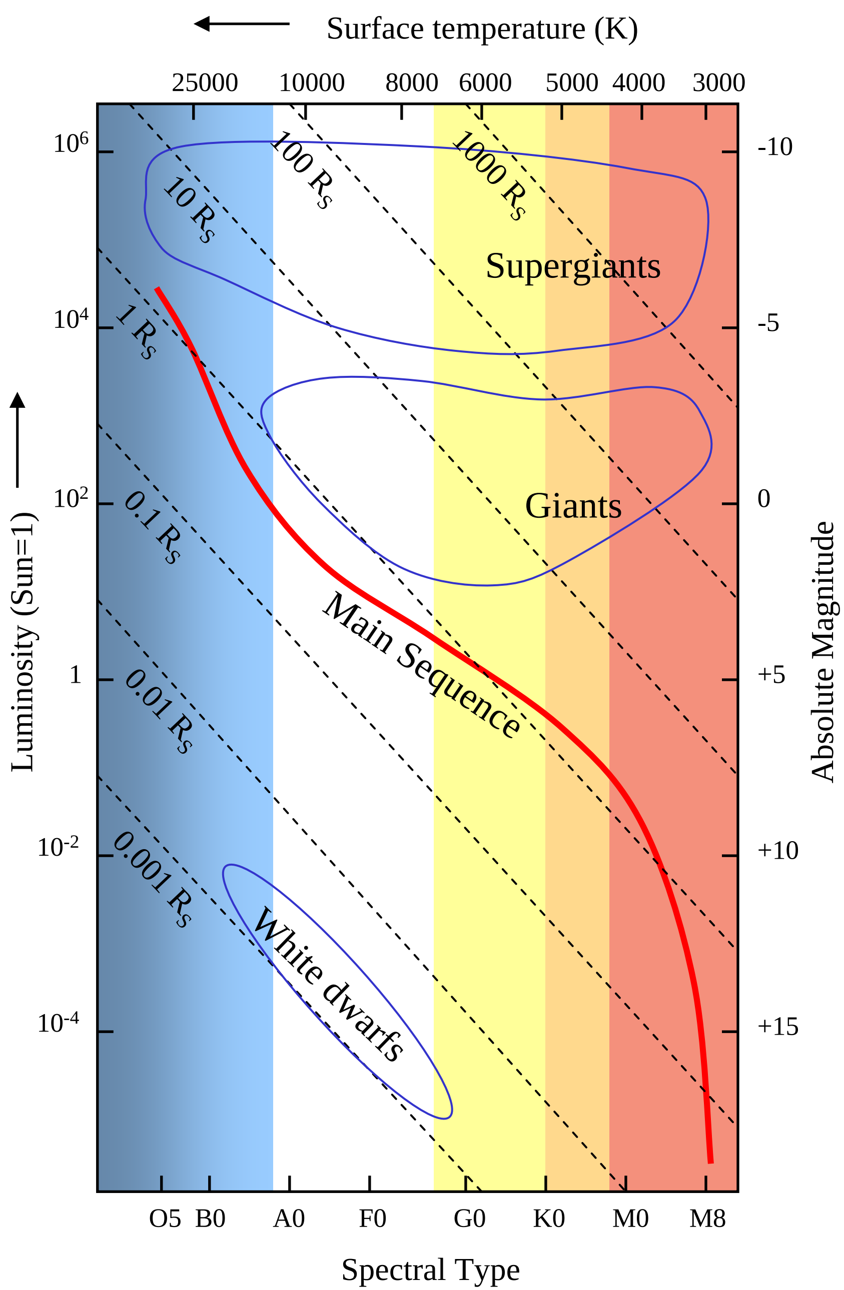
Protoplanetary Disks
Orion Nebula

HST • WFPC2

PRC95-45b • ST ScI OPO • November 20, 1995
M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA

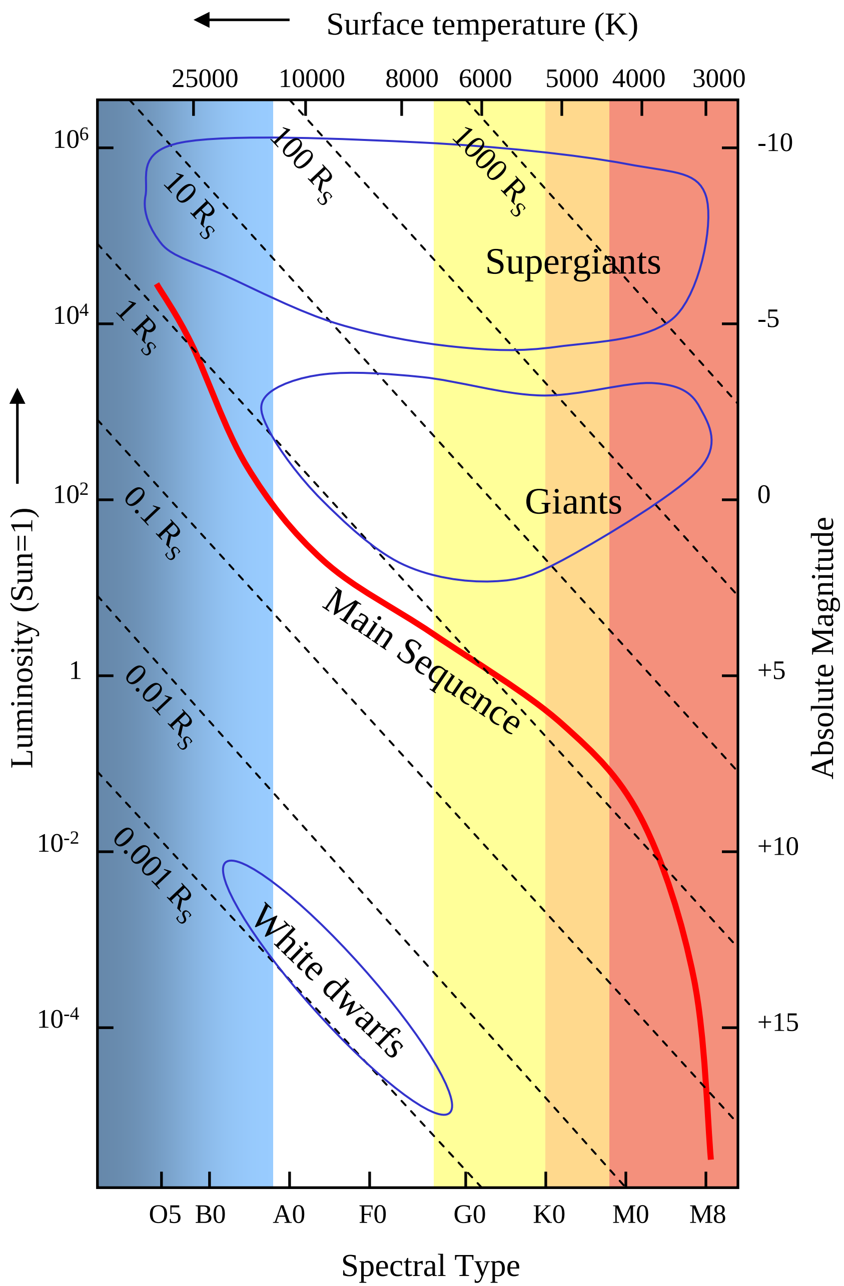


© ROE/AAO
UKS 18



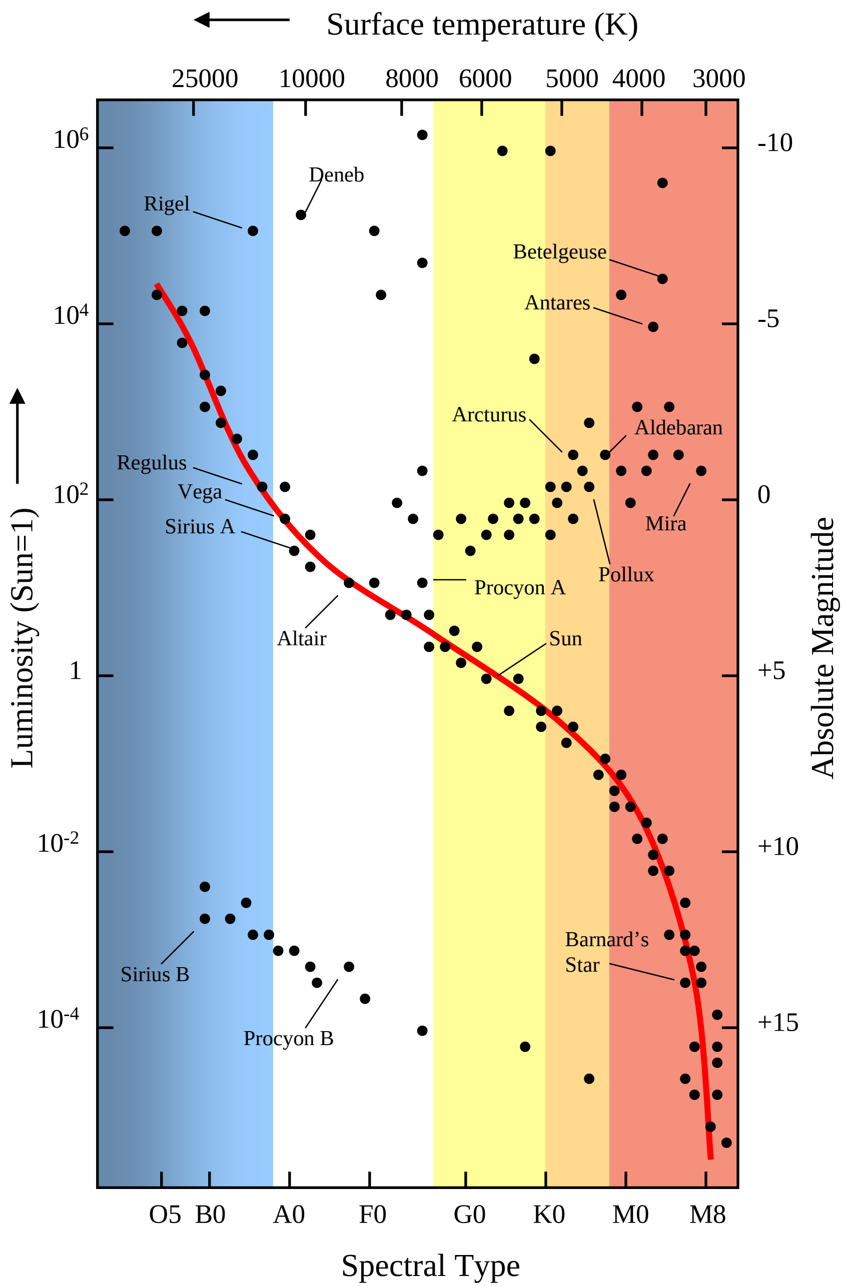
We can plot the **temperature** and **luminosity** of stars on a diagram

Stars don't appear *everywhere*: they group together, and most are found on the **Main Sequence**



Stars found on the **Main Sequence** convert hydrogen into helium.

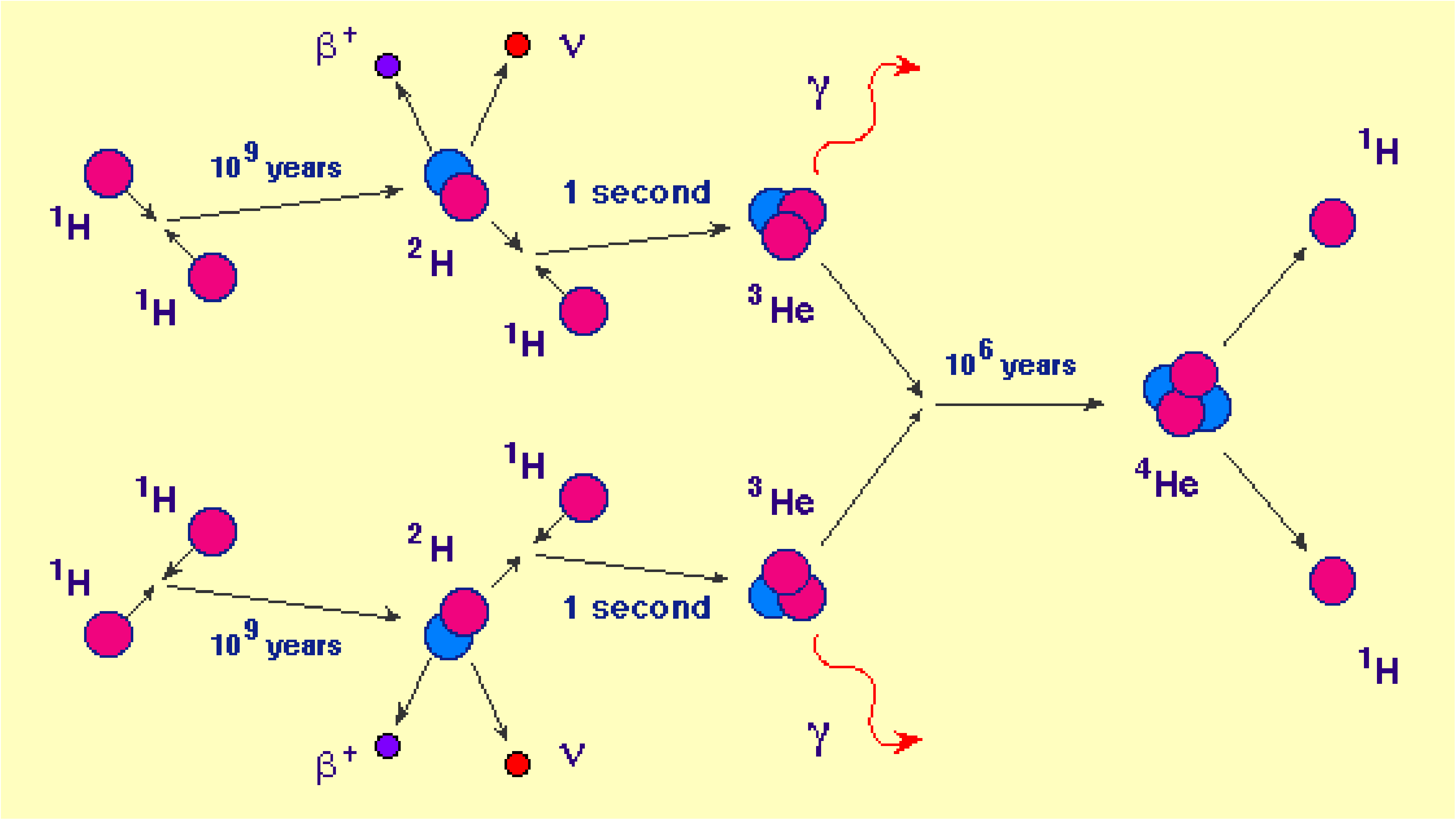
Stars like the Sun can do this for many billions of years, using the **P-P chain** of nuclear reactions

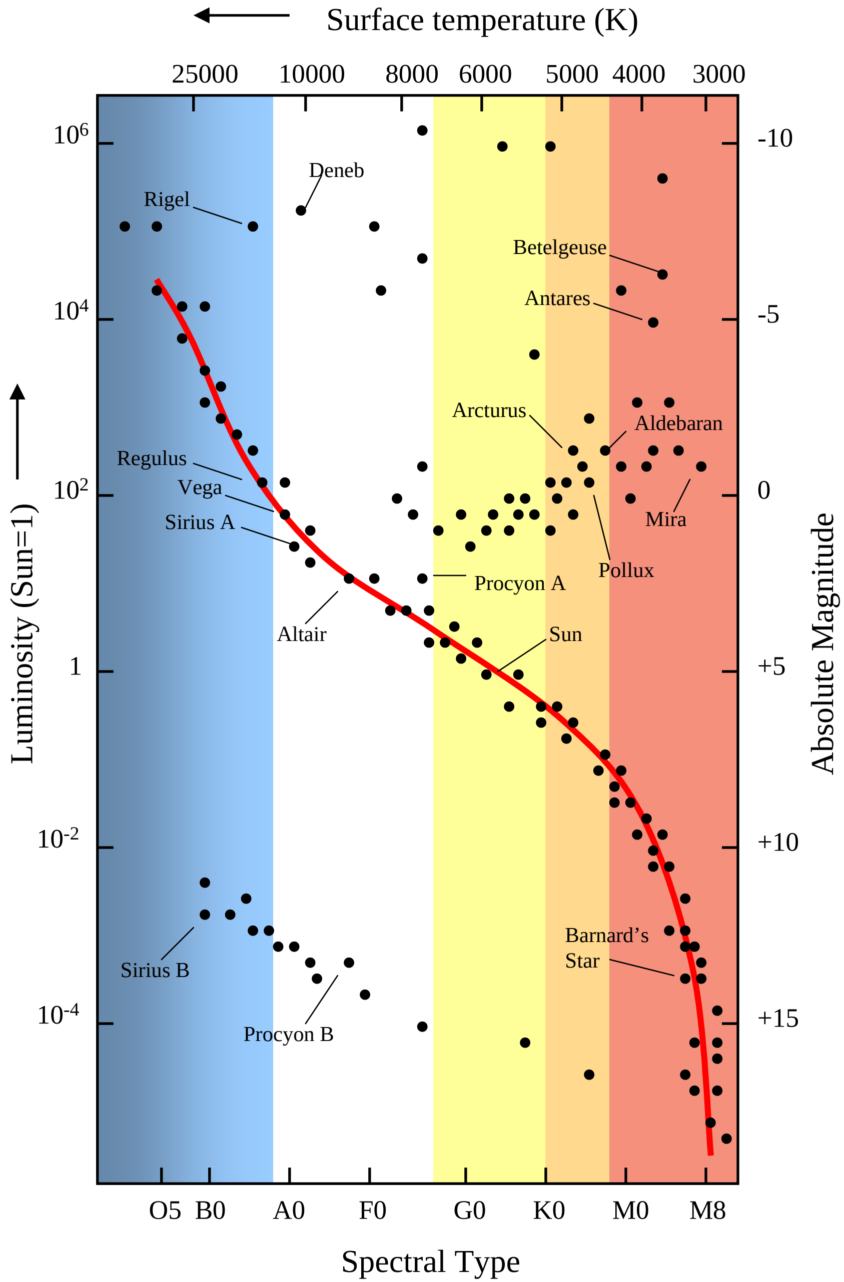


Stars found on the **Main Sequence** convert hydrogen into helium.

Stars like the Sun can do this for many billions of years, using the **P-P chain** of nuclear reactions

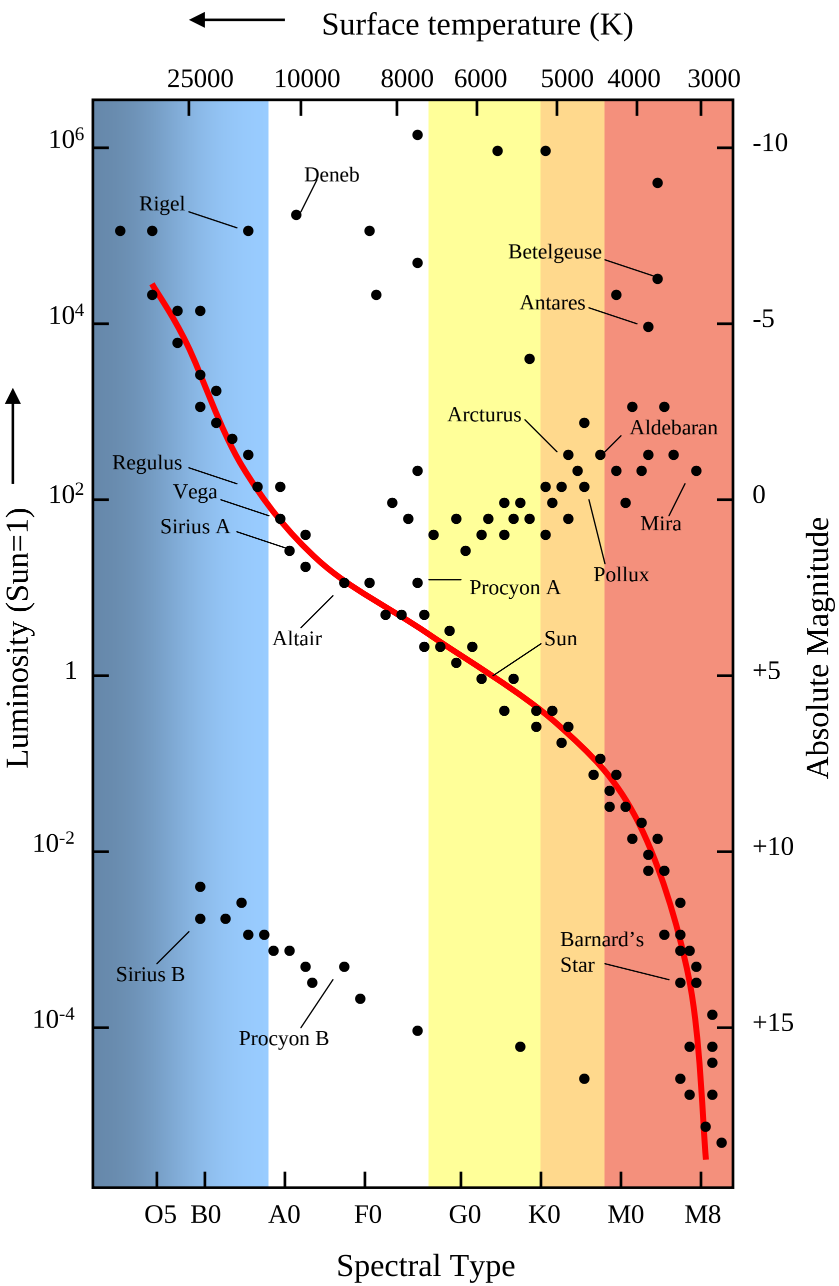
The P-P chain: converting hydrogen to helium





Stars found on the **Main Sequence** convert hydrogen into helium.

Hotter stars burn their hydrogen much faster, via the **CNO Cycle**

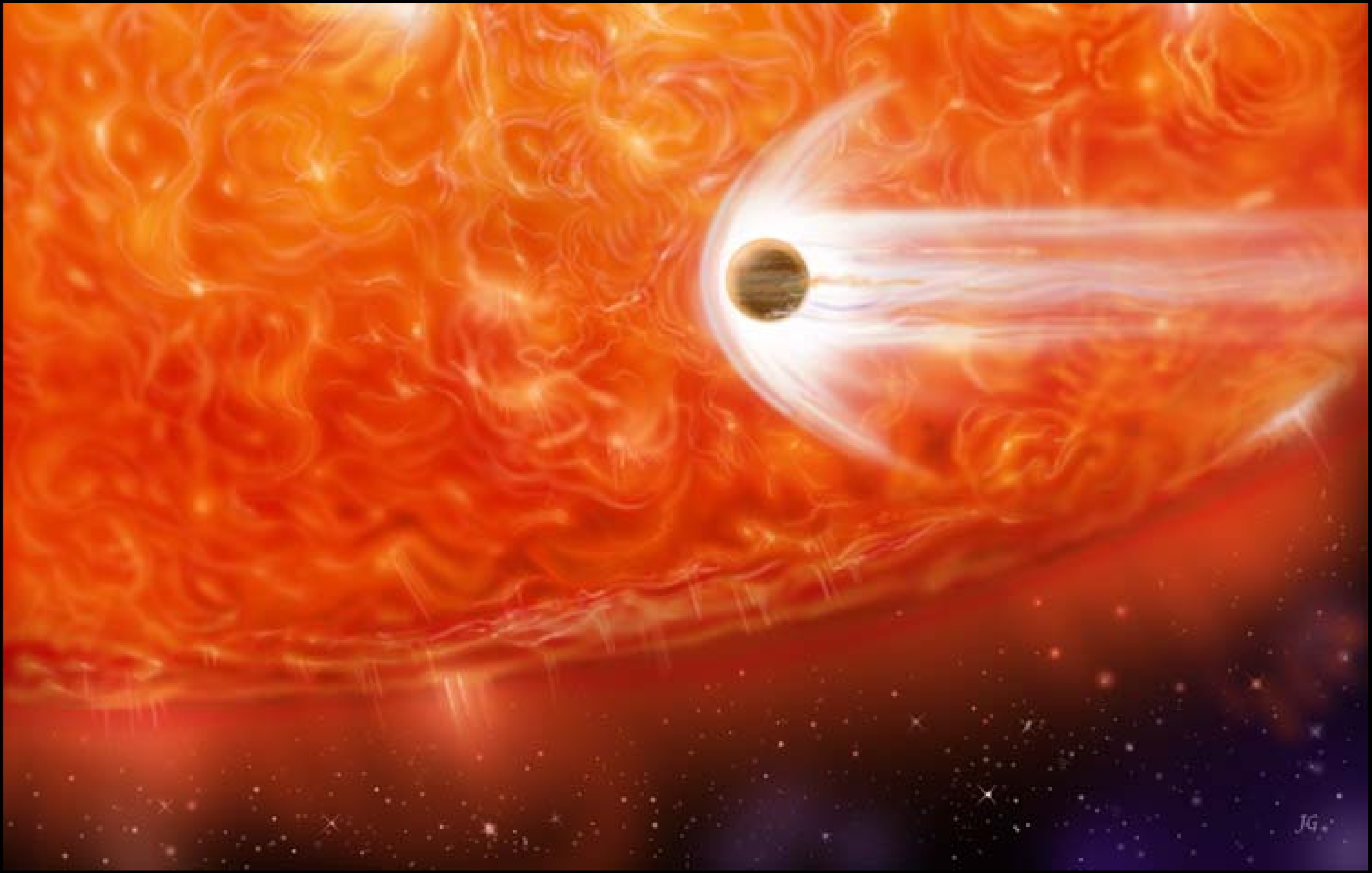


Stars on the **Main Sequence** turn hydrogen into helium.

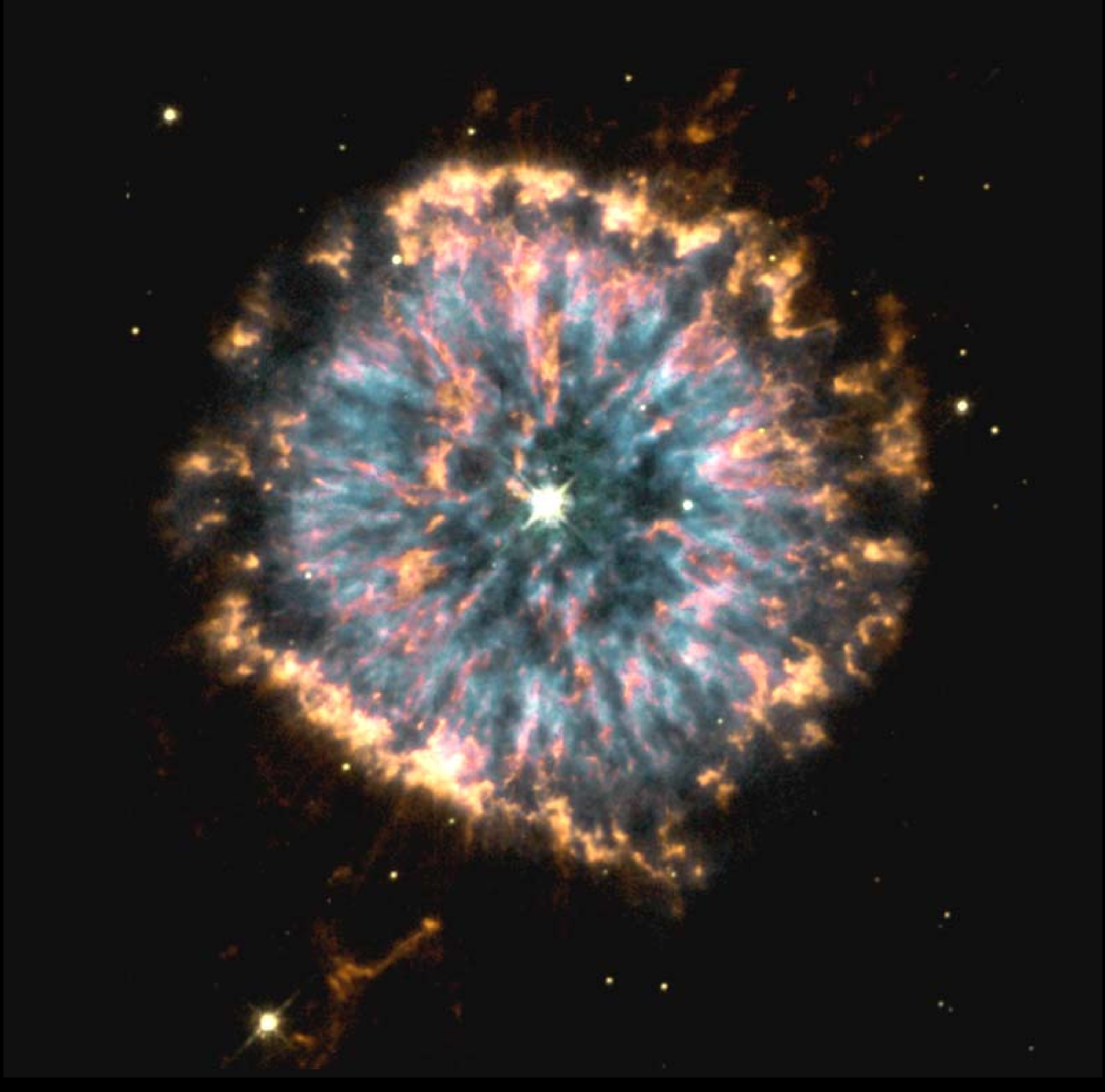
Blue stars are much hotter than the Sun, and use up their hydrogen in a few million years


© Mark A. Garlick
space-art.co.uk

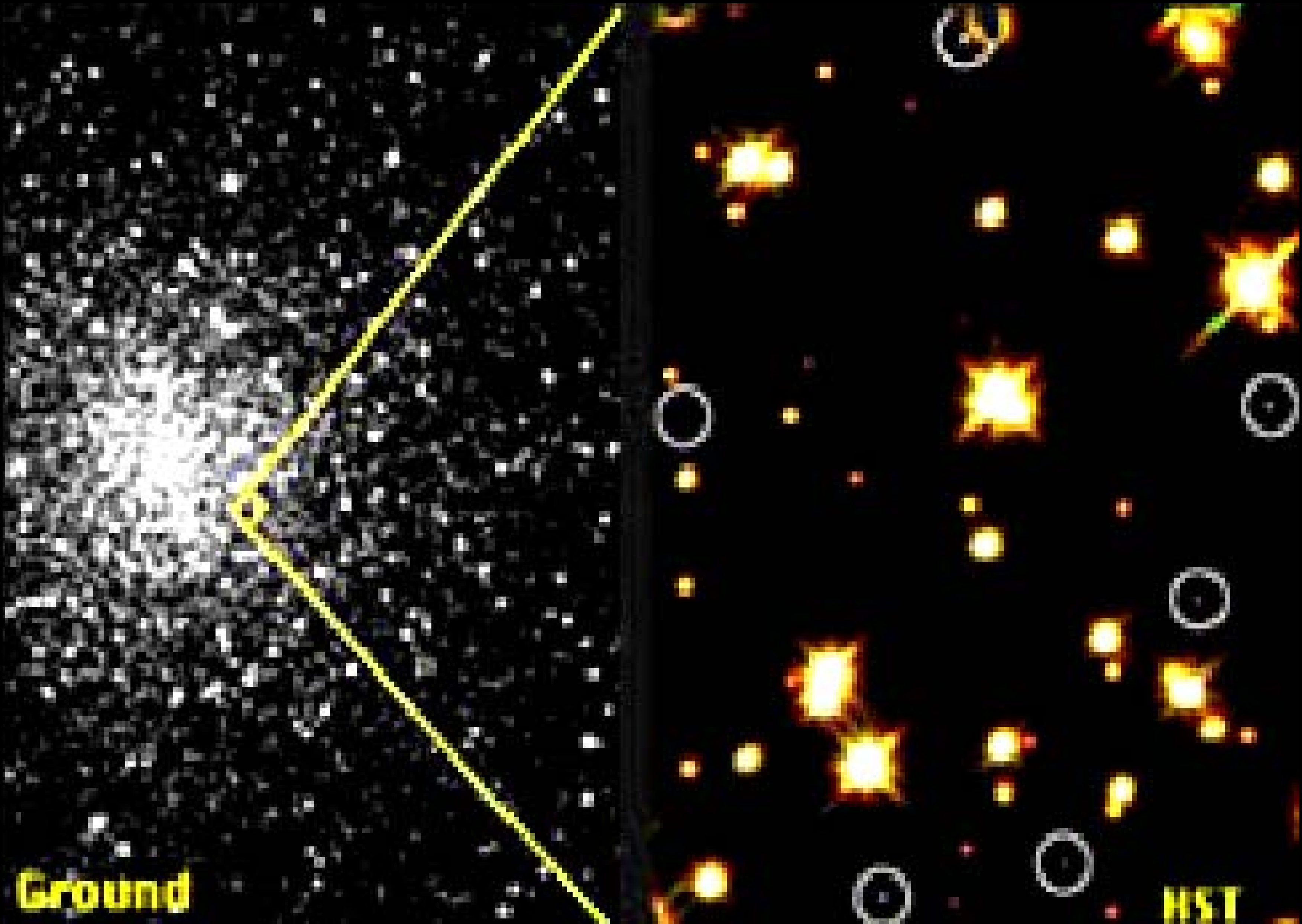
When the fuel runs out: formation of a red giant



Planetary Nebula NGC 6751

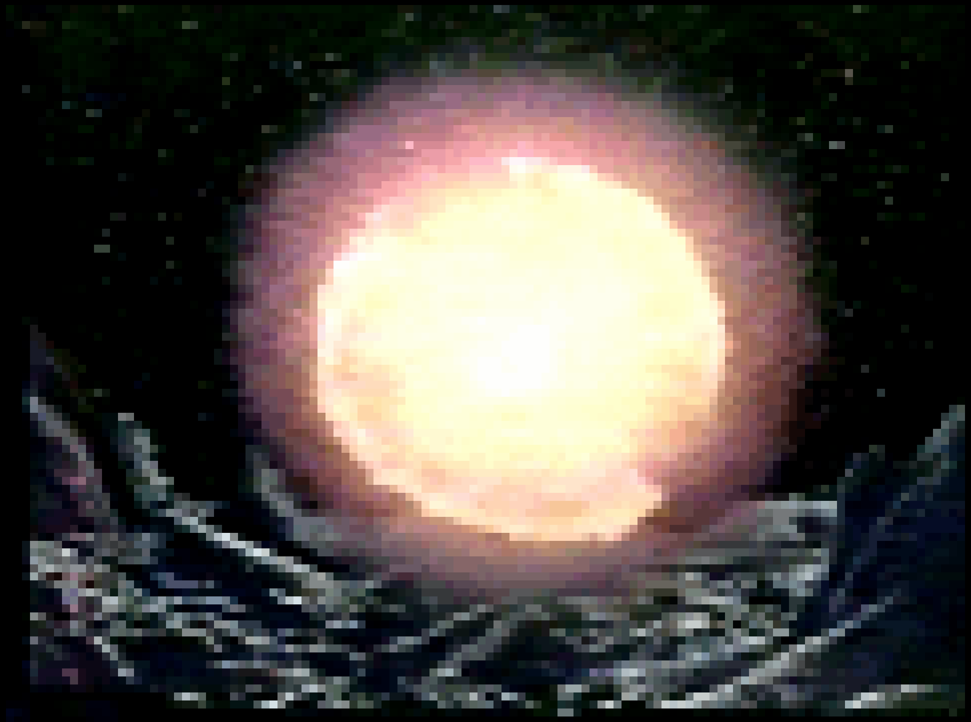


White dwarfs: earth-sized stellar relics



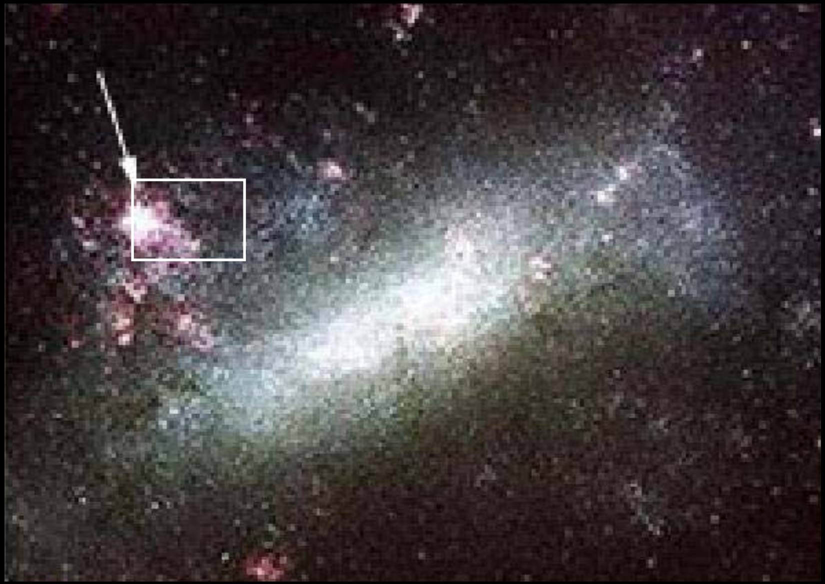
Interior of a very massive star

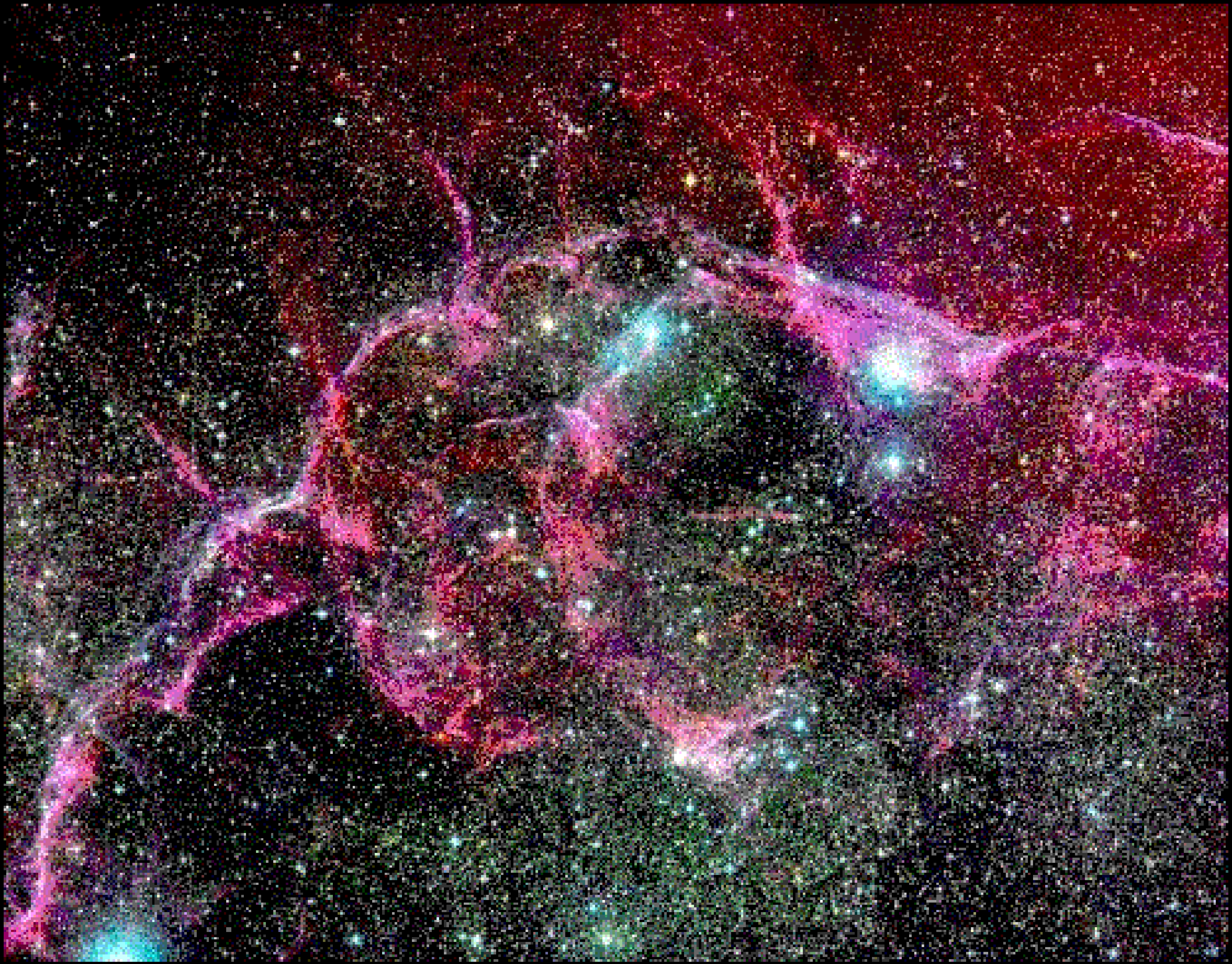
Supernova



Crab Nebula: supernova of 1054

Supernova 1987A, in the Large Magellanic Cloud





Supernovae

Putting the Iron in ***Irn Bru***

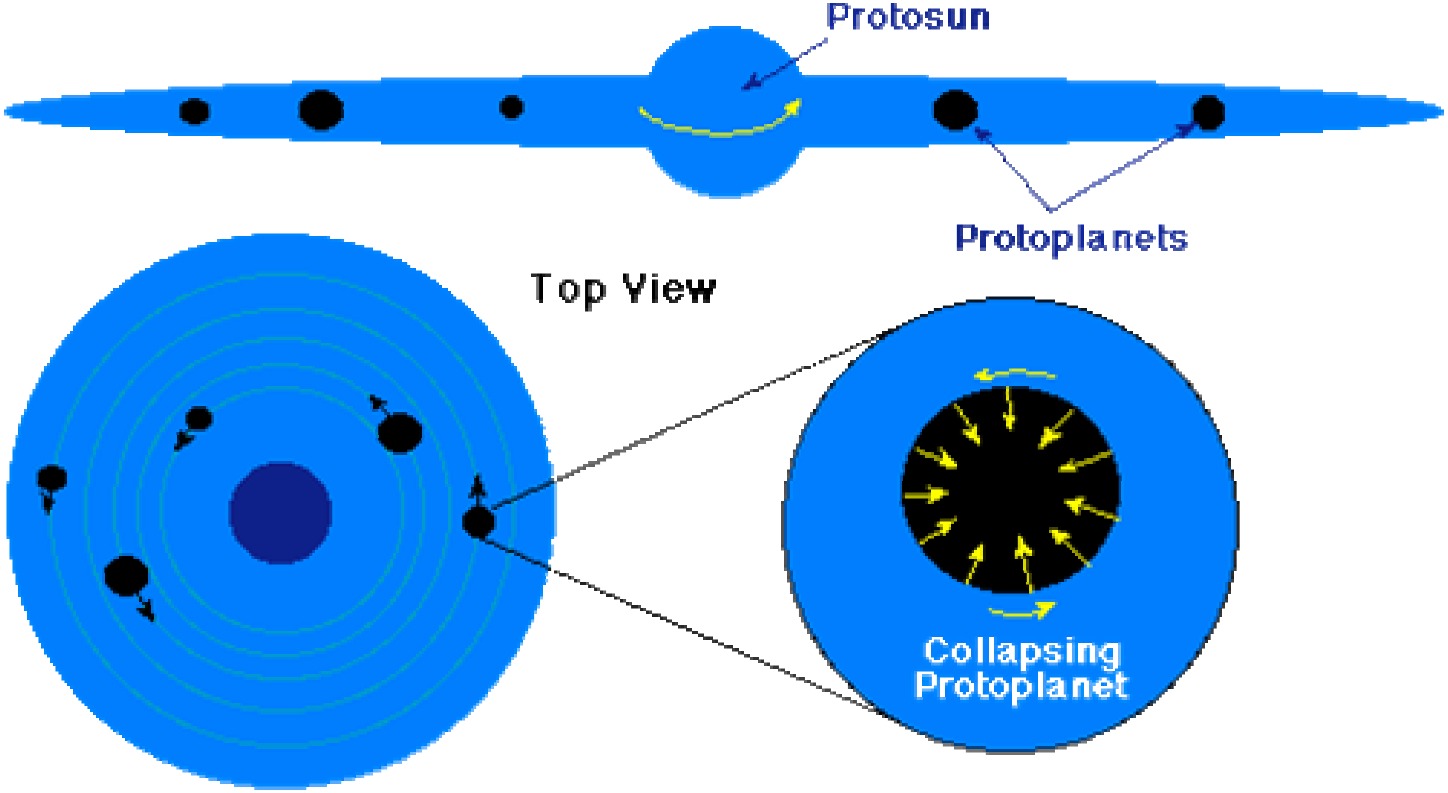
Forming stars and planets….

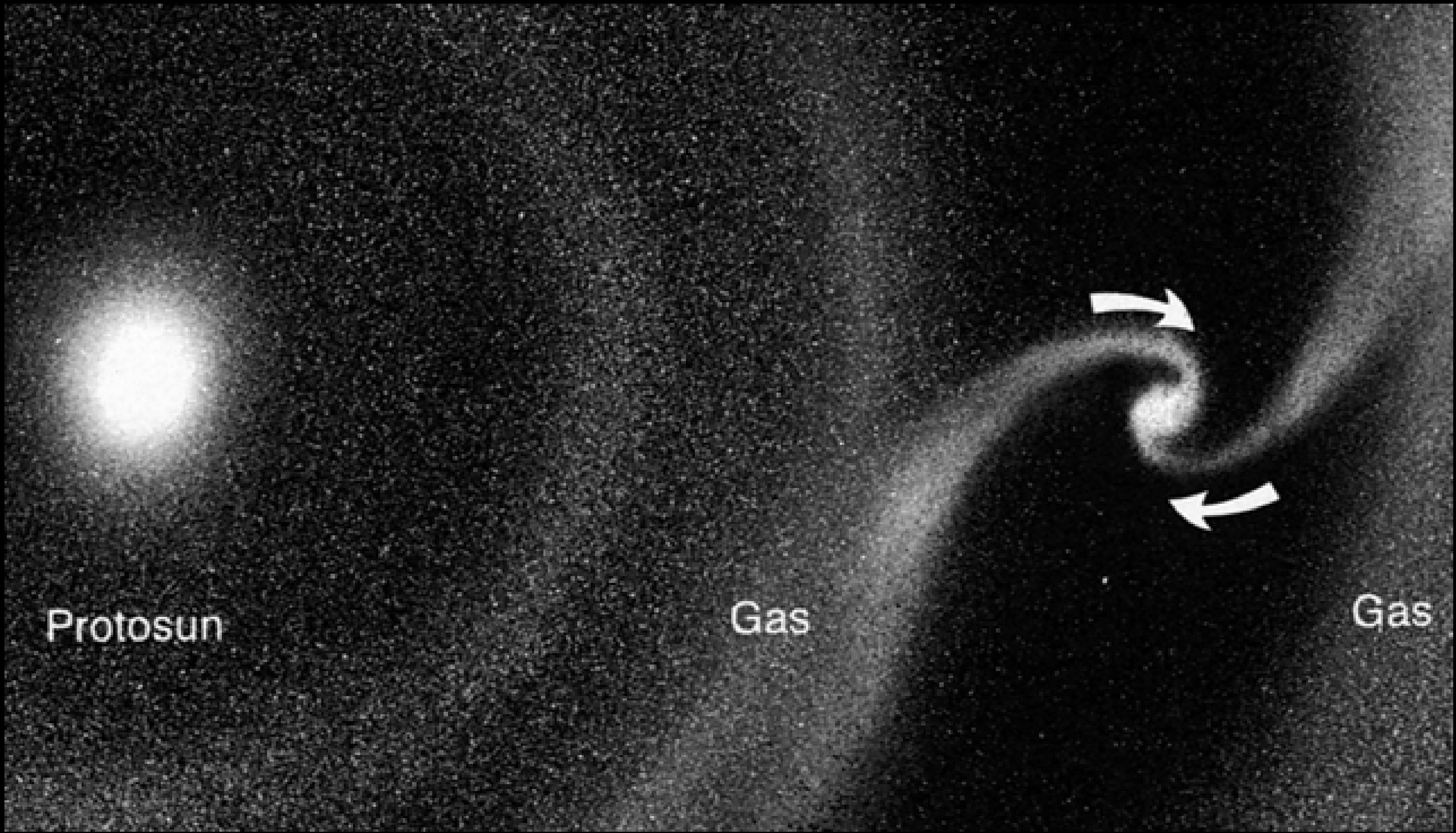
Pressure

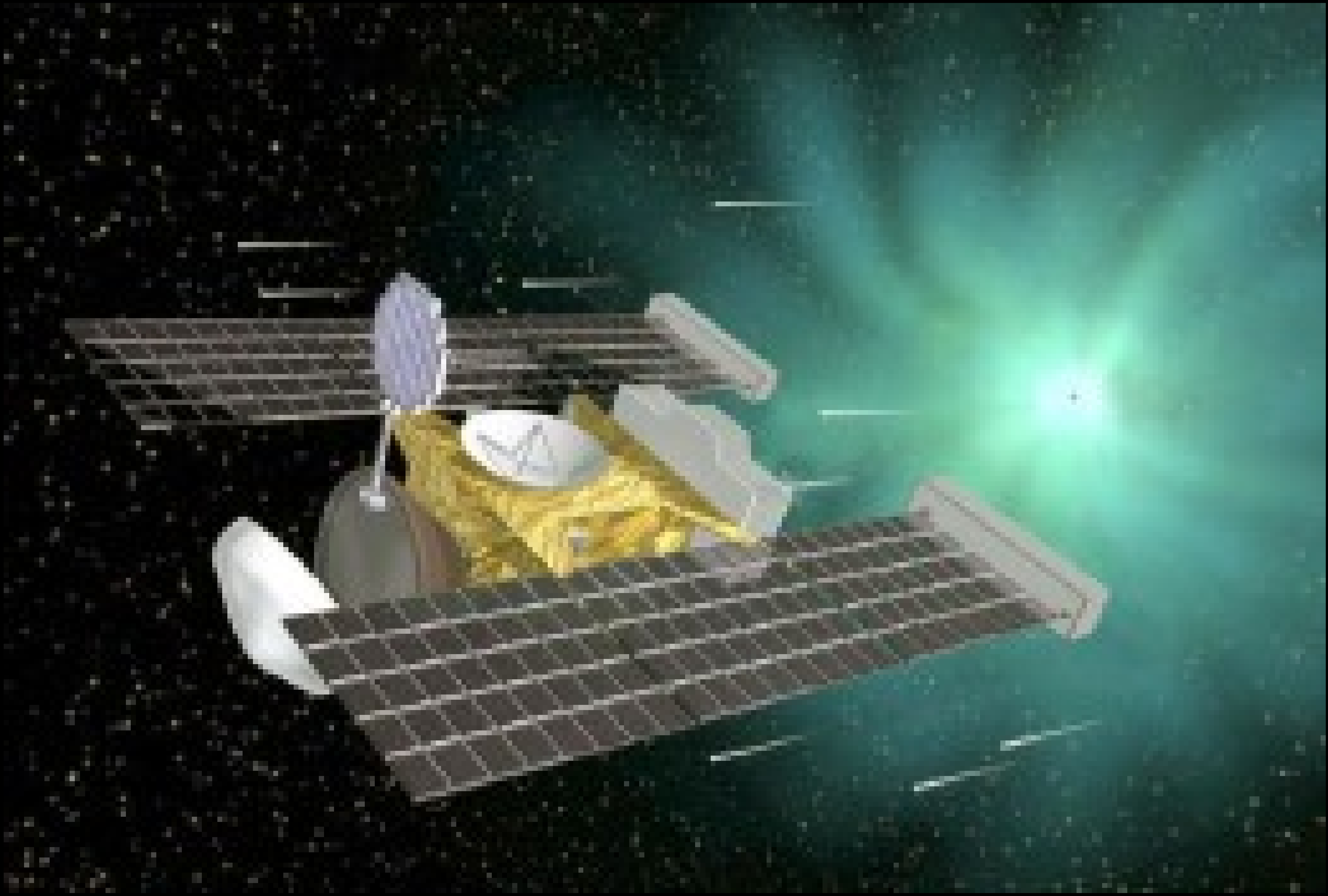
versus

Gravity

Lumps in the disk form planets




Protosun
Gas
Gas



+ SCIENCE OVERVIEW
+ WHY COMET WILD 2?
+ EVERYTHING ABOUT COMETS
+ CURATION FACILITY
– SCIENCE-IN-DEPTH
+ INTERSTELLAR DUST

STARDUST: SCIENCE IN-DEPTH

Comet Coma Sample Return Plus Interstellar Dust, Science and Technical Approach

Oct 21, 1994

by Donald E. Brownlee, Principal Investigator, University of Washington, Peter Tsou, Benton C. Clark, Paul N. Swanson, and Joseph Vellinga.

Jet Propulsion Laboratory
California Institute of Technology

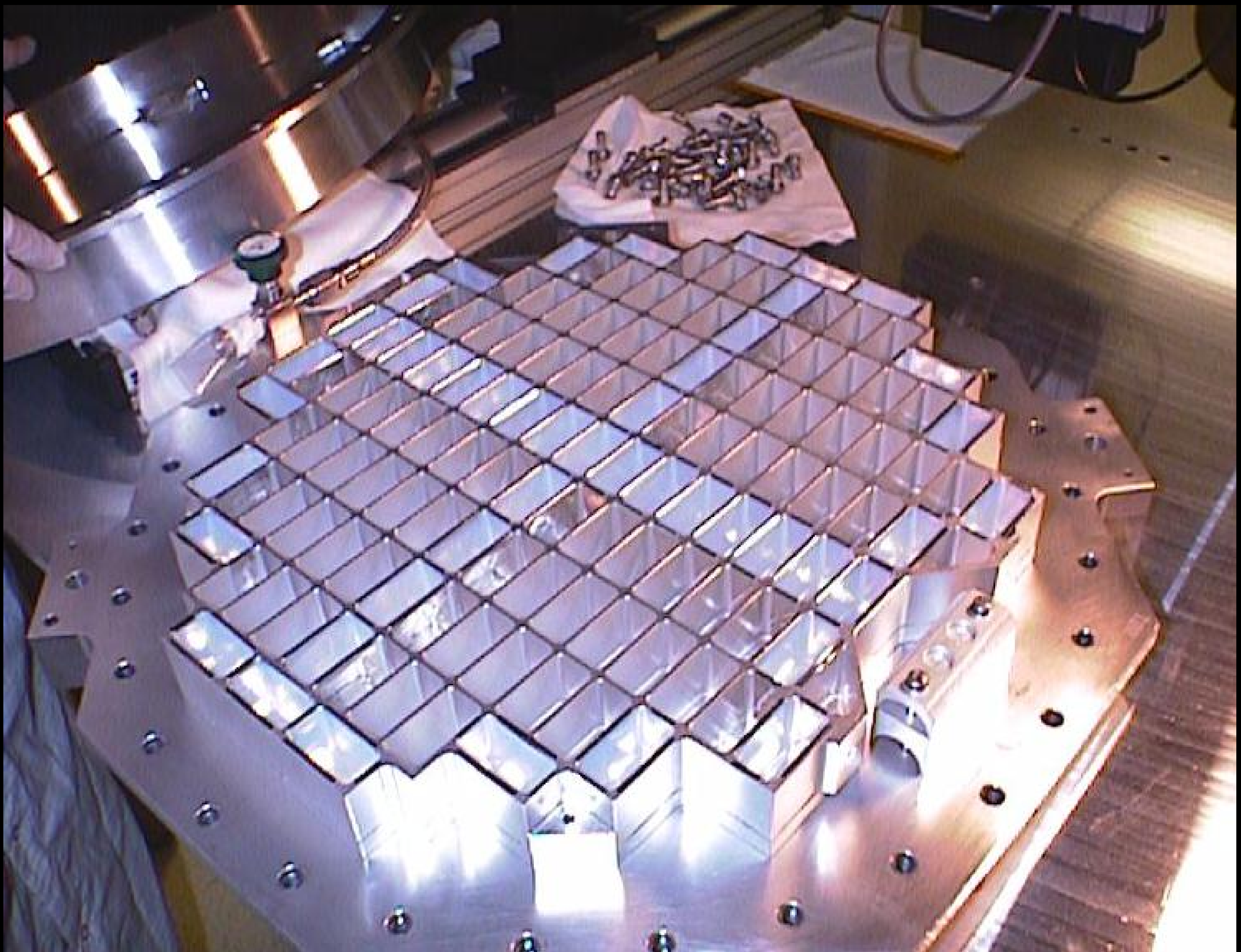
+ View the NASA Portal

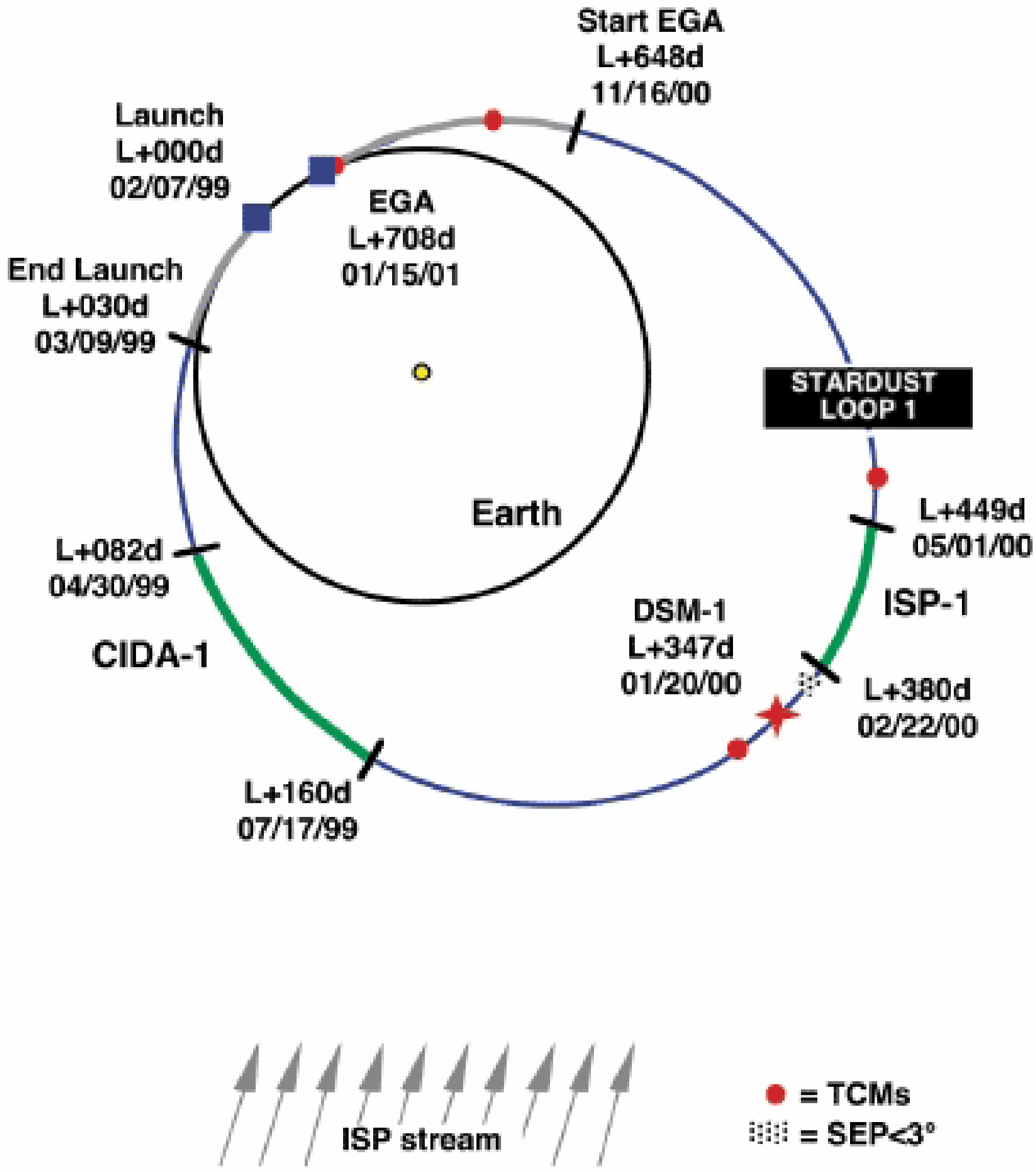
Search Stardust

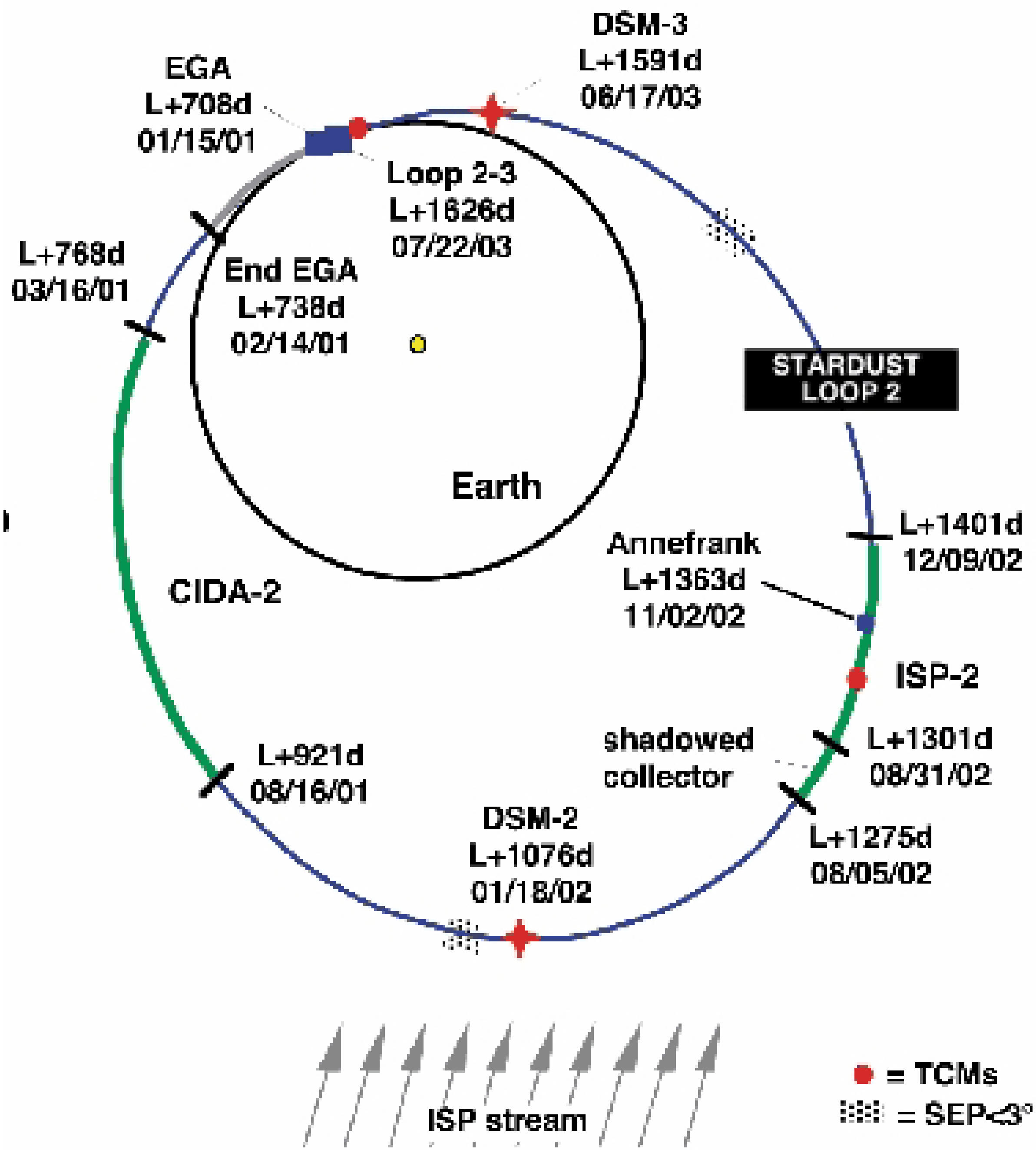
JPL HOME | EARTH | SOLAR SYSTEM | STARS & GALAXIES | TECHNOLOGY

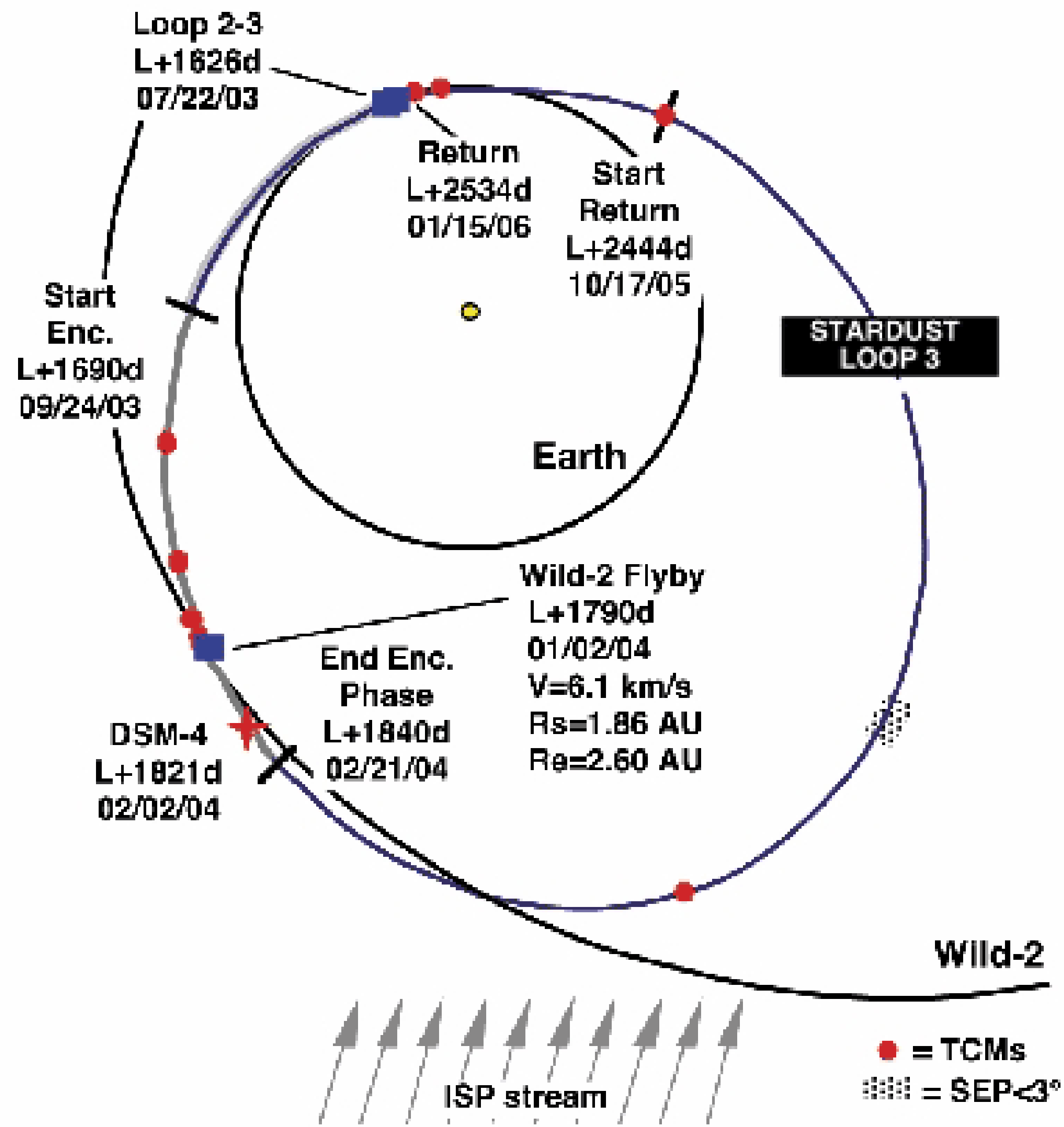
It will be possible to determine:

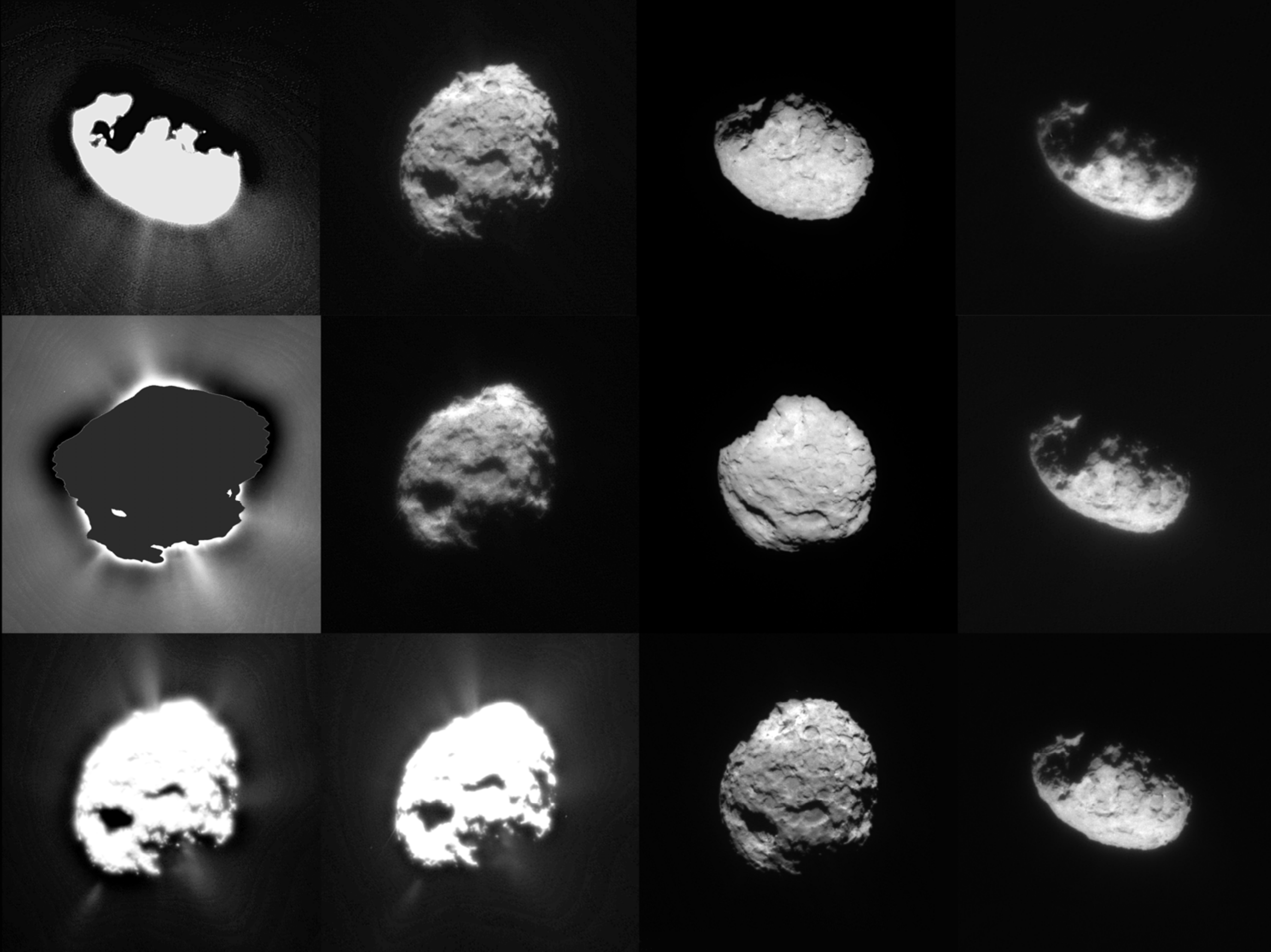
1. the elemental composition of the grains;
2. the isotopic composition of several important elements, such as C, H, Mg, Si, and O;
3. the mineralogical and textural character of surviving phases;
4. whether all IS grains are isotopically anomalous,
5. the mineralogy of the silicate grains - whether glassy or crystalline, as well as their Si:O ratio;
6. the prevalence of graphite particles, including whether their abundance is sufficient to explain the IS 0.22 micron extinction bump;
7. the extent of physical mixing of the mineral phases, including whether the grains have a silicate core/organic refractory mantle structure, and also if they are a heterogeneous mixture or not, and
8. whether there is any evidence for grain processing in the ISM, especially whether the effects of shock sputtering, collisions, accretion and chemical alteration can be identified.




Start EGA
L+648d
11/16/00
Launch
L+000d
02/07/99
EGA
L+708d
01/15/01
End Launch
L+030d
03/09/99
STARDUST
LOOP 1
L+449d
05/01/00
Earth
L+082d
04/30/99
ISP-1
DSM-1
L+347d
01/20/00
CIDA-1
L+380d
02/22/00
L+160d
07/17/99
ISP stream
= TCMs
= SEP<3°


DSM-3
L+1591d
06/17/03
EGA
L+708d
01/15/01
Loop 2-3
L+1626d
07/22/03
L+768d
03/16/01
End EGA
L+738d
02/14/01
STARDUST
LOOP 2
Earth
L+1401d
12/09/02
Annefrank
L+1363d
11/02/02
CIDA-2
ISP-2
shadowed
collector
L+1301d
08/31/02
L+921d
08/16/01
DSM-2
L+1076d
01/18/02
L+1275d
08/05/02
= TCMs
= SEP<3°
ISP stream


Loop 2-3
L+1626d
07/22/03
Return
L+2534d
01/15/06
Start
Return
L+2444d
10/17/05
STARDUST
LOOP 3
Start
Enc.
L+1690d
09/24/03
Earth
Wild-2 Flyby
L+1790d
01/02/04
V=6.1 km/s
Rs=1.86 AU
Re=2.60 AU
End Enc.
Phase
L+1840d
02/21/04
DSM-4
L+1821d
02/02/04
Wild-2
ISP stream
= TCMs
= SEP<3°



BACKGROUND

STARDUST@HOME

BACKGROUND | SCIENTIFIC MOTIVATION | THE CHALLENGE | PARTICIPATION | PROFESSIONAL RECOGNITION | PRE-REGISTRATION | FAQ

Stardust@Home: A distributed search by volunteers for interstellar dust in the Stardust interstellar dust collector

In January 2004, the Stardust spacecraft flew through the coma of comet Wild2 and captured thousands of cometary dust grains in special aerogel collectors. Two years later, in January 2006, Stardust will return these dust grains --- the first sample return from a solid solar-system body beyond the Moon --- to Earth. But Stardust carries an equally important payload on the opposite side of the cometary collector: the first samples of contemporary interstellar dust ever collected. As well as being the first mission to return samples from a comet, Stardust is the first sample return mission from the Galaxy. But finding the incredibly tiny interstellar dust impacts in the Stardust Interstellar Dust Collector (SIDC) will be extremely difficult.

We are seeking volunteers to help us to search for these tiny samples of matter from the galaxy. Volunteers are critical to the success of this project. Please help us find the first samples of contemporary Stardust ever collected.

SCIENTIFIC MOTIVATION

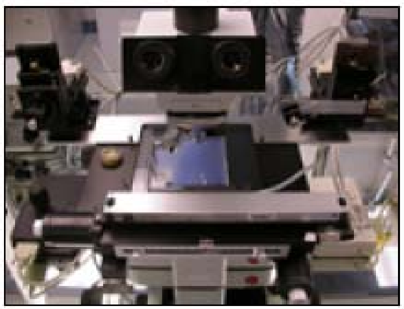
STARDUST@HOME

"We are Stardust..."
Joni Mitchell, *Woodstock*

The scientific importance of these first solid samples from our Galaxy can't be overstated. Interstellar dust and gas were the building blocks of our solar system, the Earth, and all living things, including people. We are truly made of stardust. But we don't know what the typical interstellar dust grain looks like. **Not even one contemporary interstellar dust grain has ever been studied in the laboratory!** In January 2006, the Stardust spacecraft will return to Earth, for the first time, a few dozen precious contemporary interstellar dust grains. We are extremely excited about the prospect of directly studying contemporary interstellar dust for the first time.

PARTICIPATION

STARDUST@HOME



The only way that we can think of to find these exciting interstellar dust grains is to recruit talented volunteers to help us search. First, you will go through a web-based training session. This is not for everyone: you must pass a test to qualify to register to participate. After passing the test and registering, you will be able to download a virtual microscope (VM). The VM will automatically connect to our server and download so-called "focus movies" -- stacks of images that we will collect from the Stardust Interstellar Dust Collector using an automated microscope at the Cosmic Dust Lab at Johnson Space Center. The VM will work on your computer, under your control. You will search each field for interstellar dust impacts by focusing up and down with a focus control.

The more focus movies you examine, the better the chances are that you'll find an interstellar dust grain. But we have no minimum expectation -- you should search through focus movies as long as you're having fun doing it. Just remember that you are looking at the first collector that has gone into deep space and come back. This is a very special opportunity!

Stardust Timeline

Past Milestones

- **7 Feb 1999** Stardust successfully launched
- **Feb-May 2000** First IS dust collection
- **Aug-Dec 2002** Second IS dust collection
- **2 Jan 2004** Stardust successfully passes through comet Wild-2

Upcoming Events

- **15 Jan 2006** Stardust recovery
- **15 Feb 2006** Begin scanning Stardust IS dust collector
- **1 Mar 2006** First image data available for searching
- **1 Oct 2006** Estimated completion date of search

http://www.stardustathome.ssl.berkeley.edu/