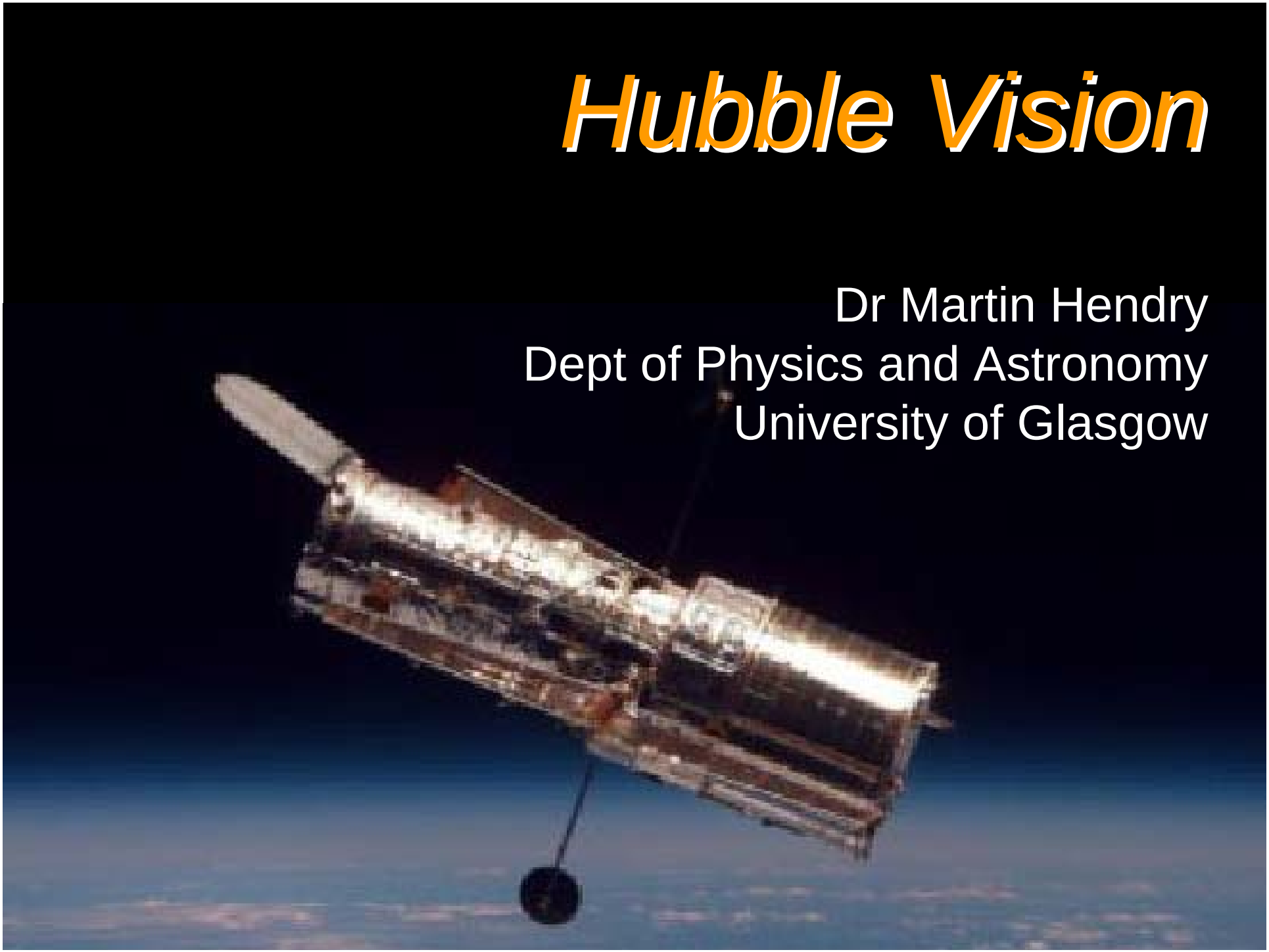
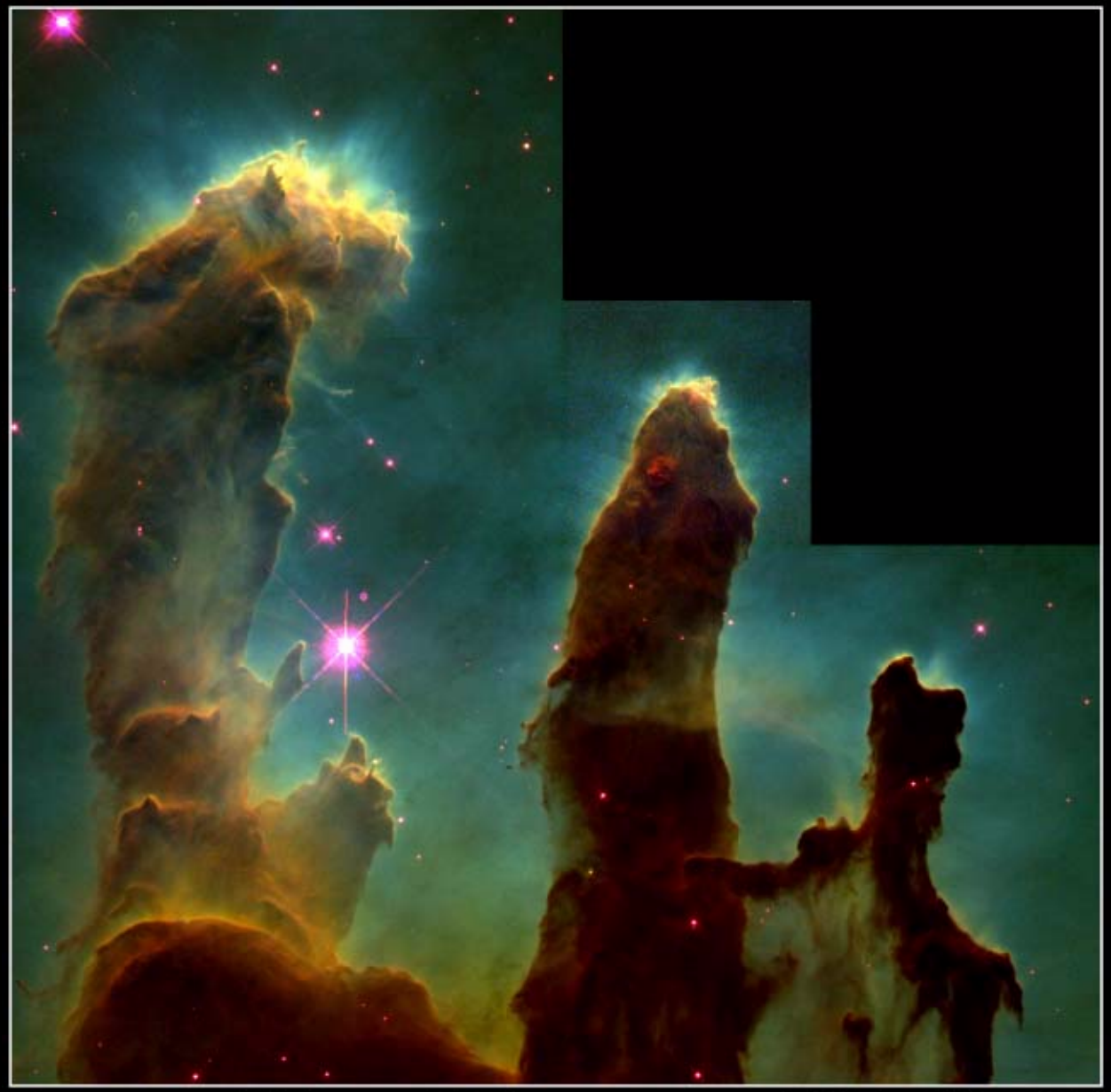
Hubble Vision

Dr Martin Hendry
Dept of Physics and Astronomy
University of Glasgow





Gaseous Pillars · M16 HST · WFPC2

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

Hubble Vision:

The Legacy of the Hubble Space Telescope

10 meetings, beginning 12/01/08

Course Coordinator

Dr Martin Hendry, martin@astro.gla.ac.uk Tel: 0141 330 5685

Course Aims

To review the scientific legacy of the Hubble Space Telescope, investigating some of the key discoveries made by HST during the telescope's 18 years of operation.

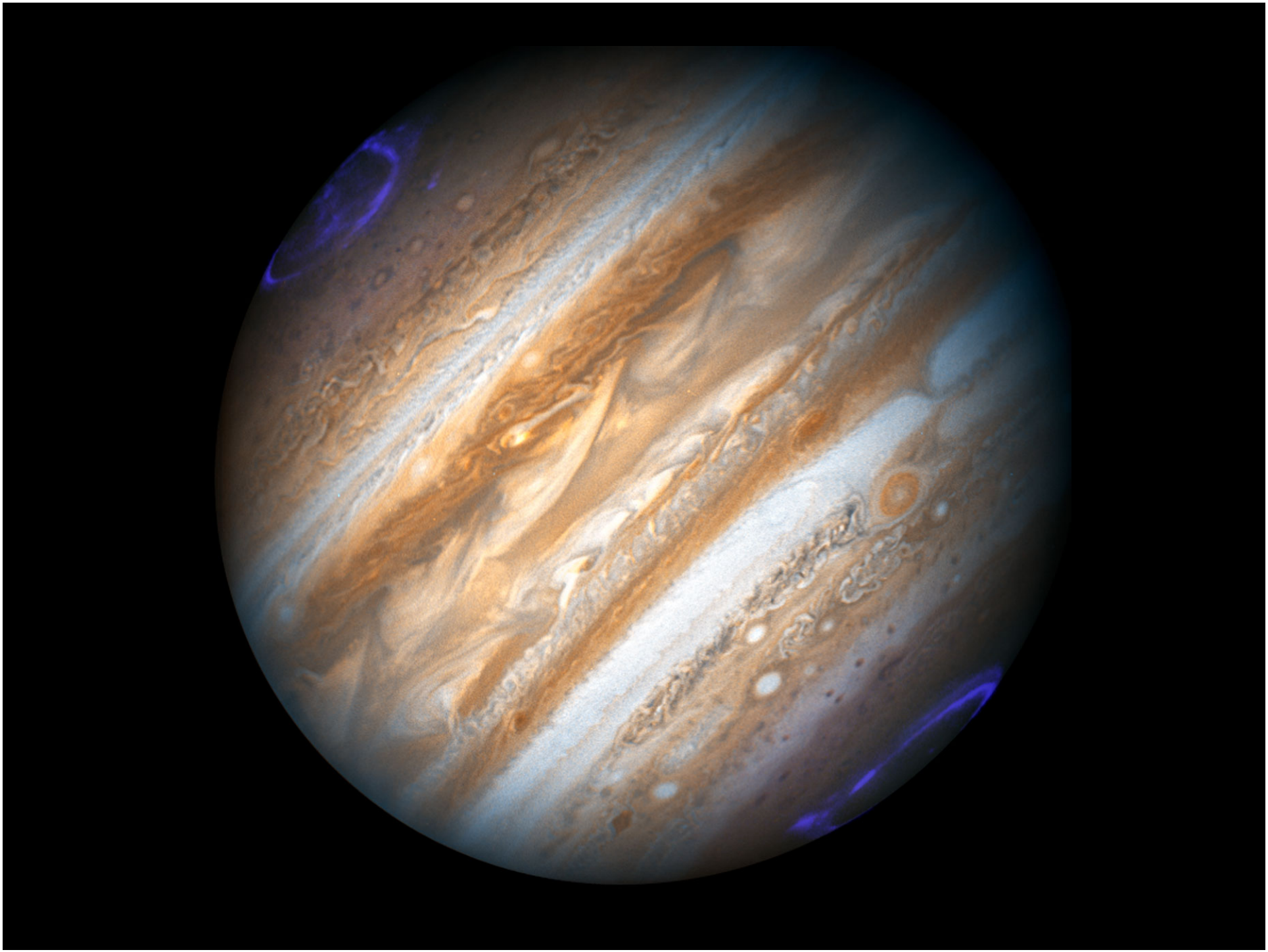
Hubble Vision:

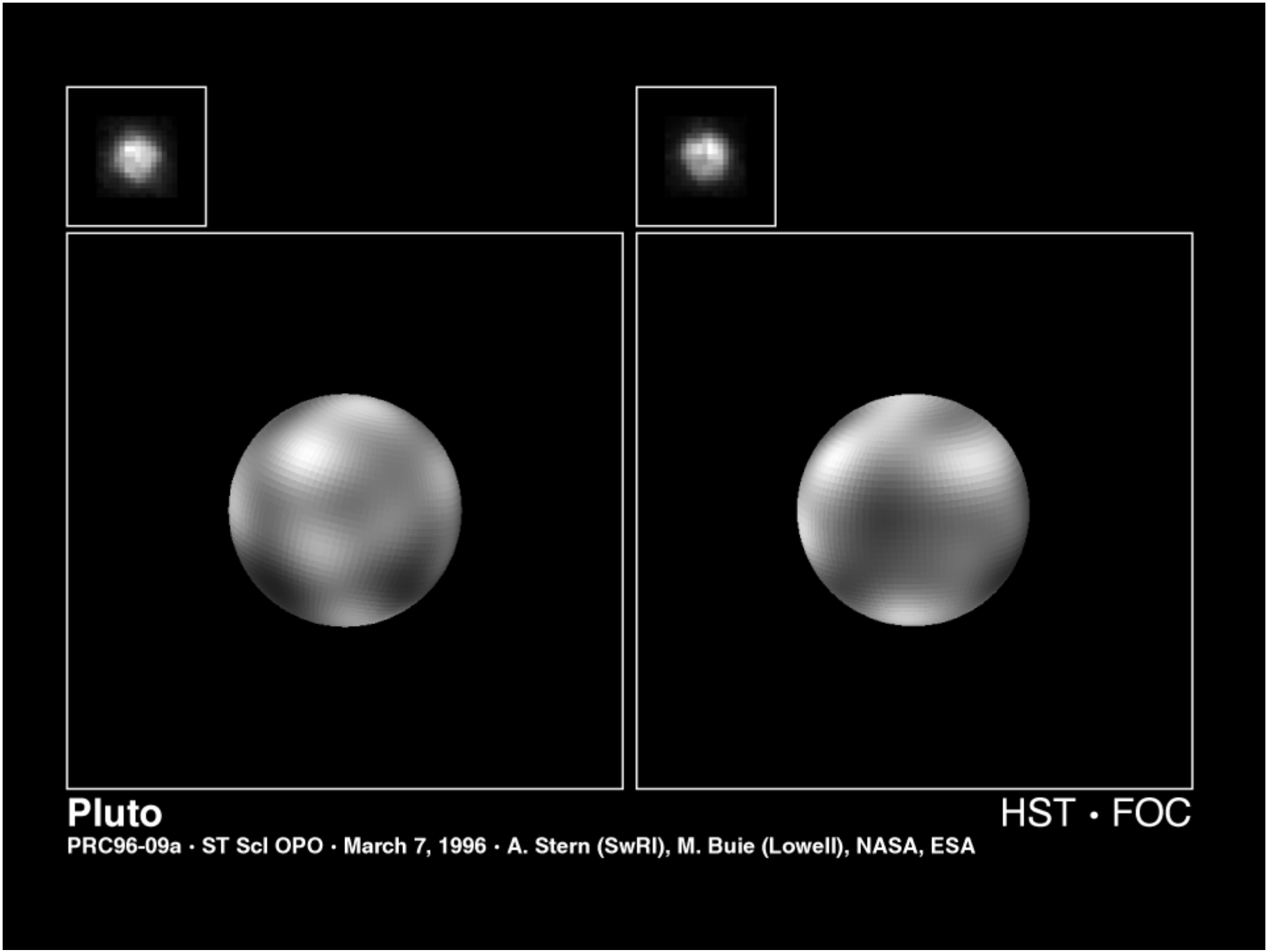
The Legacy of the Hubble Space Telescope

Intended learning outcomes

At the end of the course students should have an appreciation of:

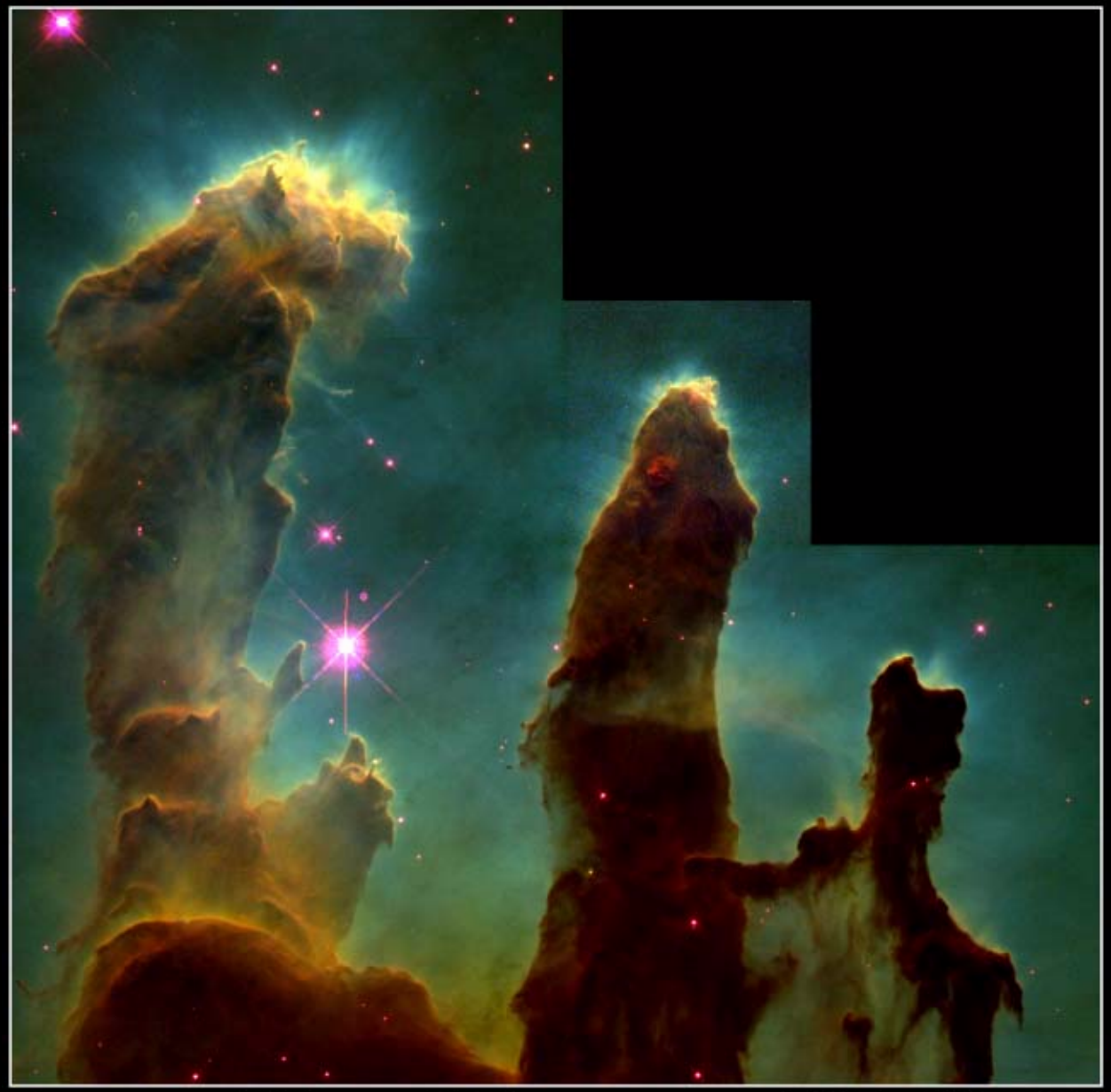
- why placing a large optical telescope above the Earth's atmosphere has had a dramatic impact on astronomy
- some of the HST "Key Projects" and the big questions they addressed
- how the scientific legacy of HST sits alongside recent discoveries made by other telescopes and satellites
- how the next generation of space telescopes will extend and enhance the legacy of HST





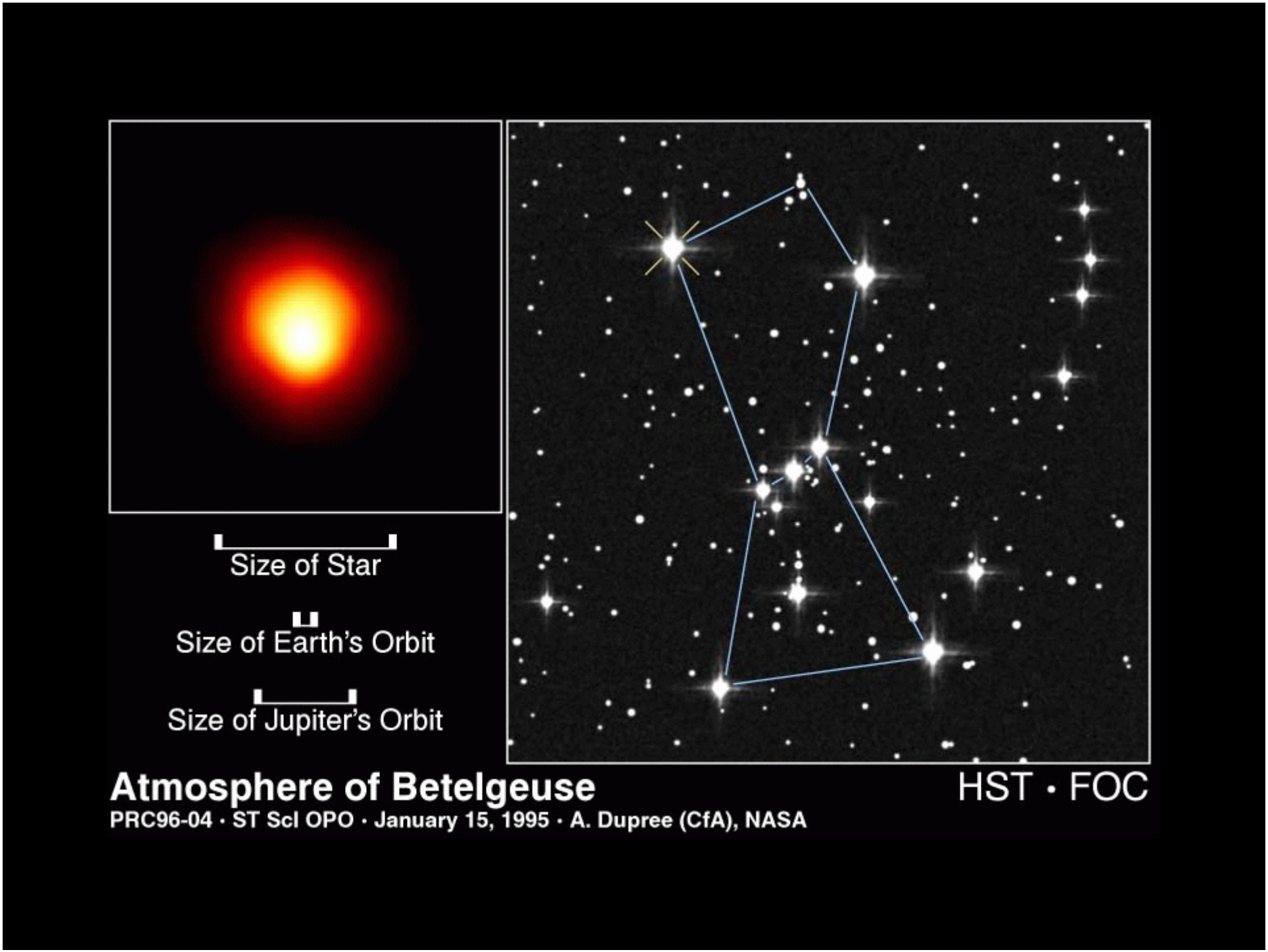
Pluto HST · FOC

PRC96-09a · ST ScI OPO · March 7, 1996 · A. Stern (SwRI), M. Buie (Lowell), NASA, ESA

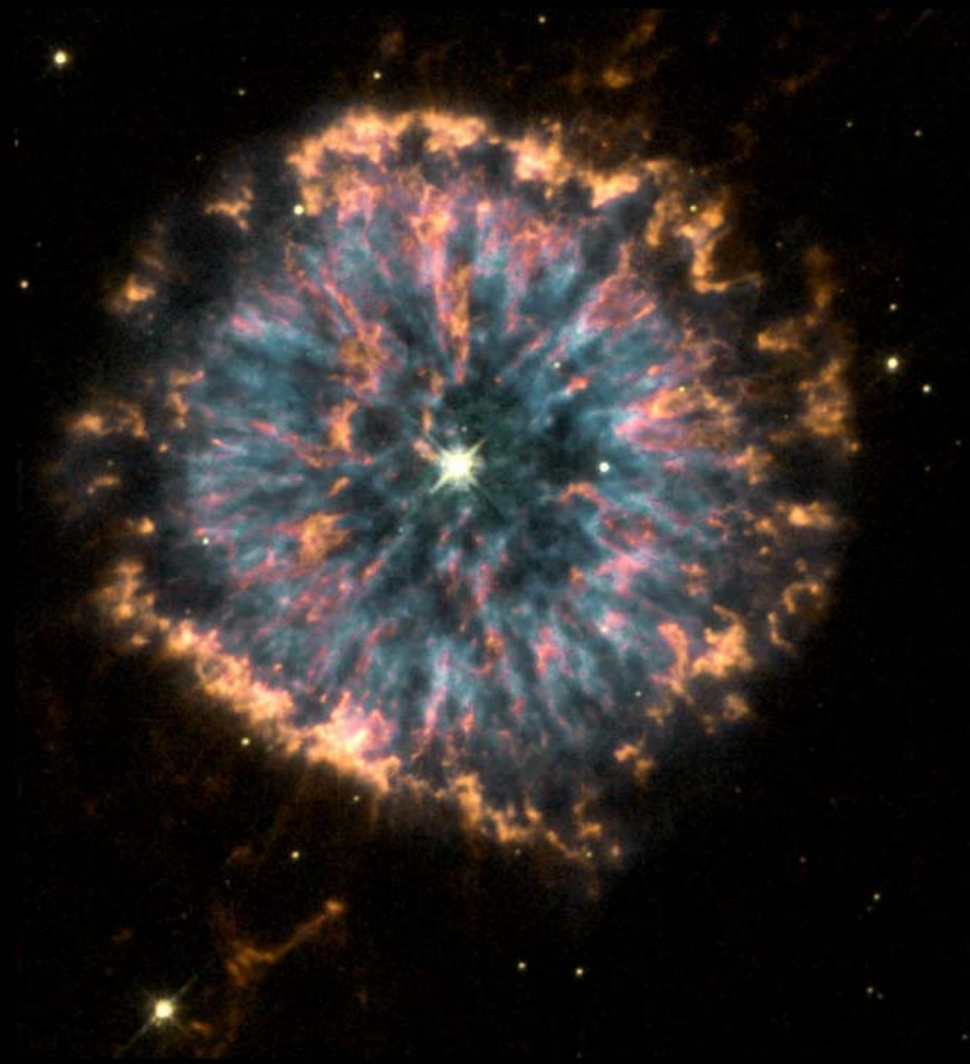


Gaseous Pillars · M16 HST · WFPC2

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

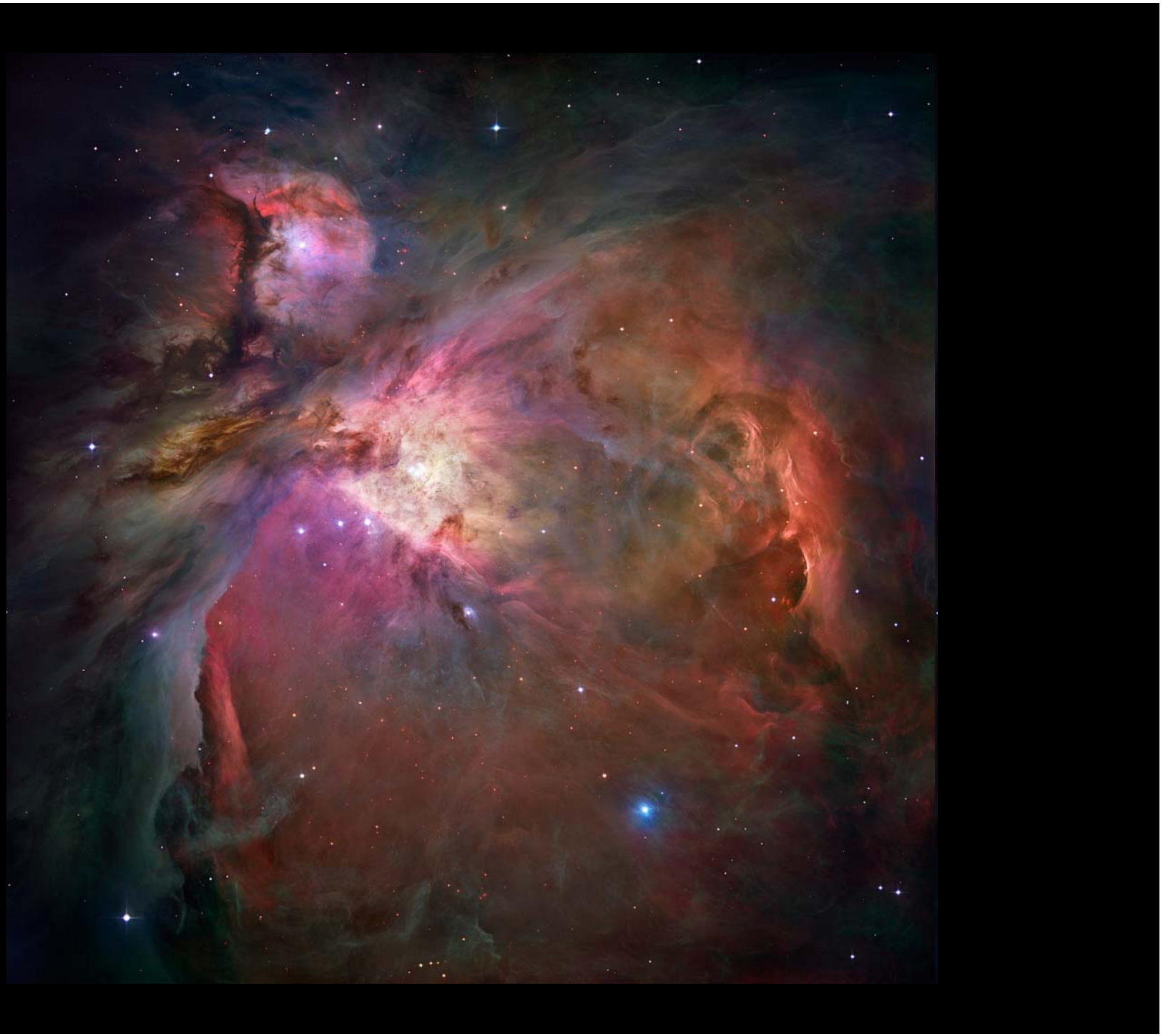

Size of Star
Size of Earth's Orbit
Size of Jupiter's Orbit
Atmosphere of Betelgeuse
PRC96-04 · ST ScI OPO · January 15, 1995 · A. Dupree (CfA), NASA
HST · FOC

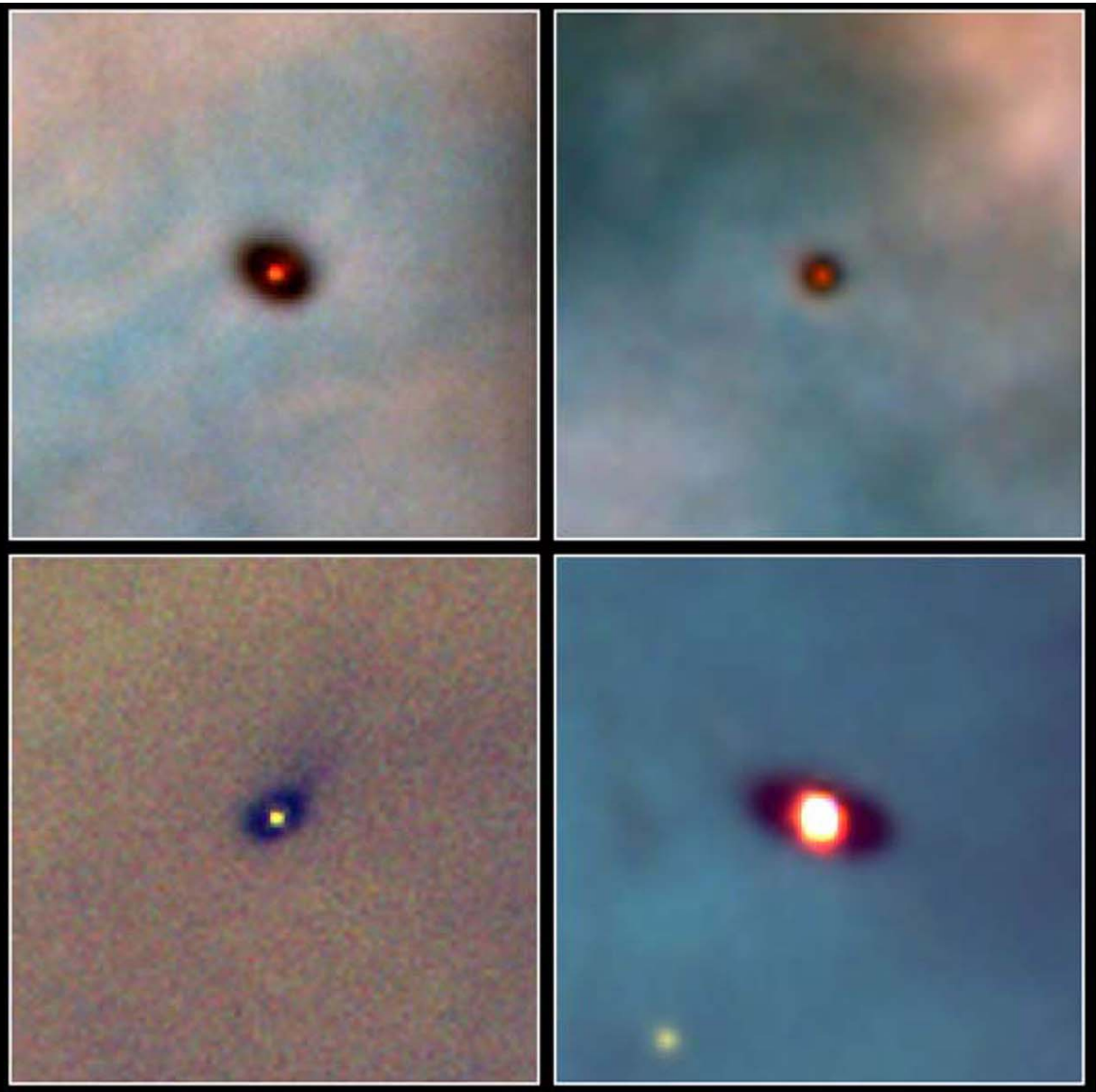
Planetary Nebula NGC 6751



Hubble Heritage

PRC00-12 • Space Telescope Science Institute • NASA and The Hubble Heritage Team (STScI/AURA)

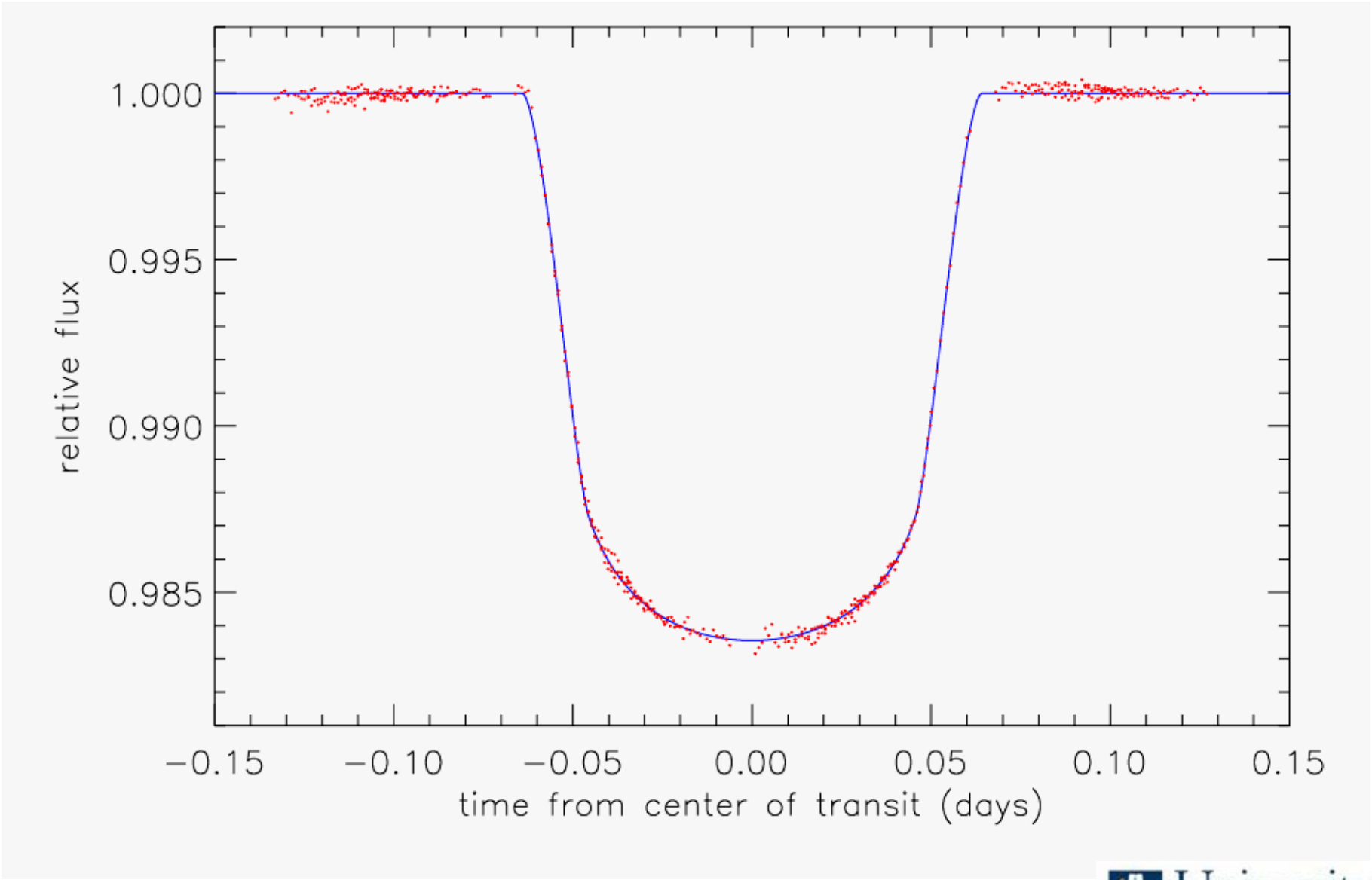




Protoplanetary Disks
Orion Nebula

HST · WFPC2

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


1.000
0.995
0.990
0.985
relative flux
−0.15
−0.10
−0.05
0.00
0.05
0.10
0.15
time from center of transit (days)

DETECTION OF OXYGEN AND CARBON IN THE HYDRODYNAMICALLY ESCAPING ATMOSPHERE OF THE EXTRASOLAR PLANET HD 209458B

A. Vidal-Madjar,[1] J.-M. Désert,[1] A. Lecavelier des Etangs,[1] G. Hébrard,[1] G. E. Ballester,[2] D. Ehrenreich,[1] R. Ferlet,[1] J. C. McConnell,[3] M. Mayor,[4] and C. D. Parkinson[5]

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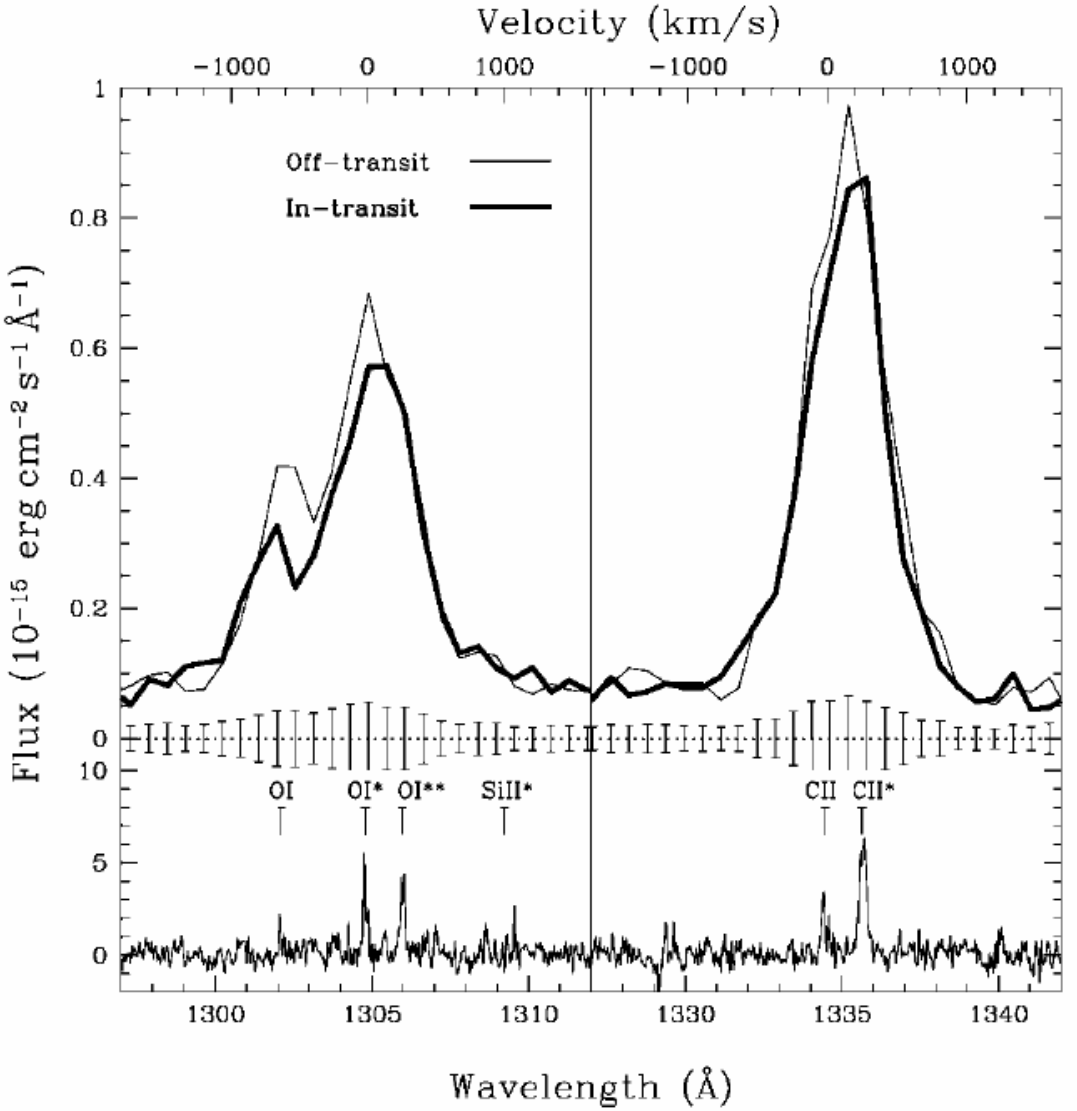
ABSTRACT

Four transits of the planet orbiting the star HD 209458 were observed with the Space Telescope Imaging Spectrograph on board the *Hubble Space Telescope*. The wavelength domain (1180–1710 Å) includes H I as well as C I, C II, C IV, N V, O I, S I, Si II, Si III, and Si IV lines. During the transits, absorptions are detected in H I, O I, and C II (5% ± 2%, 13% ± 4.5%, and 7.5% ± 3.5%, respectively). No absorptions are detected for other lines. The 5% mean absorption over the whole H I Lyα line is consistent with the previous detection completed in 2003 at higher resolution (Vidal-Madjar et al.). The absorption depths in O I and C II show that oxygen and carbon are present in the extended upper atmosphere of HD 209458b (nicknamed "Osiris"). These species must be carried out up to the Roche lobe and beyond, most likely in a state of hydrodynamic escape.

Subject headings: planetary systems — stars: individual (HD 209458)

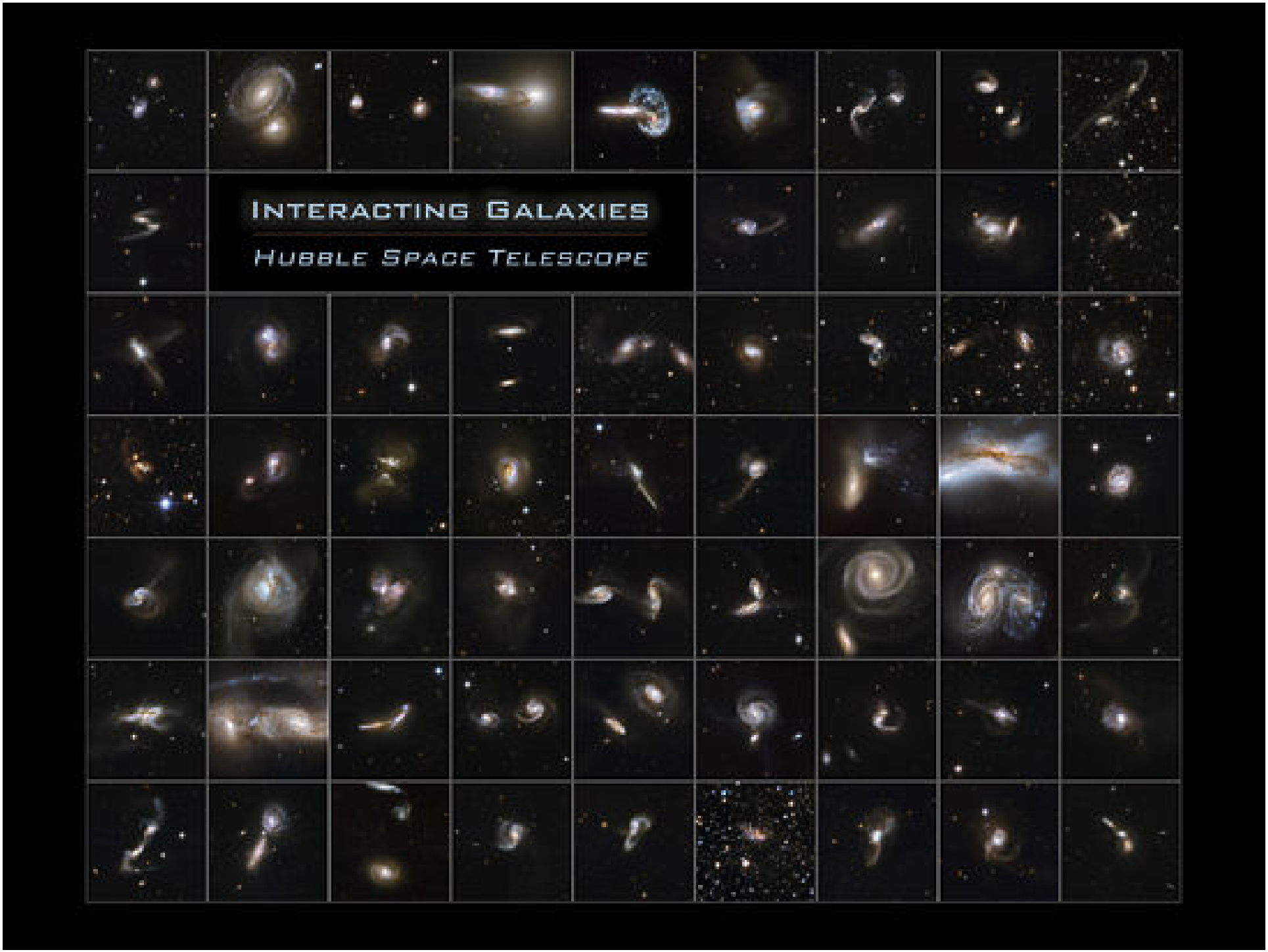
On-line material: color figures

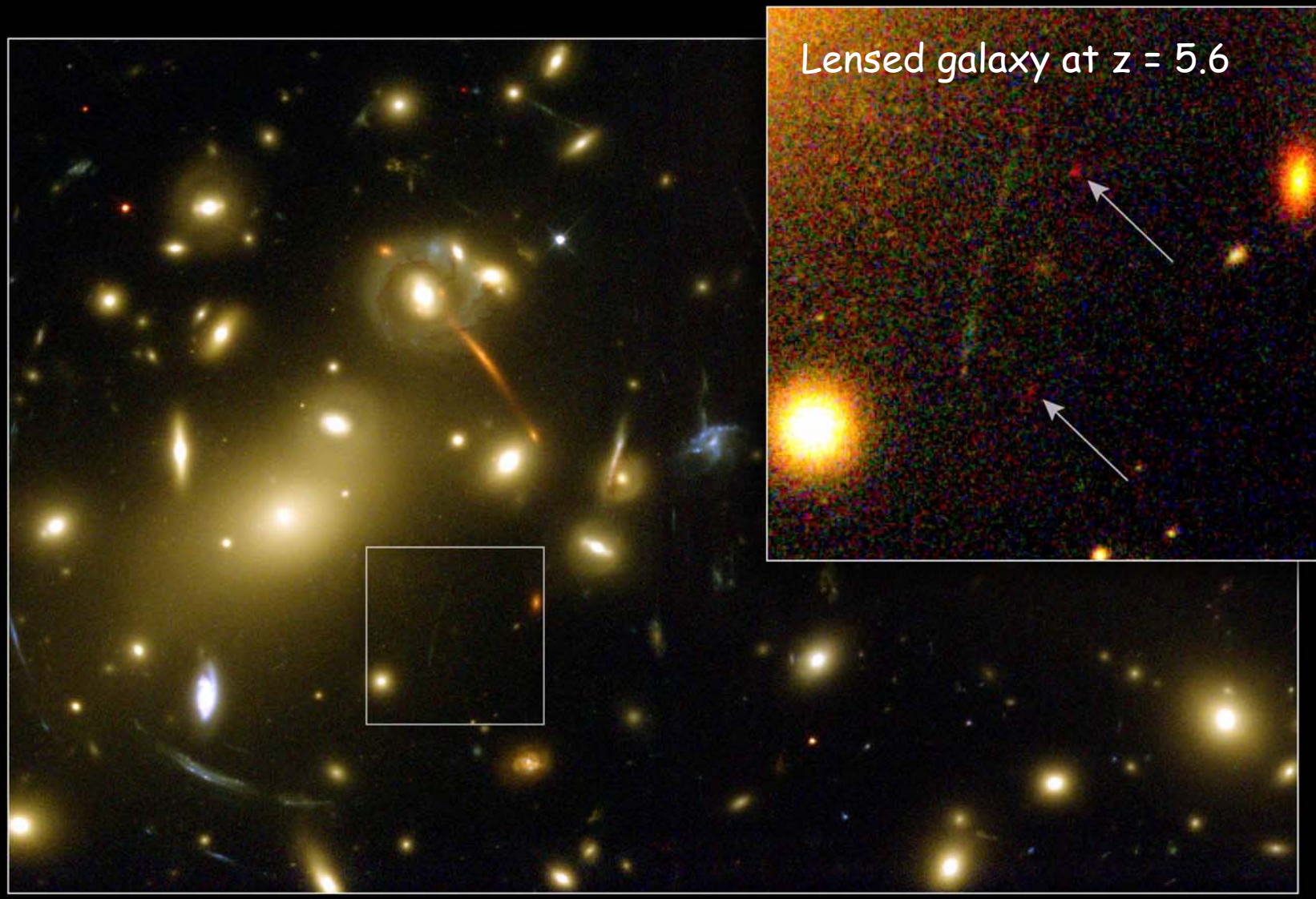


Spiral Galaxy M74

Hubble Heritage

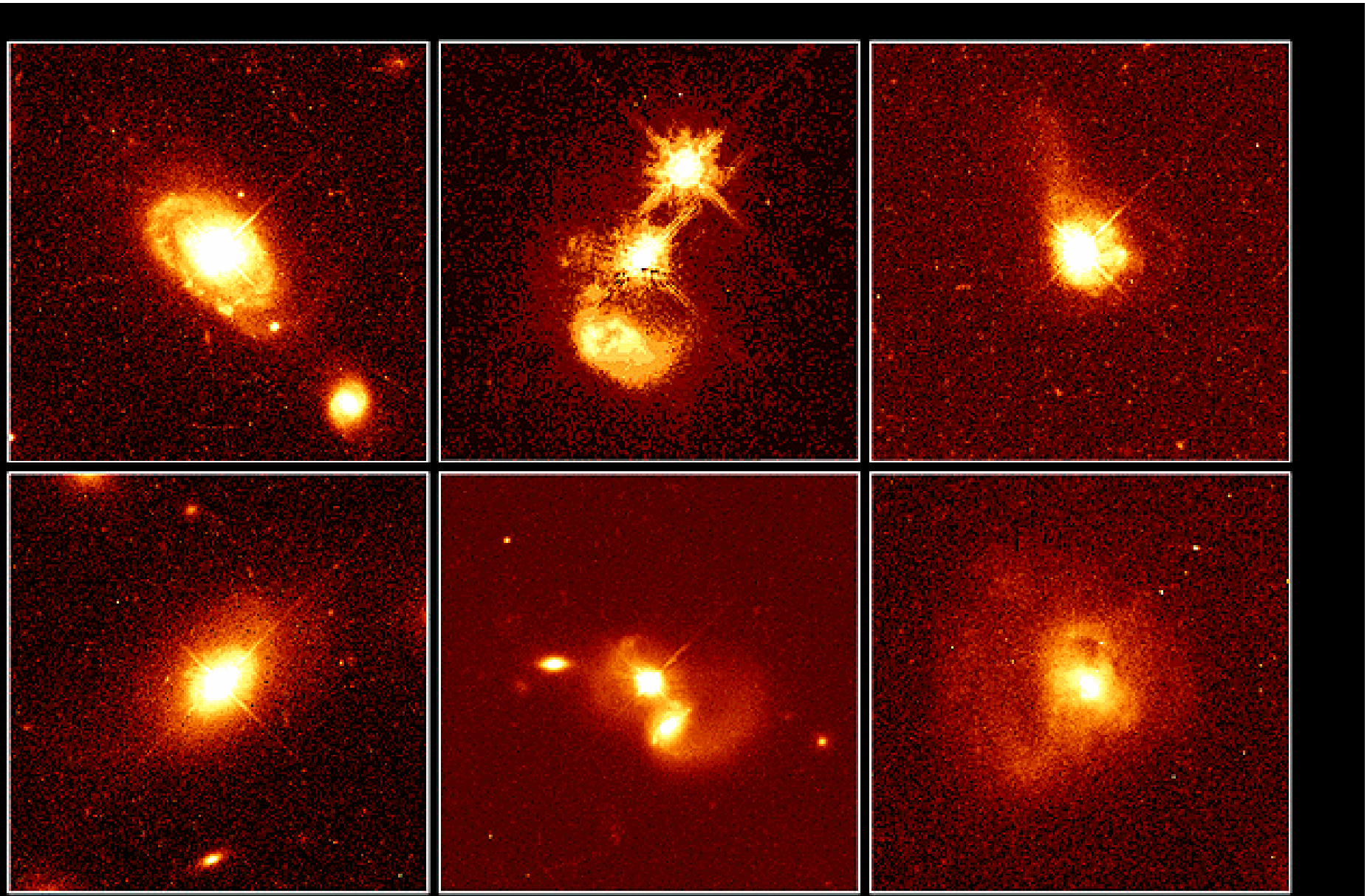
NASA, ESA, and the Hubble Heritage Team (STScI/AURA)-ESA/Hubble Collaboration • *HST*/ACS • STScI-PRC07-41


INTERACTING GALAXIES
HUBBLE SPACE TELESCOPE



Distant Object Gravitationally Lensed by Galaxy Cluster Abell 2218
Hubble Space Telescope • WFPC2

NASA, ESA, R. Ellis (Caltech) and J.-P. Kneib (Observatoire Midi-Pyrenees) • STScI-PRC01-32



Quasar Host Galaxies

HST • WFPC2

PRC96-35a • ST ScI OPO • November 19, 1996

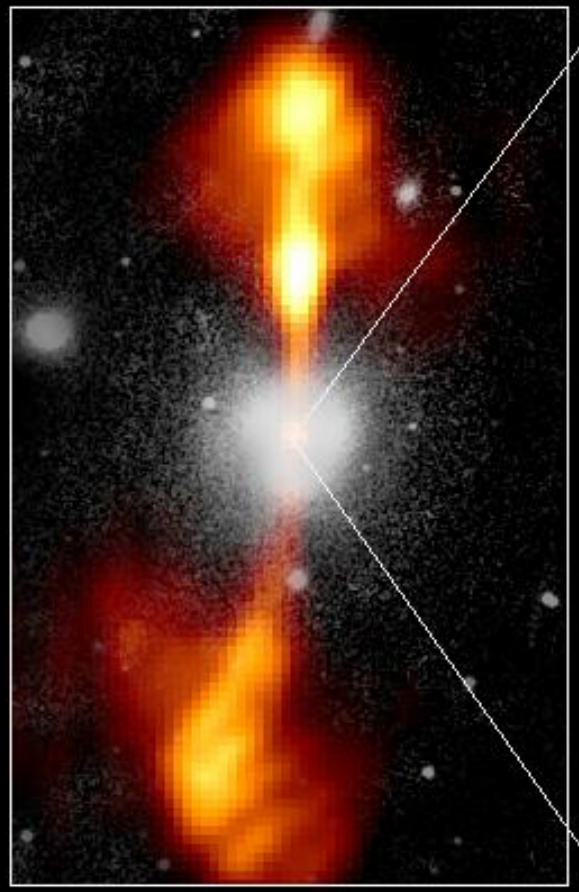
J. Bahcall (Institute for Advanced Study), M. Disney (University of Wales) and NASA

Core of Galaxy NGC 4261

Hubble Space Telescope

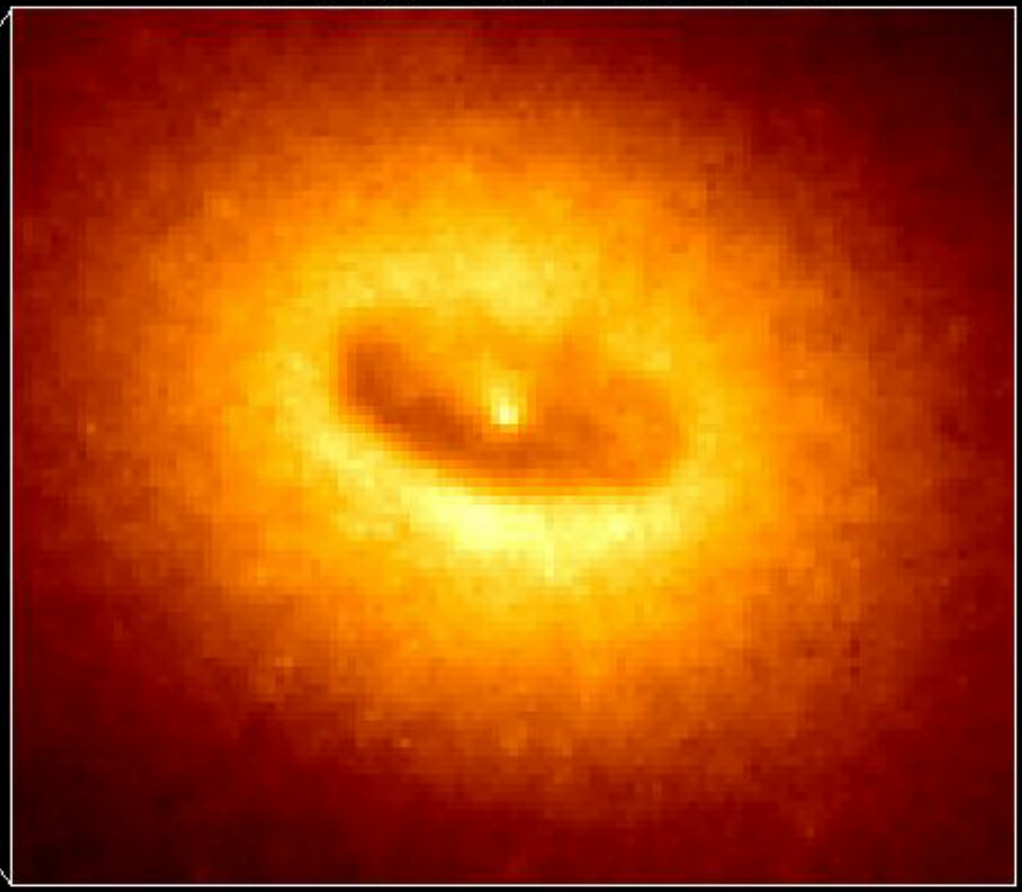
Wide Field / Planetary Camera

Ground-Based Optical/Radio Image

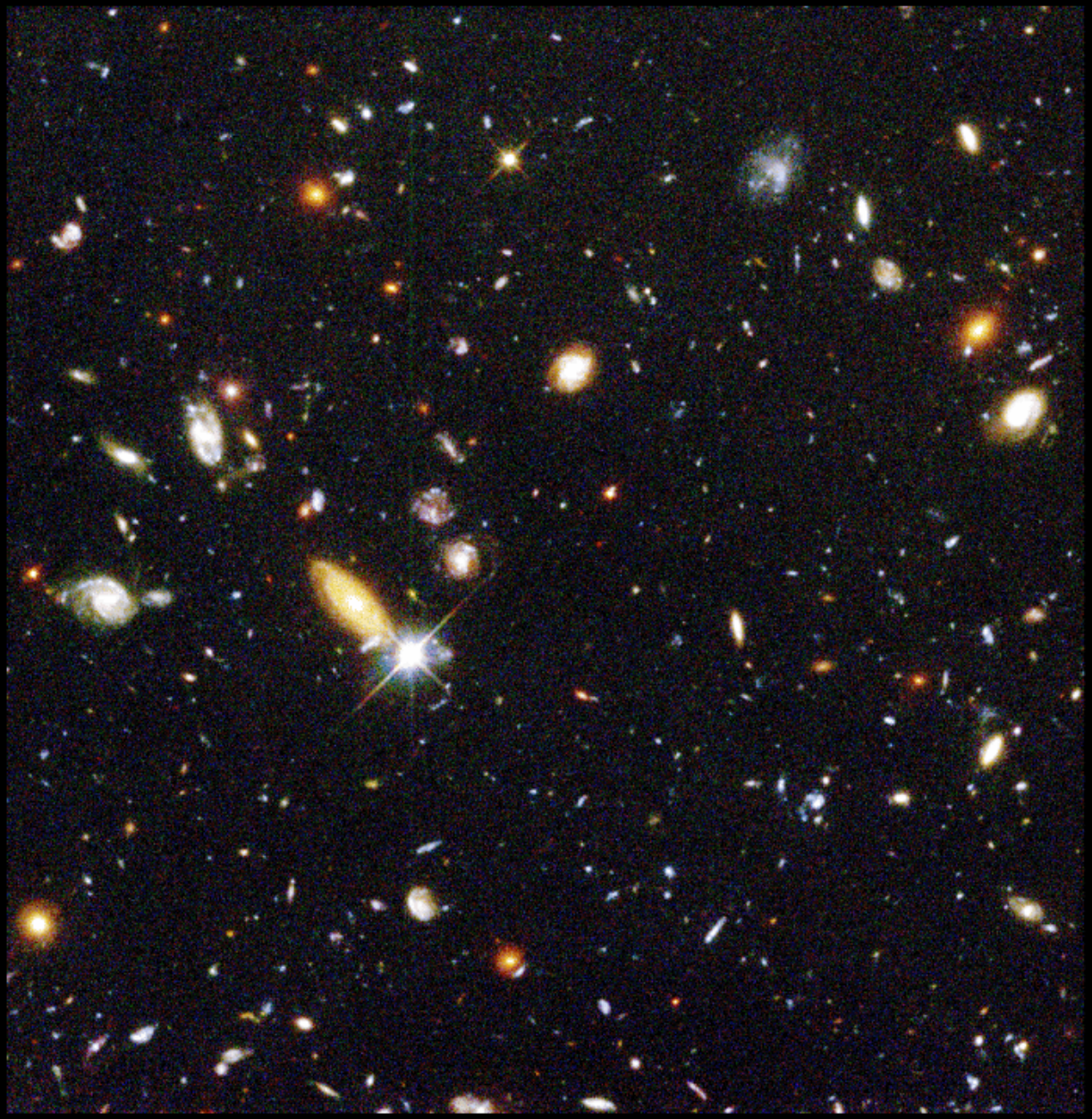


380 Arc Seconds
88,000 LIGHT-YEARS

HST Image of a Gas and Dust Disk



1.7 Arc Seconds
400 LIGHT-YEARS



Hubble Deep Field HST • WFPC2

PRC96-01a • ST ScI OPO • January 15, 1996 • R. Williams (ST ScI), NASA

Hubble Vision:

Course Topics

- A brief history of telescopes, and the ‘case for space’
- HST and the Solar System
- HST and the lives and deaths of stars
- The search for extra-solar planets
- From Hubble the man to Hubble the telescope
- Mapping and measuring the Universe with HST
- A long time ago, in a galaxy far, far away
- Space telescopes across the E-M spectrum and beyond
- After Hubble: the James Webb Space Telescope

Hubble Vision:

Resources on the web

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

Username: space
Password: telescope

THE UNIVERSE
YOURS TO DISCOVER

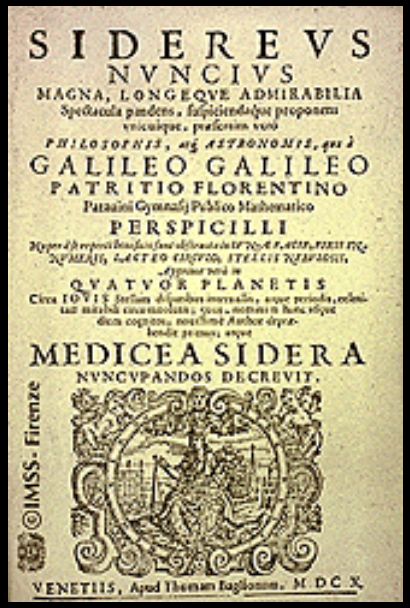
INTERNATIONAL YEAR OF
ASTRONOMY
2009

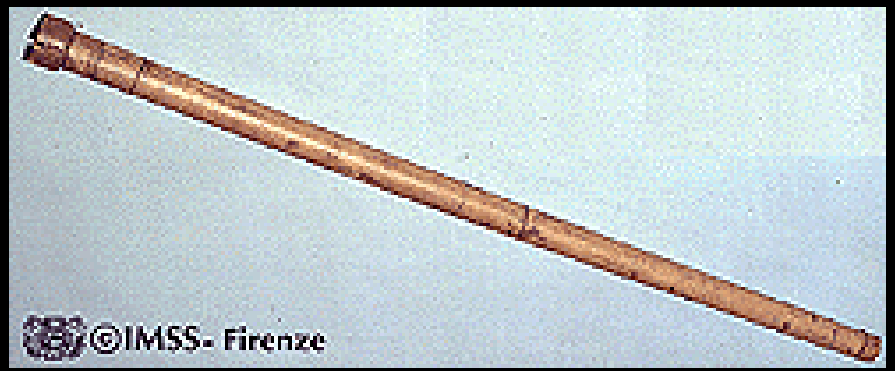
SUPA

IGR

University of Glasgow

Galileo Galilei:
1564 – 1642 AD


SIDEREVS
NVNCIVS
MAGNA, LONGEQVE ADMIRABILIA
Spectacula pandens, suspiciendaque proponens
unicuique, præsertim verò
PHILOSOPHIS, necnon ASTRONOMIS, quæ à
GALILEO GALILEO
PATRITIO FLORENTINO
Patauini Gymnasij Publico Mathematico
PERSPICILLI
QVATVOR PLANETIS
MEDICEA SIDERA
NVNCVPANDOS DECREVIT.
VENETIIS, Apud Thomam Baglionum. M. DC X.

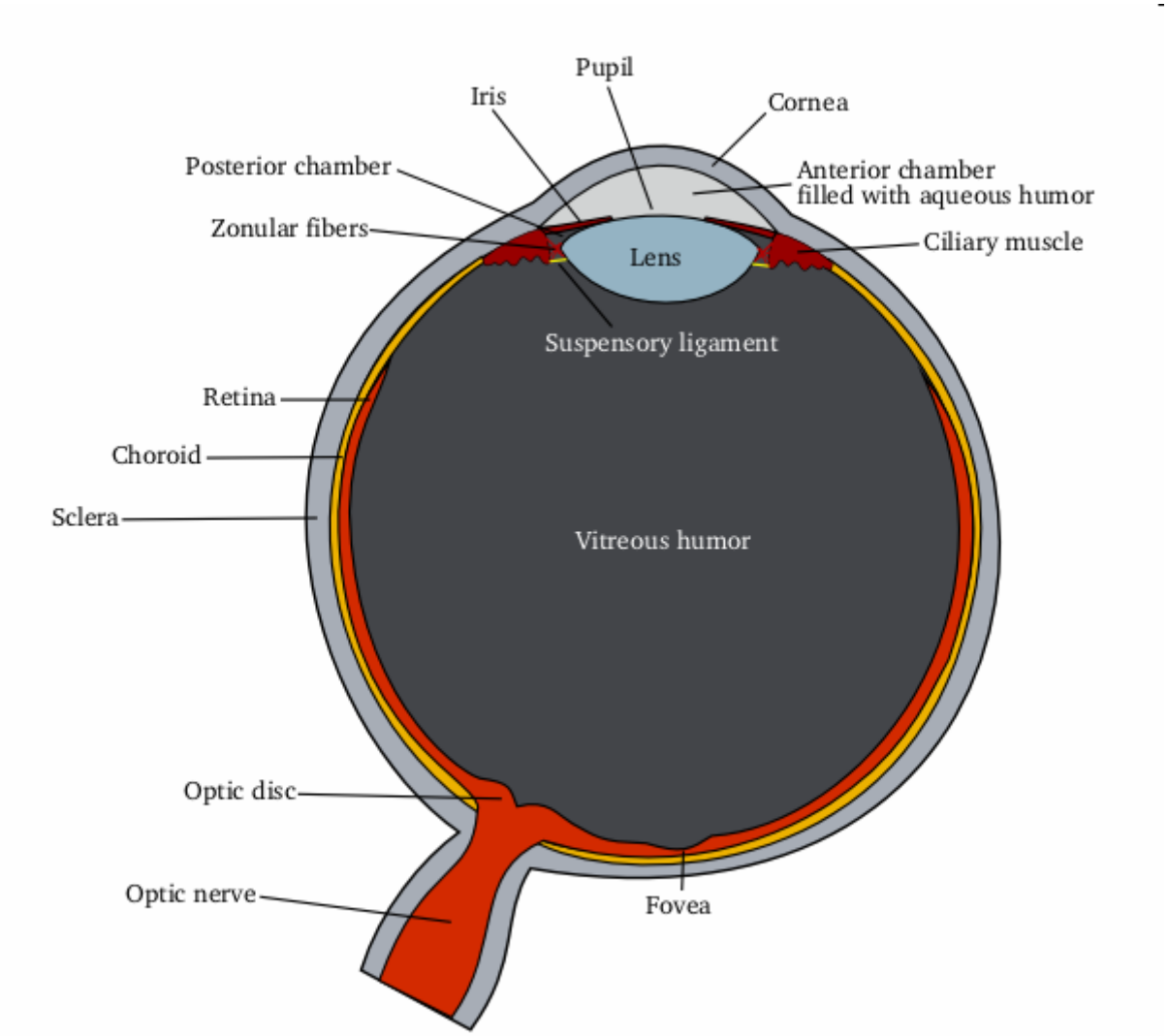


Telescope:

An optical device for collecting light so as to form an image of a distant object

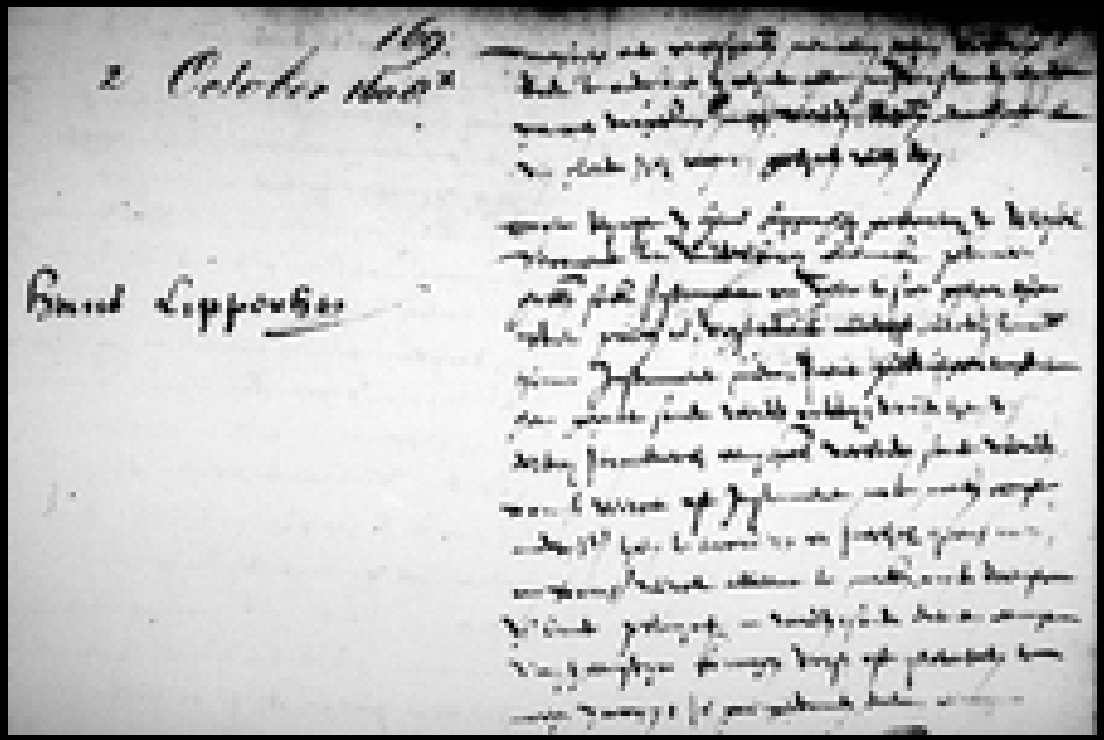
(MacMillan Dictionary of Astronomy)

The Human Eye

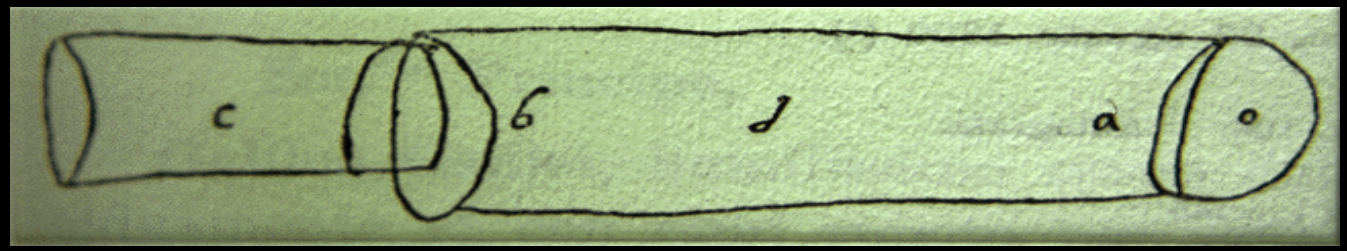


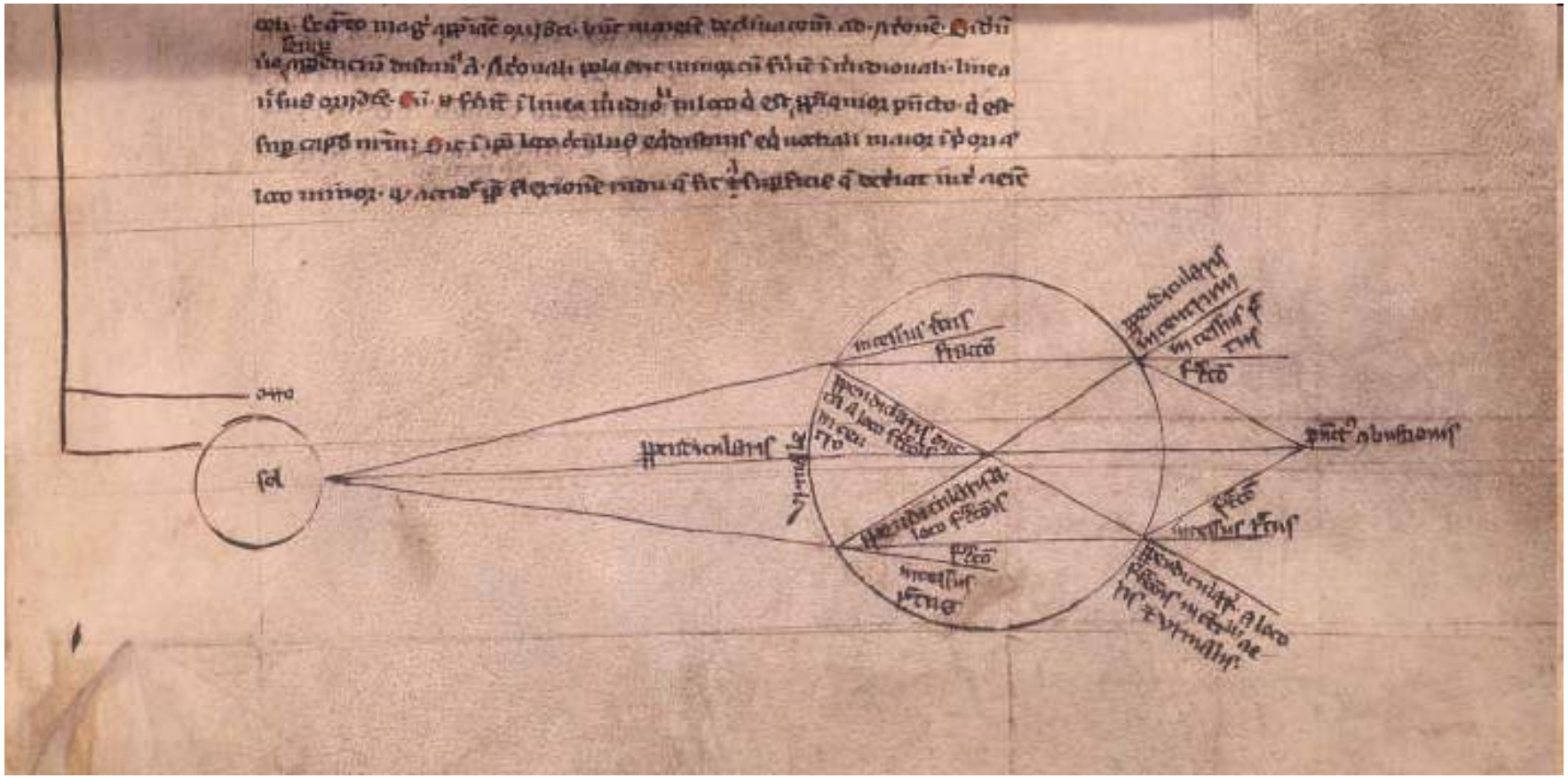
The Spectacle Vendor by Johannes Stradanus, 1582

Hans Lippershey's 1608 patent of a device for "seeing faraway things as though nearby."

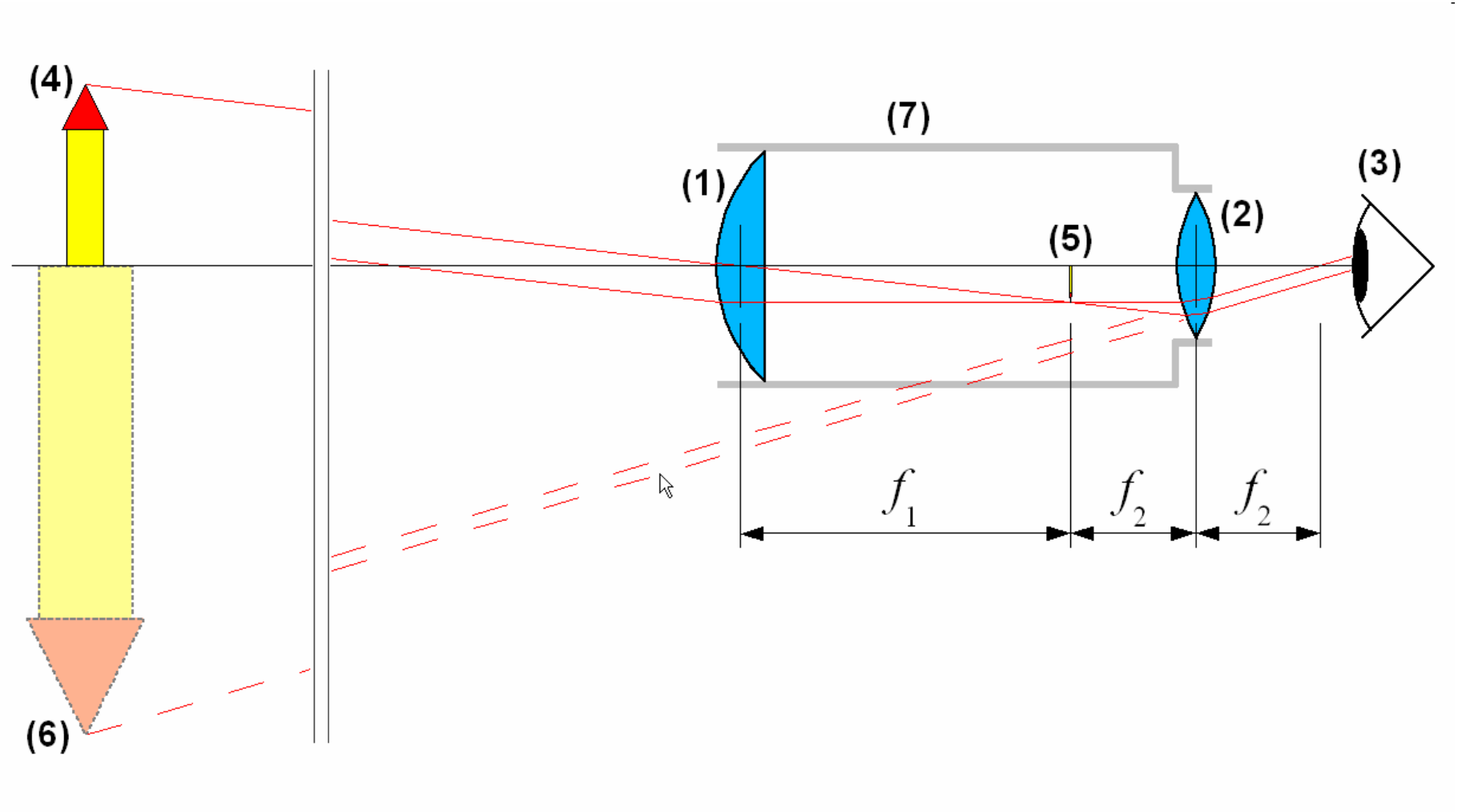


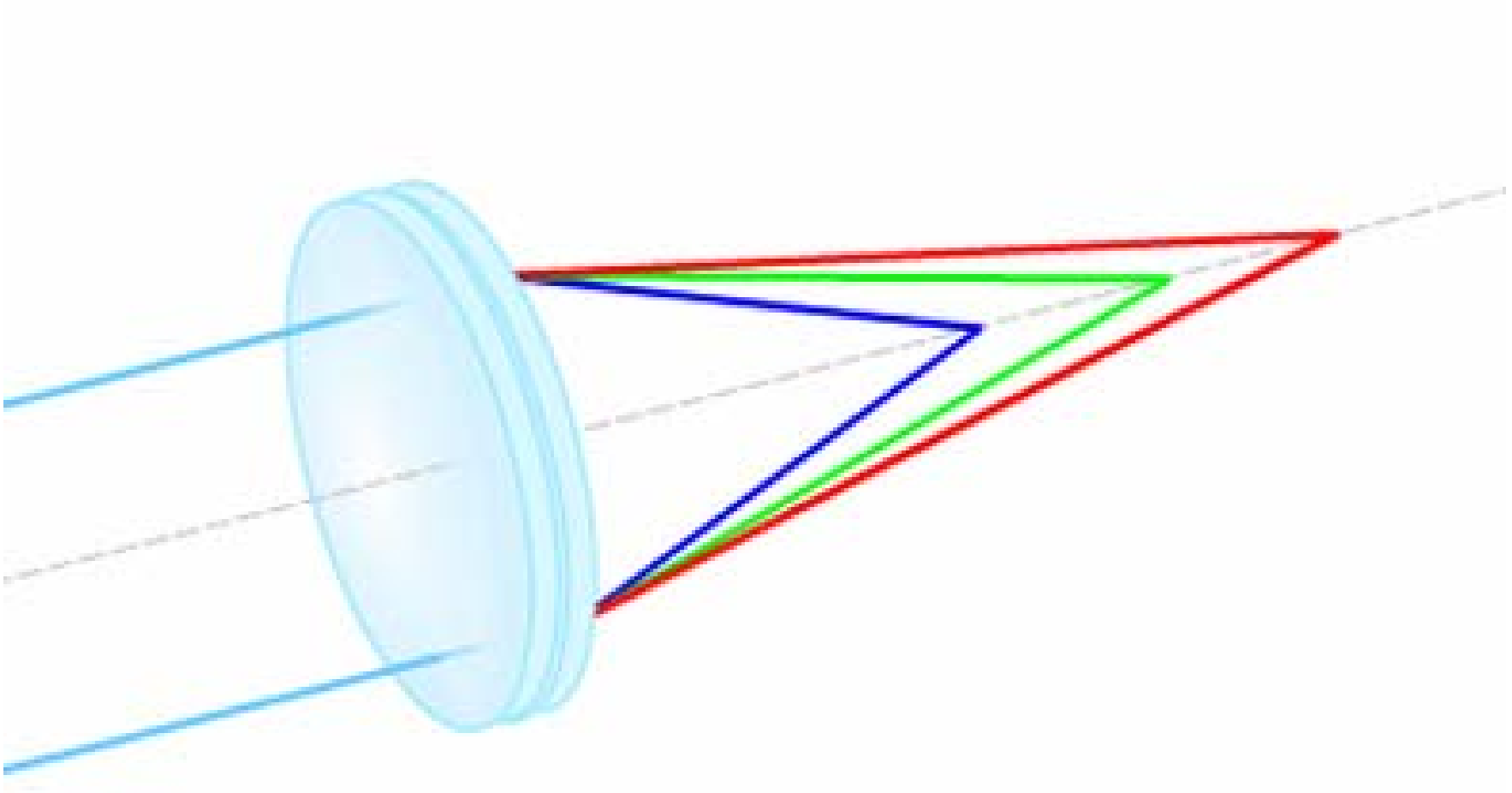
Porta's sketch of a telescope, August 1609



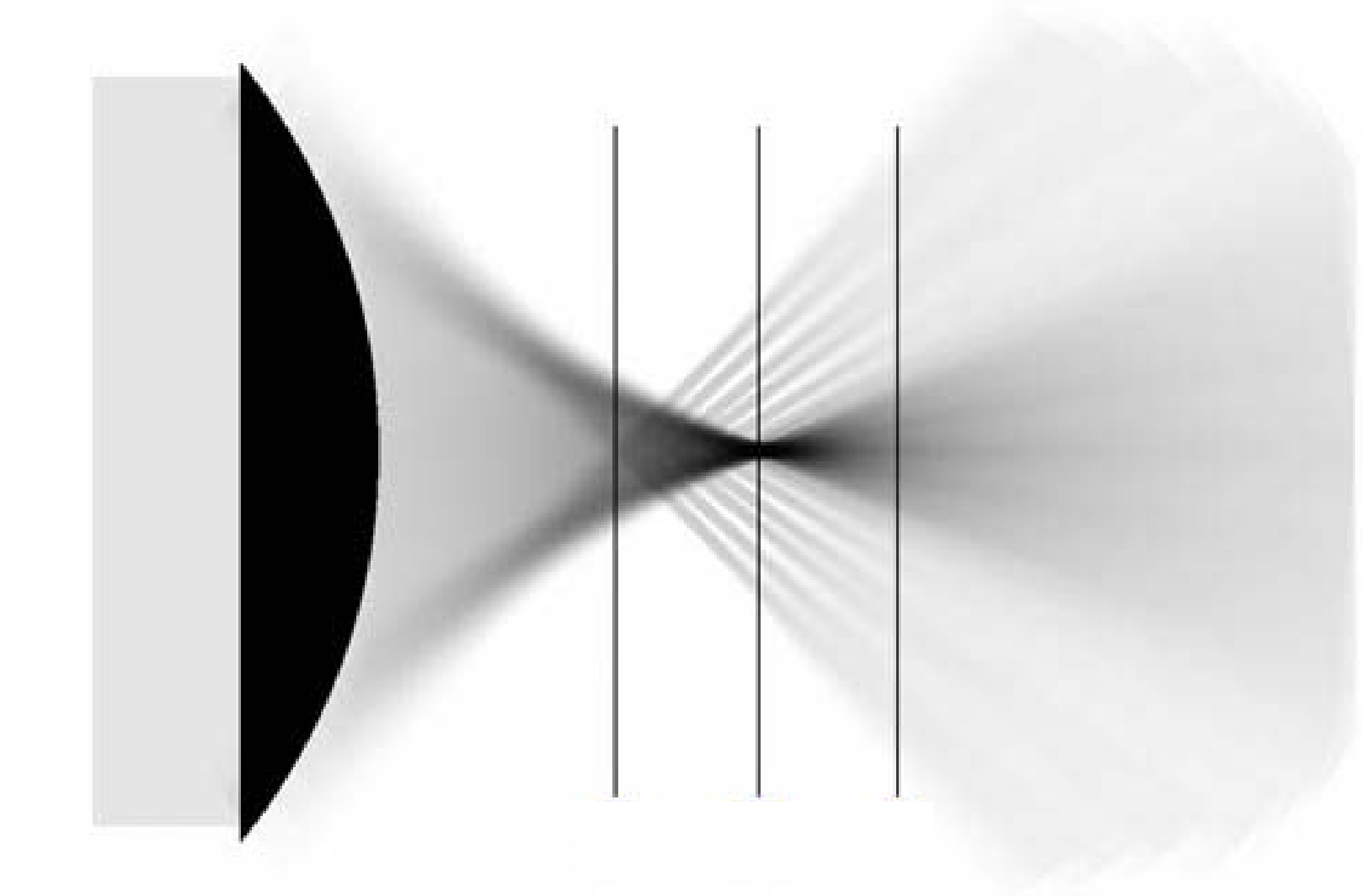

Sol

Basic design of the refractor

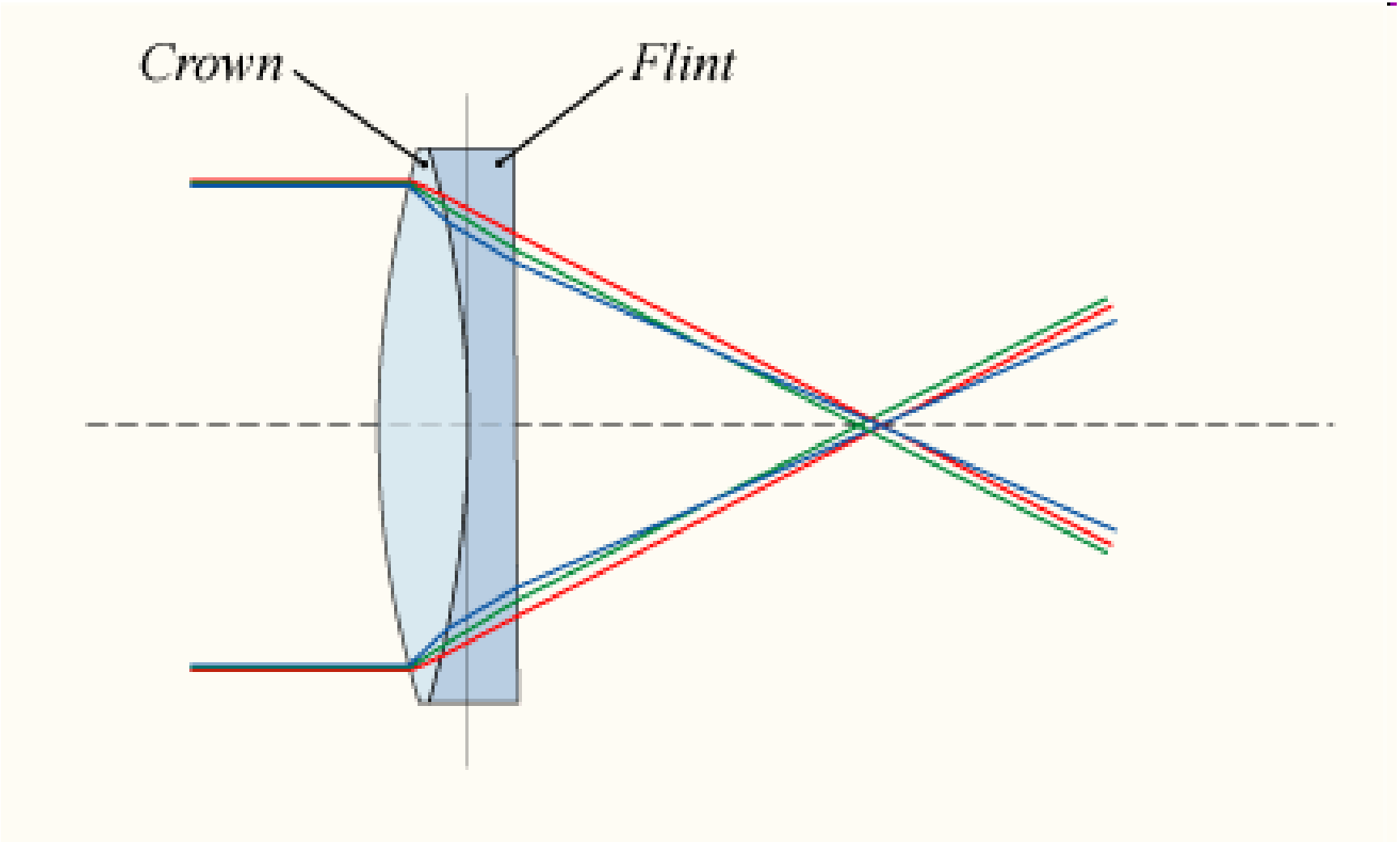




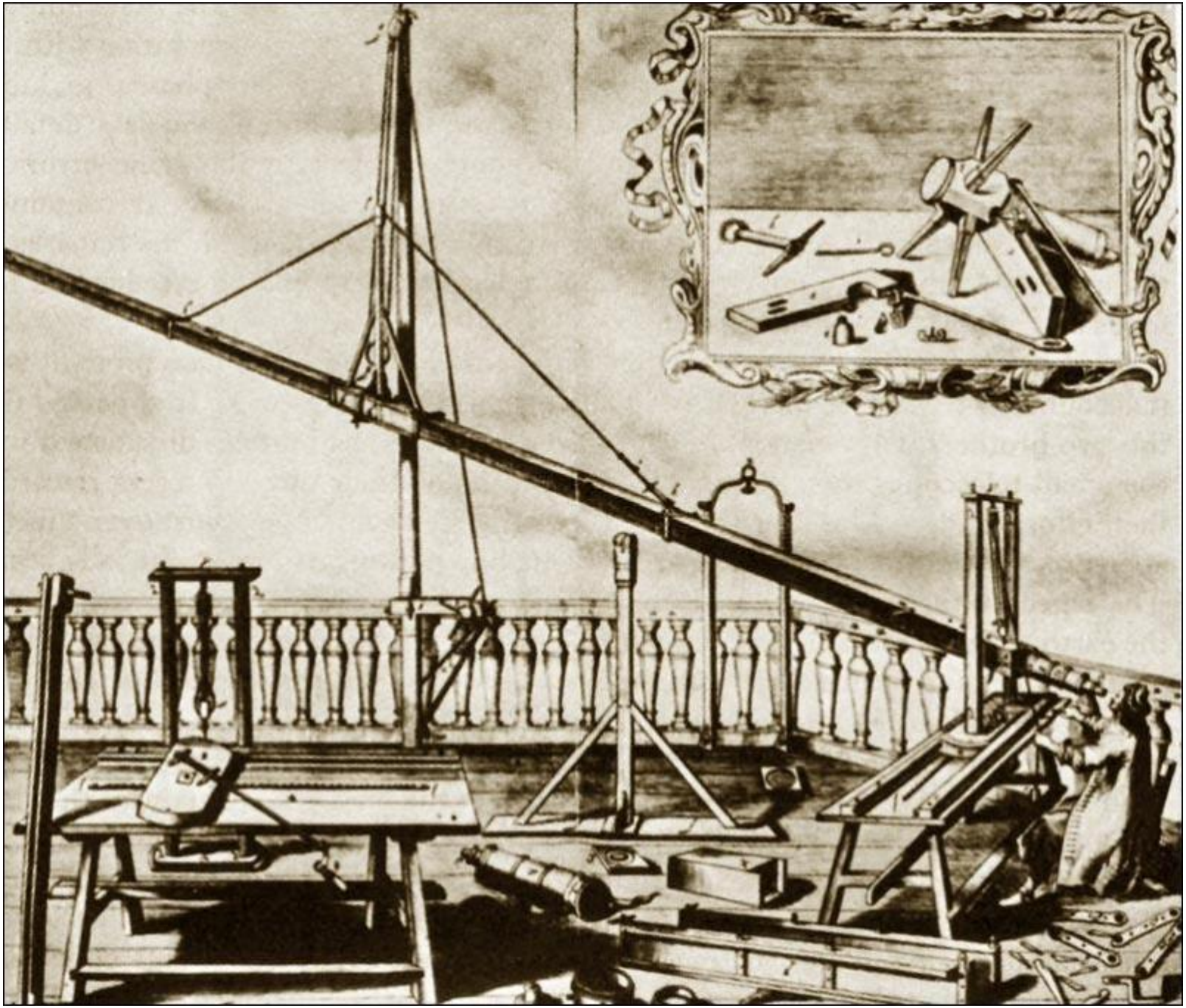
Lenses suffer from **chromatic aberration…**

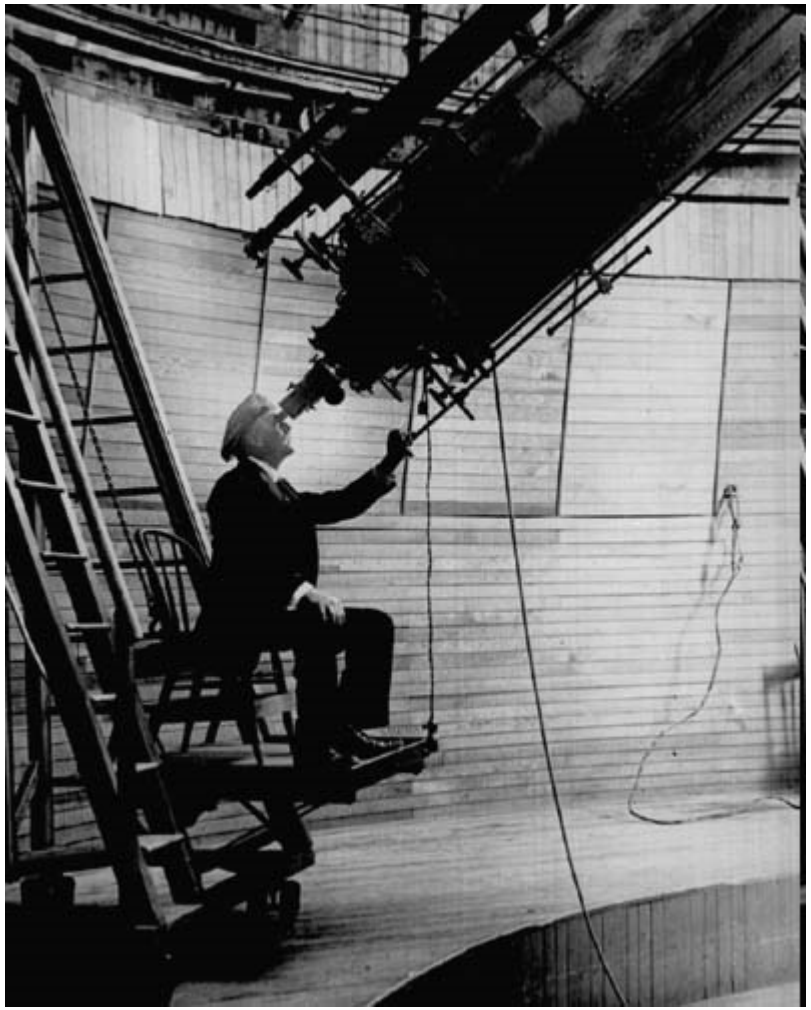


…and from **spherical aberration**

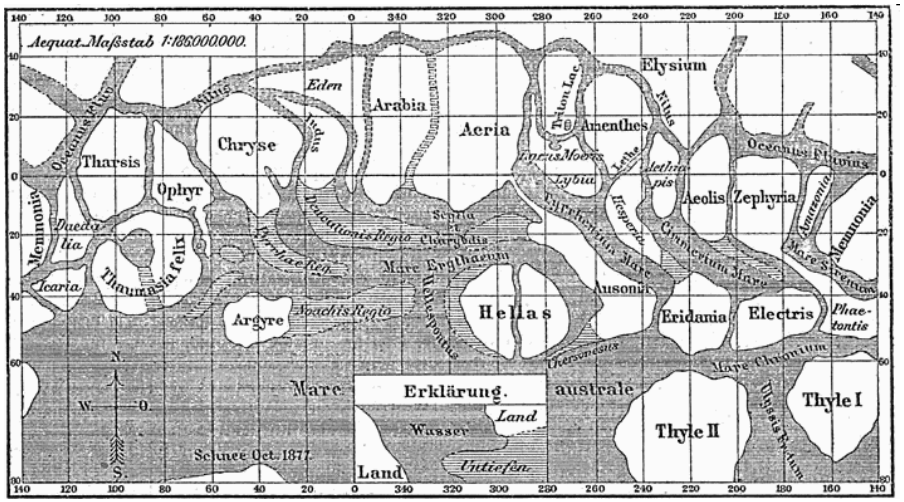


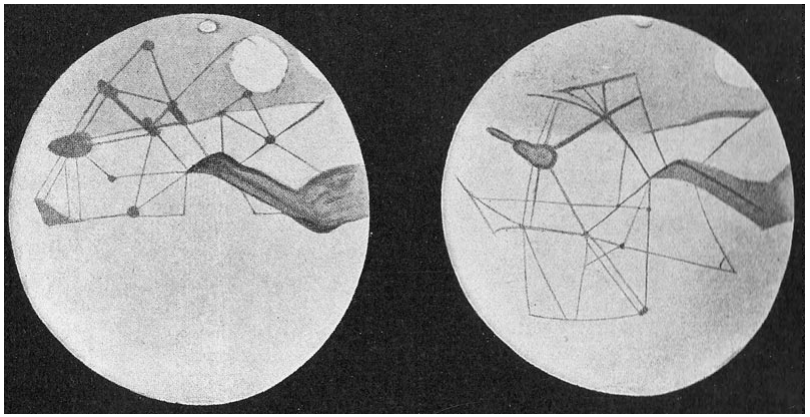
Using an **achromatic doublet** can help…

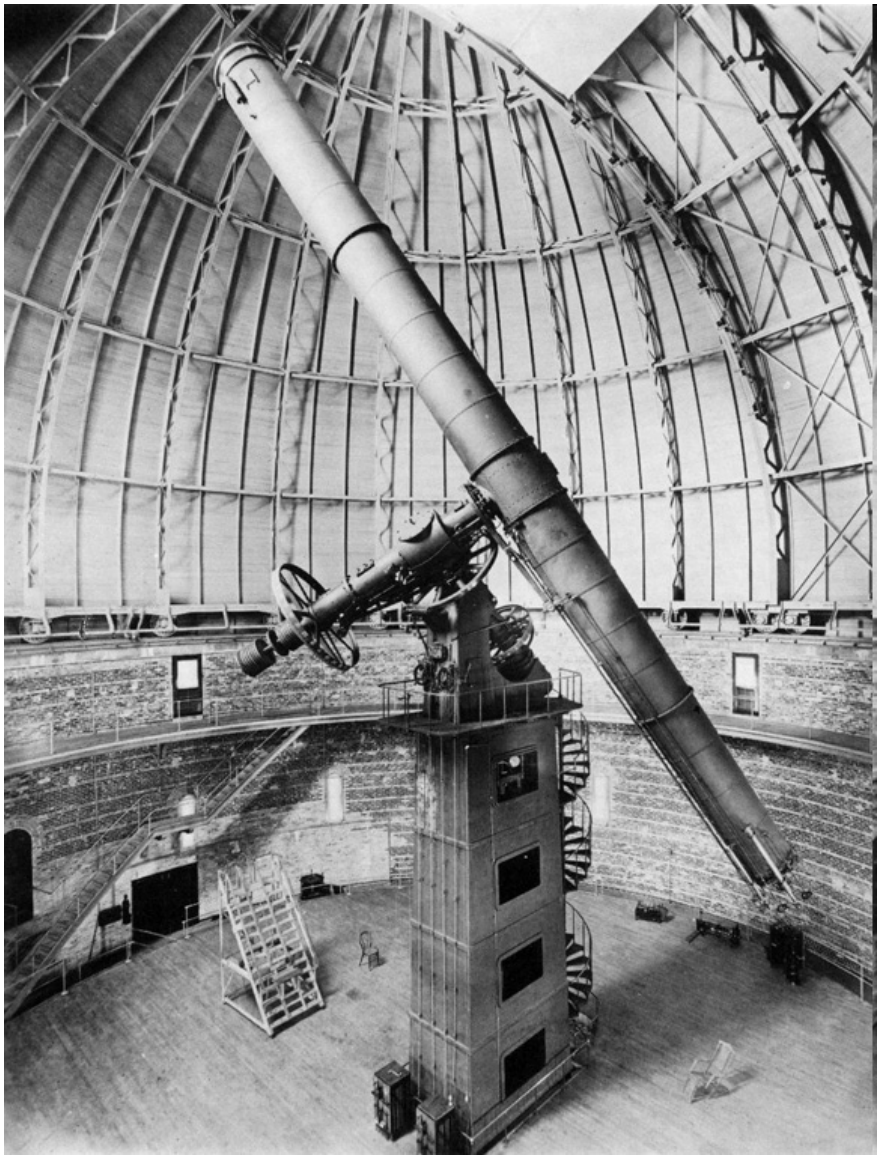




Percival Lowell observing Mars with the 24-inch refractor at Flagstaff, Arizona



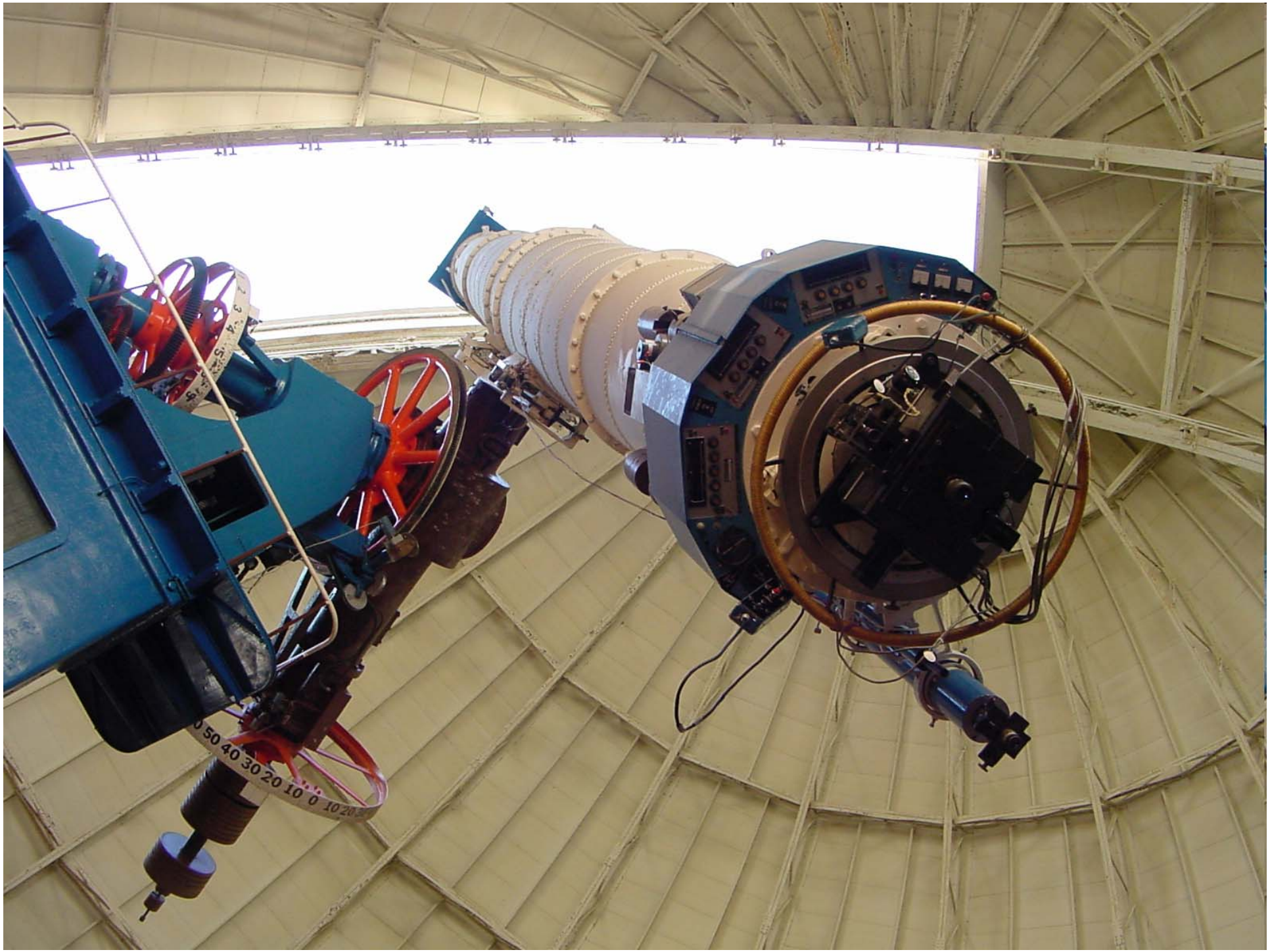




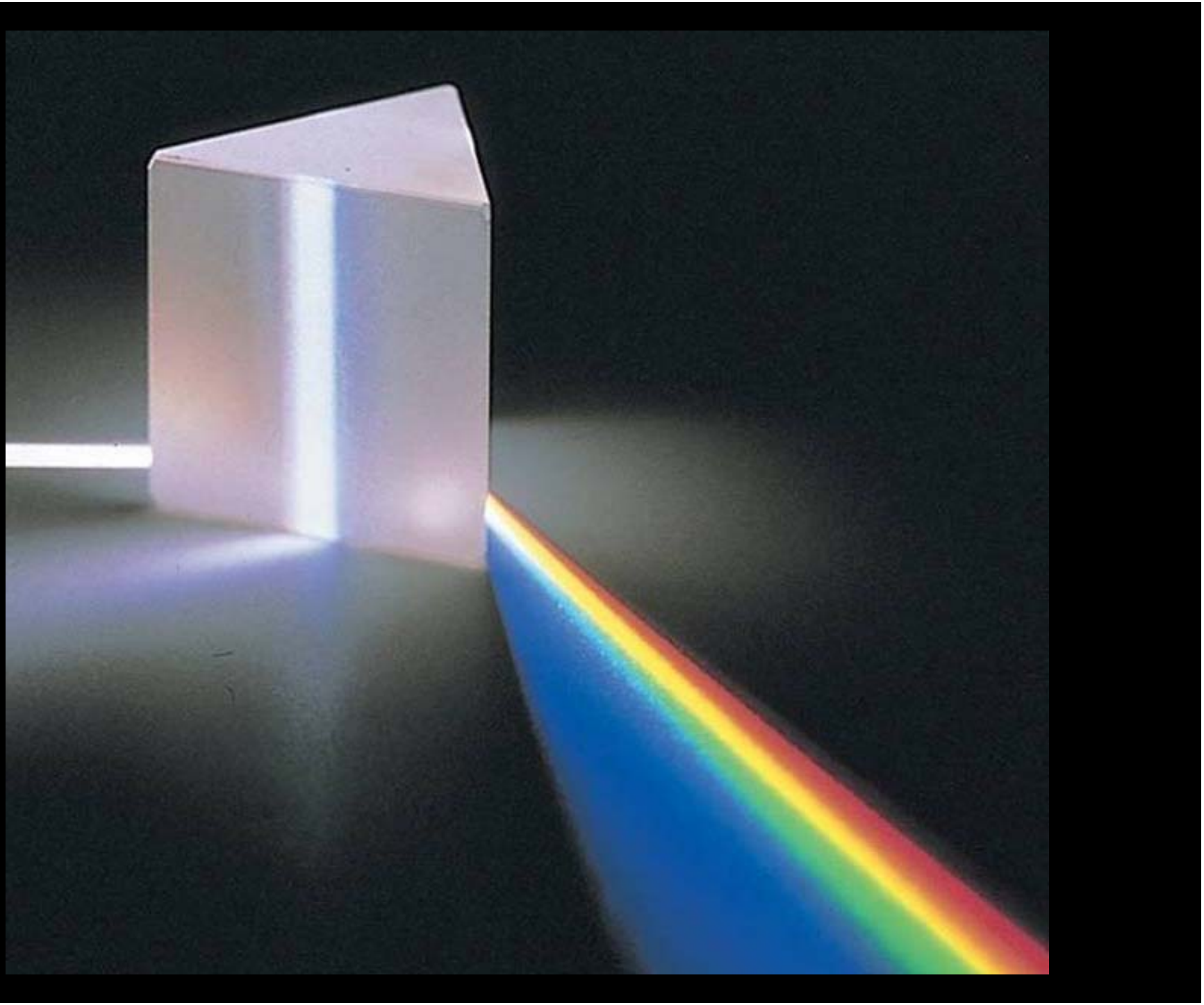
World's largest refractor:

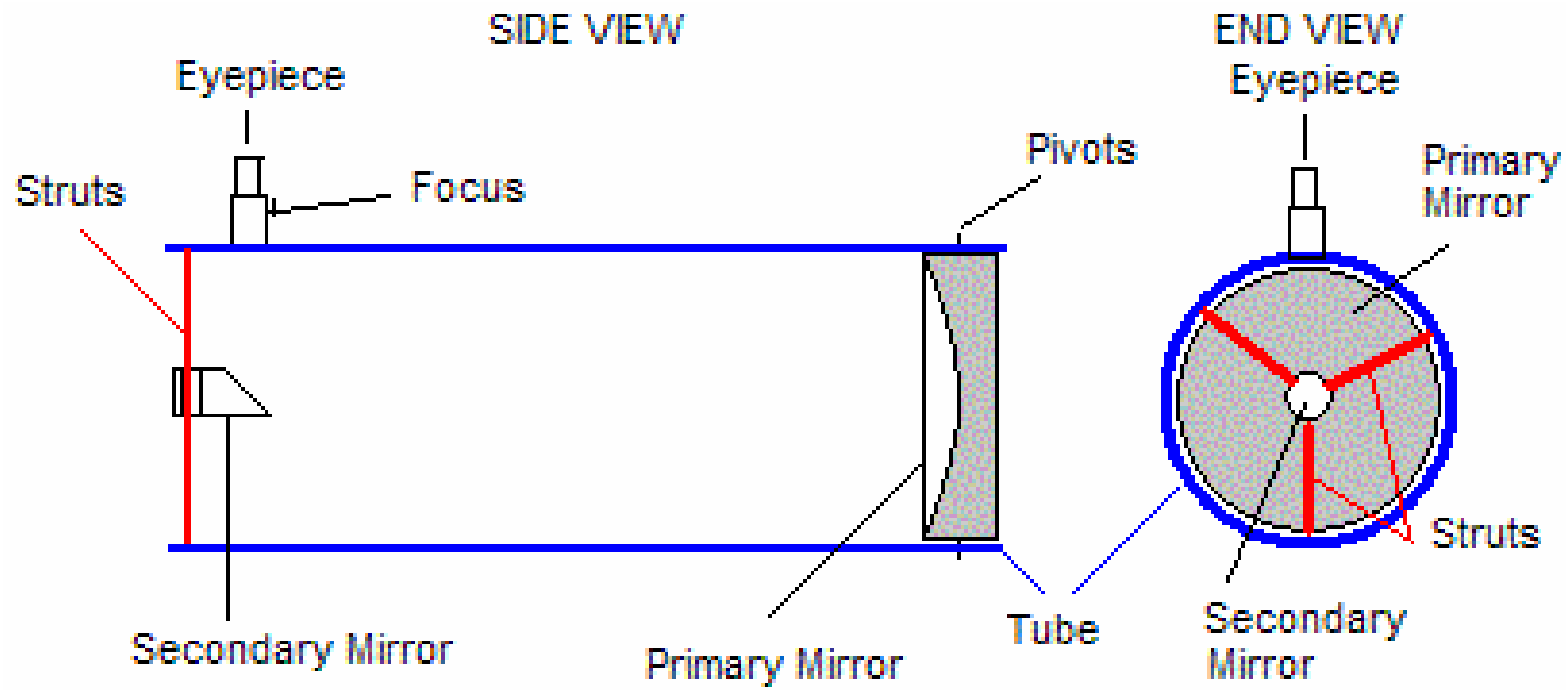
40-inch Yerkes telescope, built in 1897.

Still operational today!



Newtonian reflector
1672




SIDE VIEW
Eyepiece
Struts
Focus
Pivots
Secondary Mirror
Primary Mirror
Tube
END VIEW
Eyepiece
Primary Mirror
Struts
Secondary Mirror

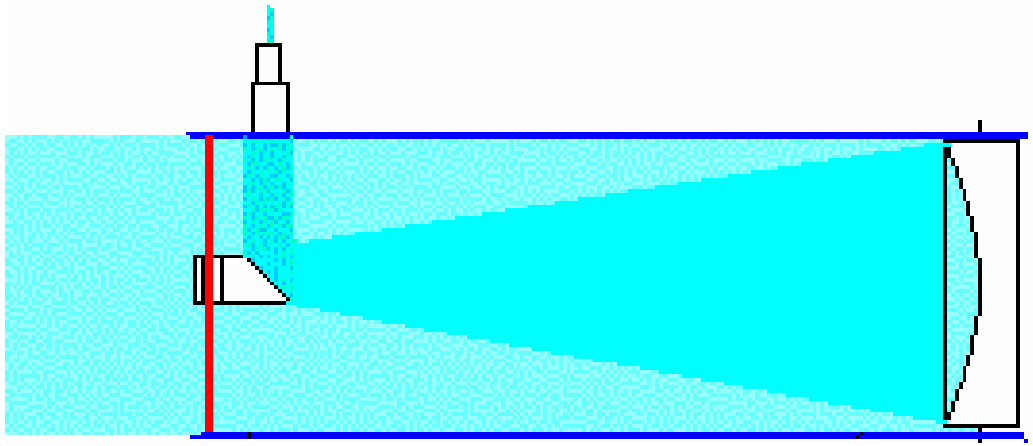
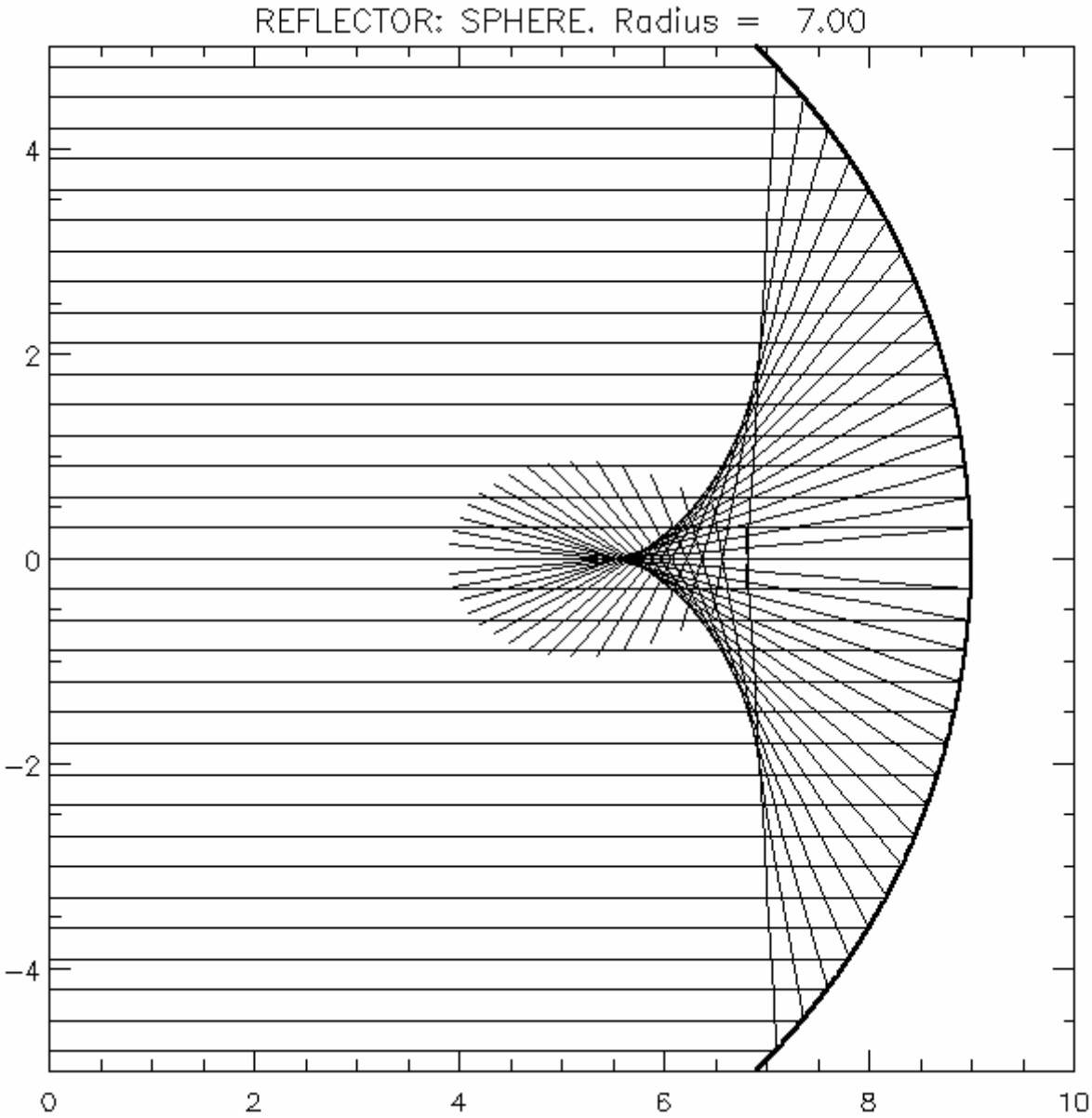
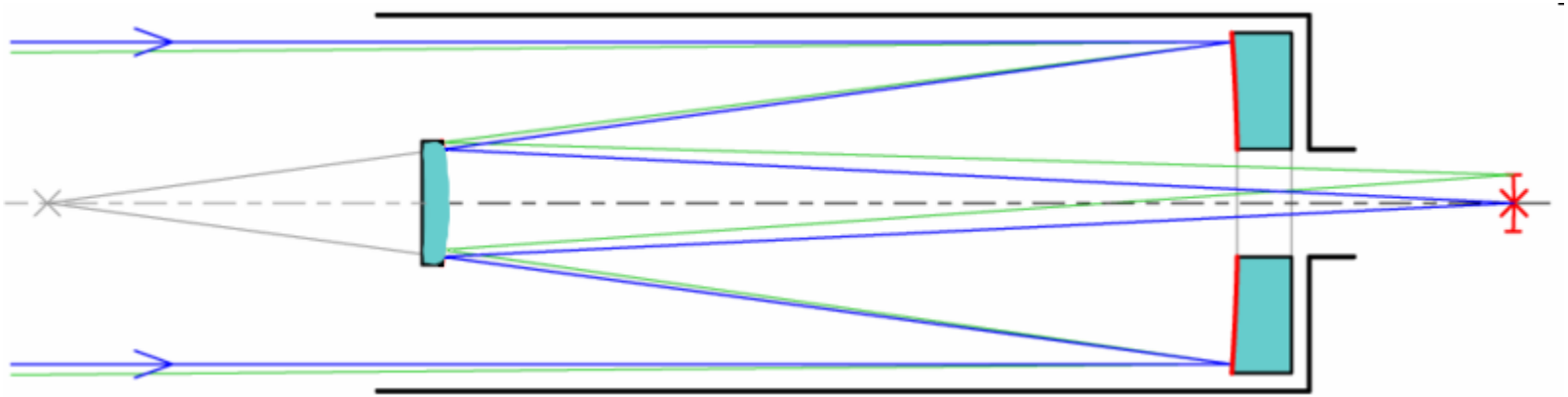
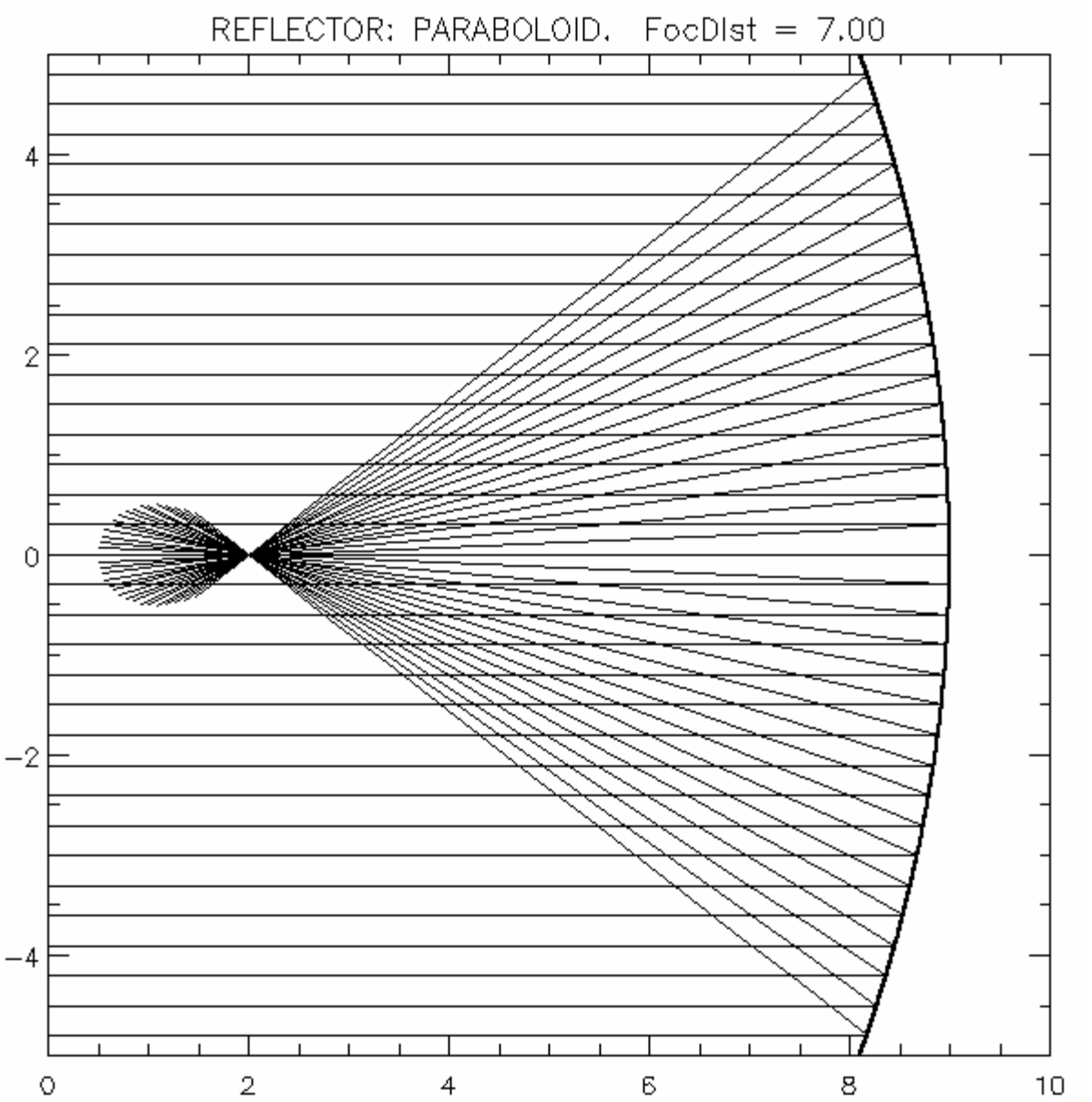


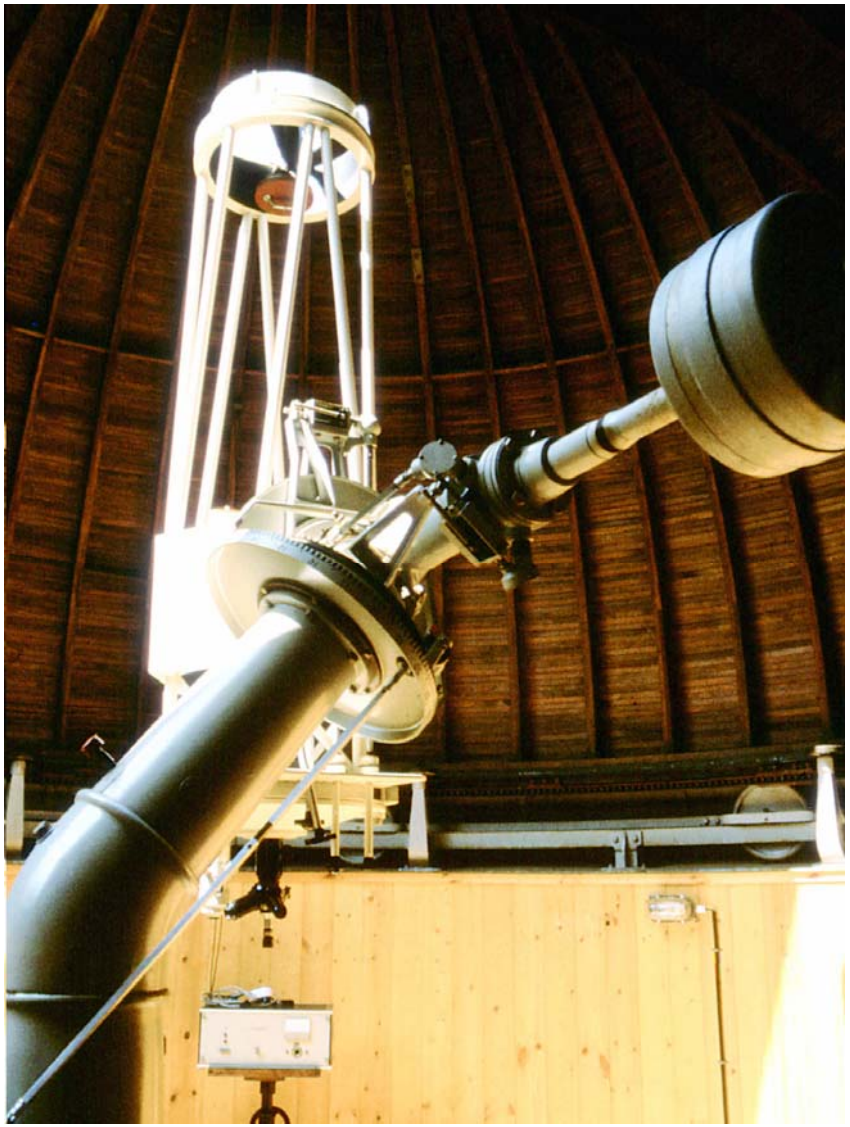
Image Path

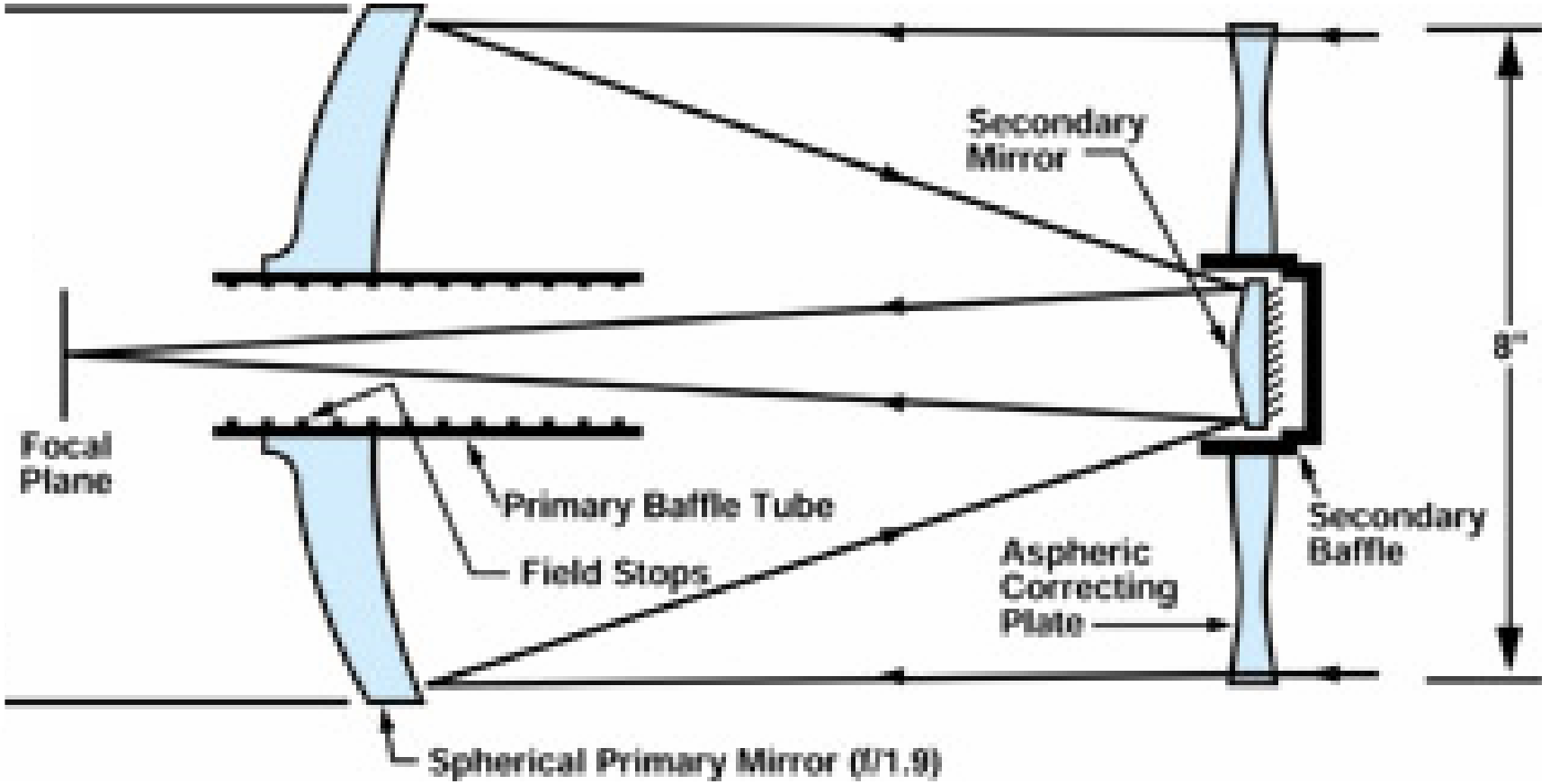

REFLECTOR: SPHERE. Radius = 7.00
4
2
0
−2
−4
0
2
4
6
8
10



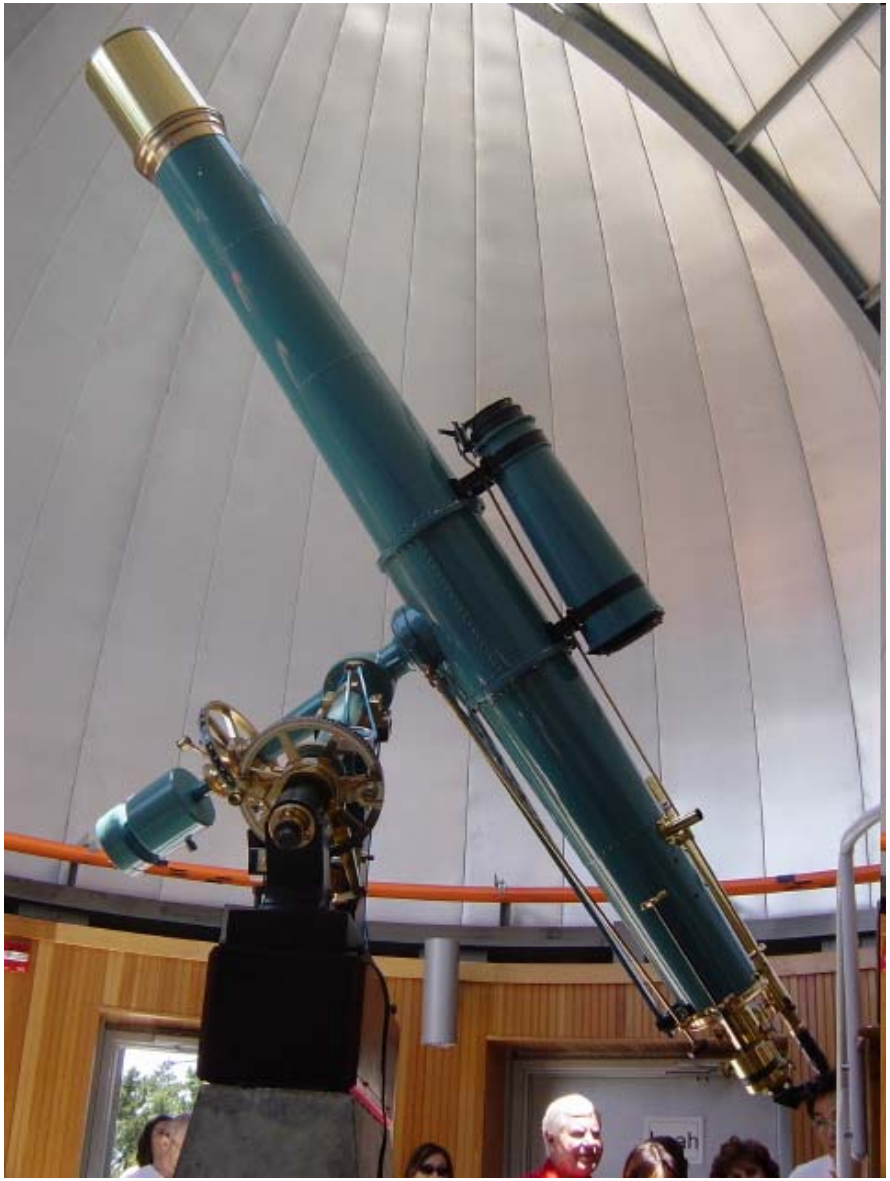
Cassegrain reflector (1672) used a convex secondary mirror and a concave **parabolic** primary mirror


REFLECTOR: PARABOLOID. FocDist = 7.00
4
2
0
−2
−4
0
2
4
6
8
10

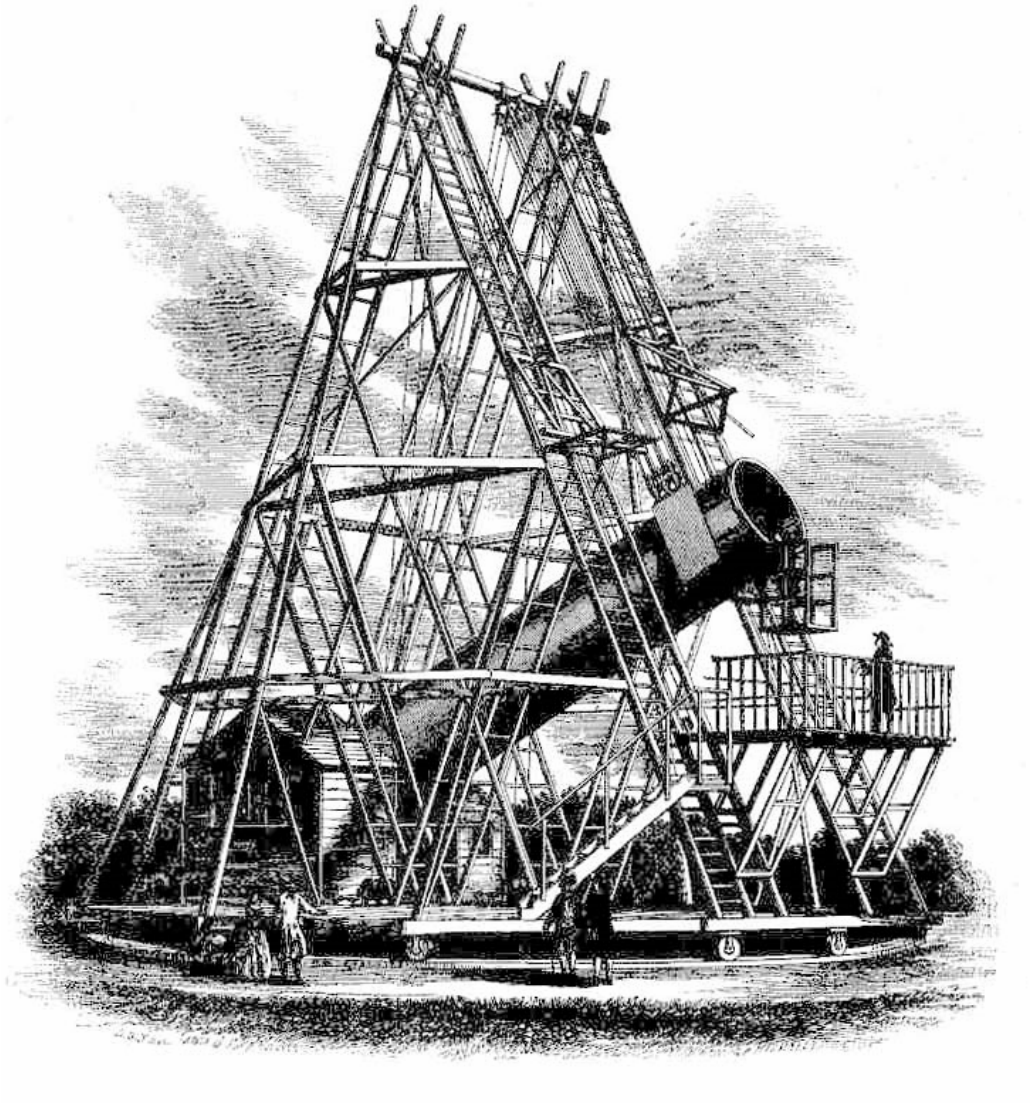


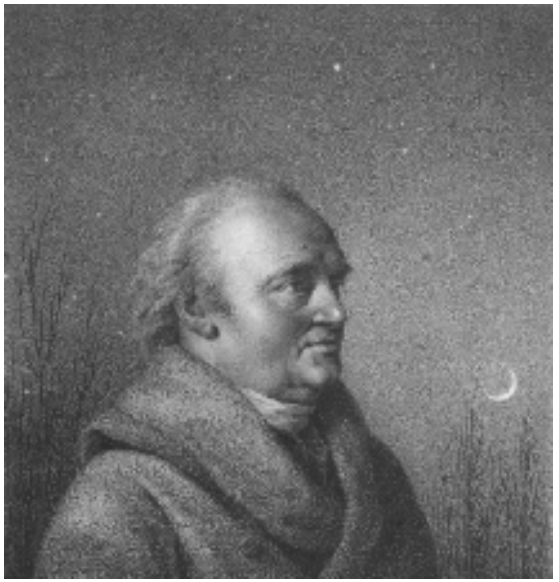


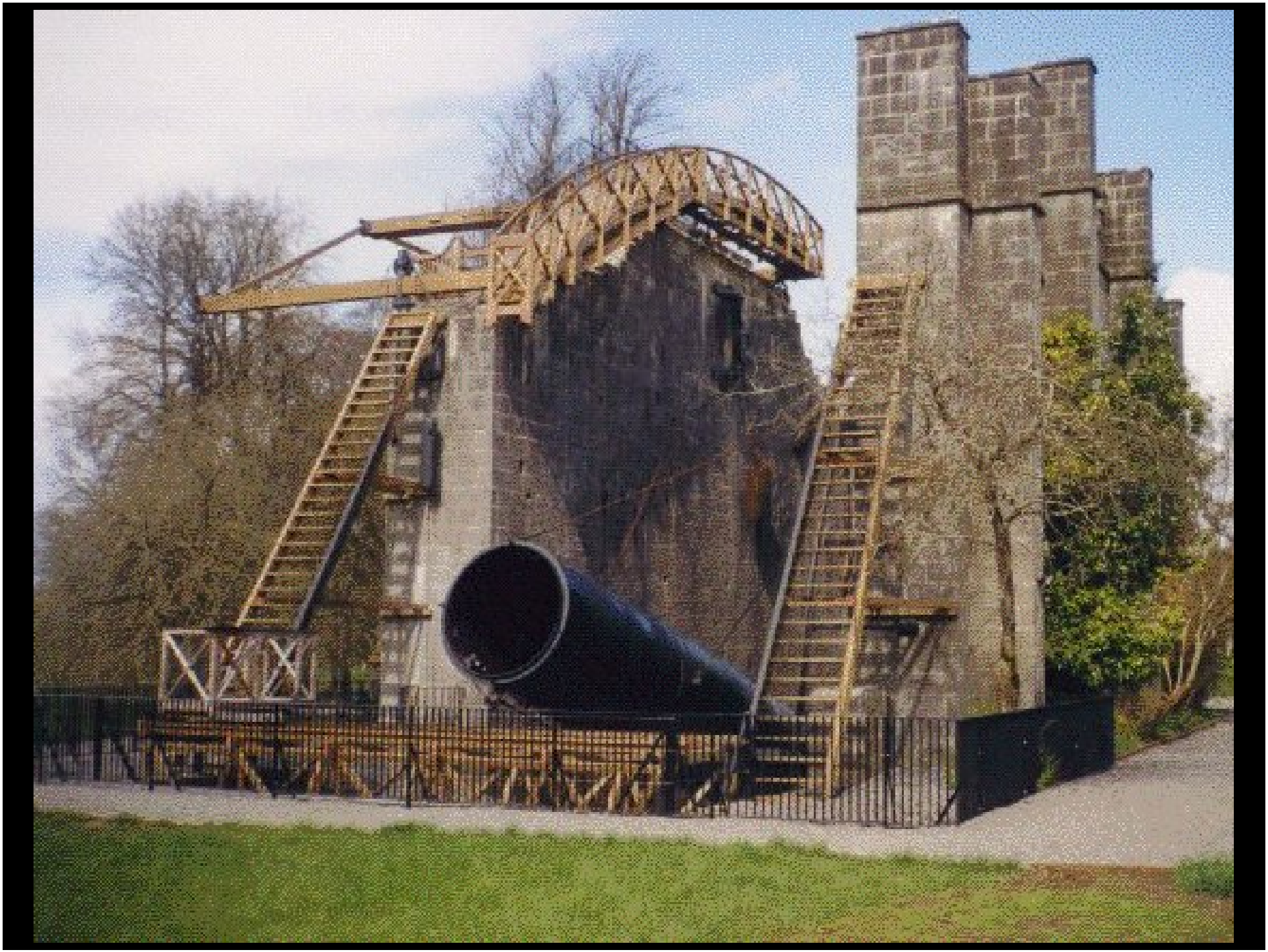
Schmidt-Cassegrain: correcting plate achieves a more compact design




MEADE
LX90







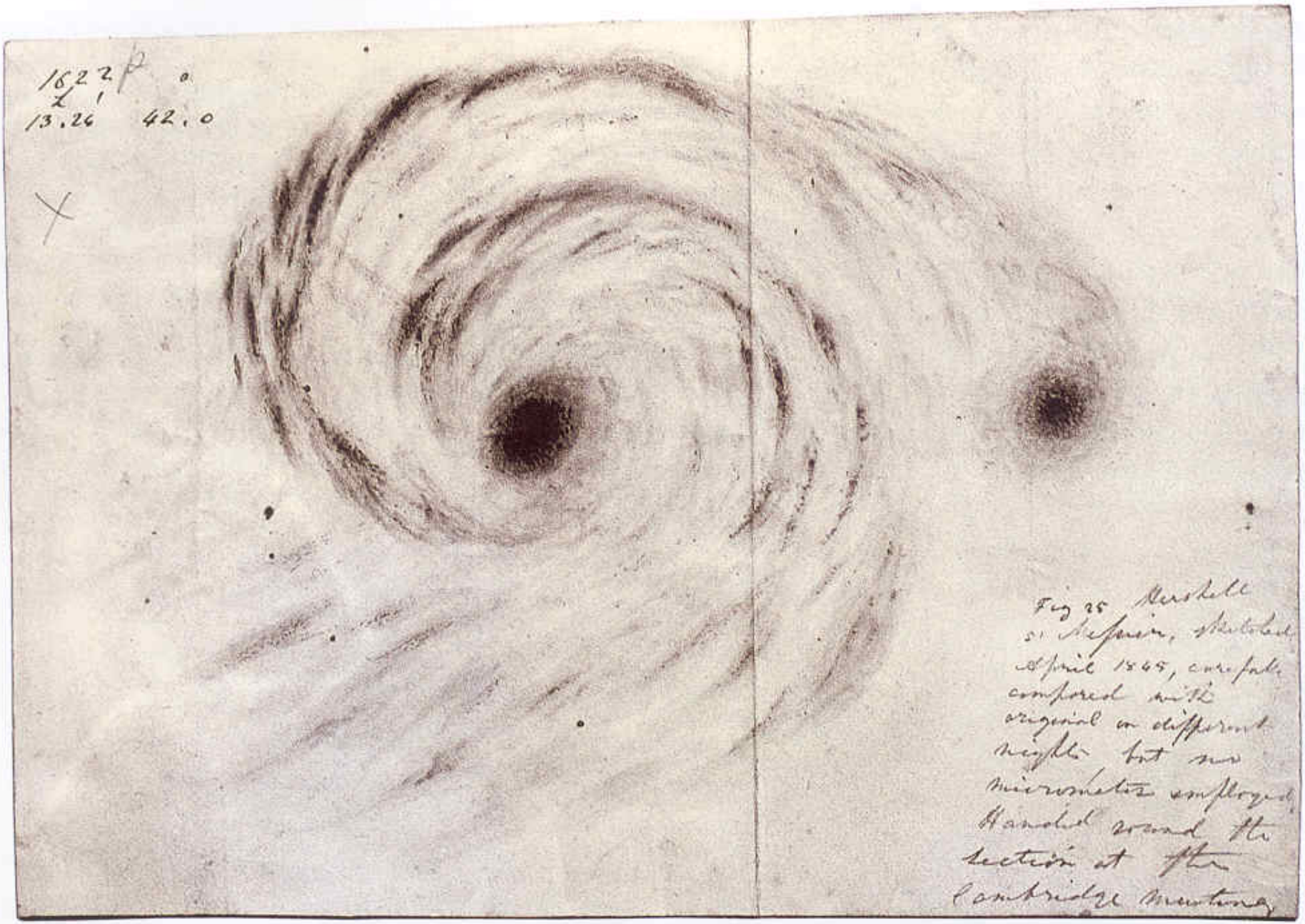
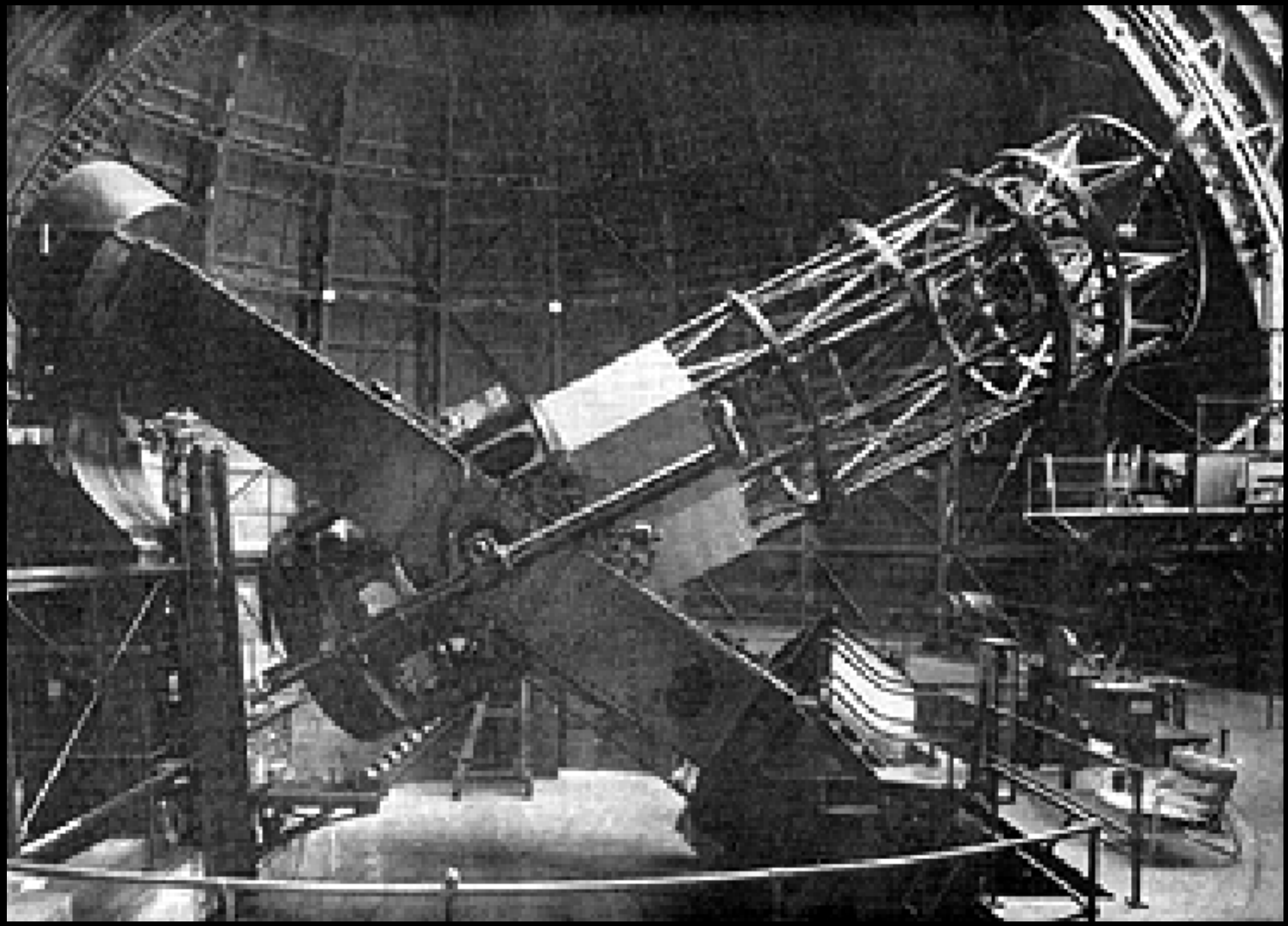
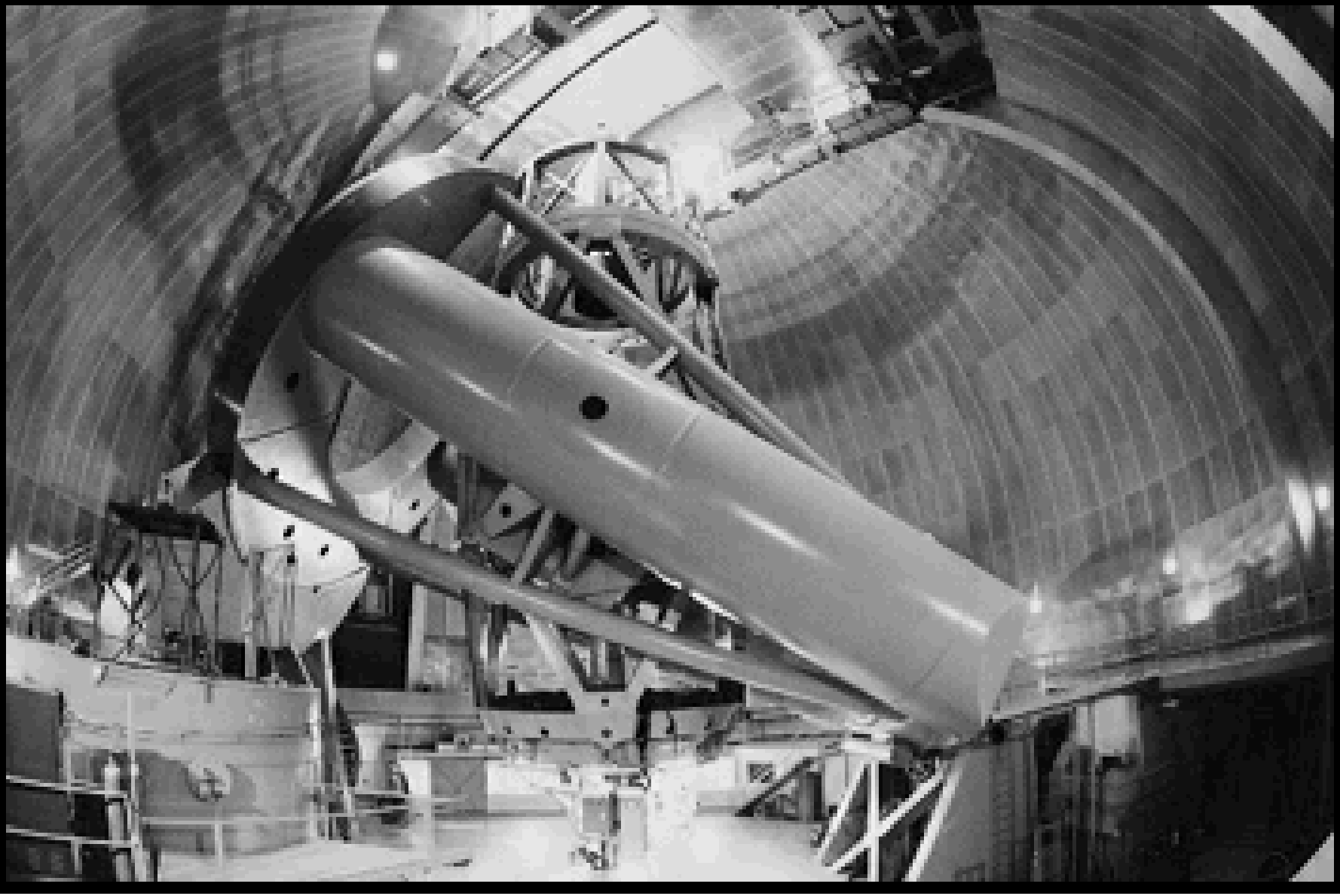


Fig 25 Marshall
St Neots, sketched
April 1845, carefully
compared with
original on different
nights but no
micrometer employed
Handed round the
section at after
Cambridge Meeting

100 inch Hooker reflector on Mount Wilson



200 inch Hale Reflector, Mt Palomar

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