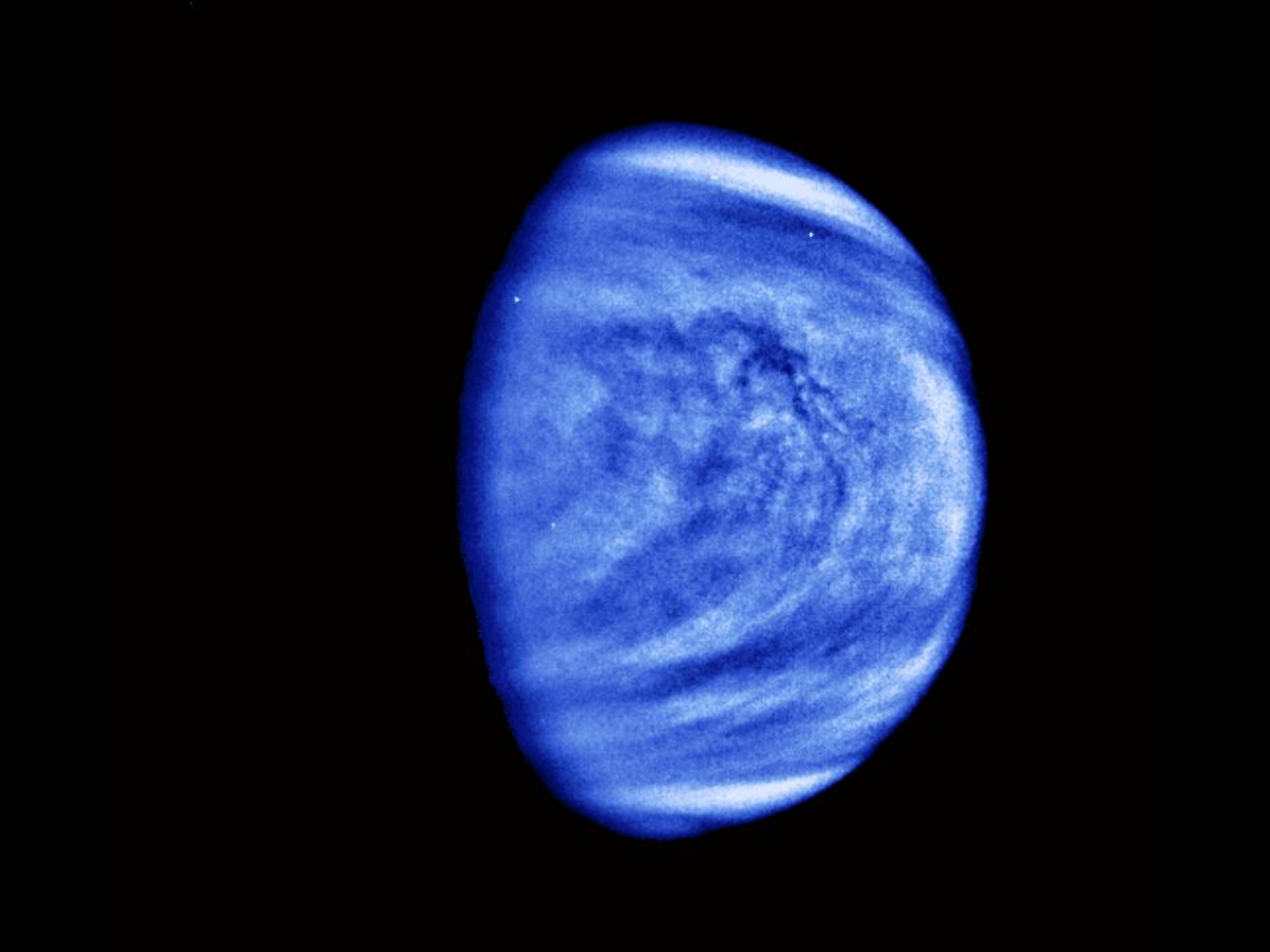
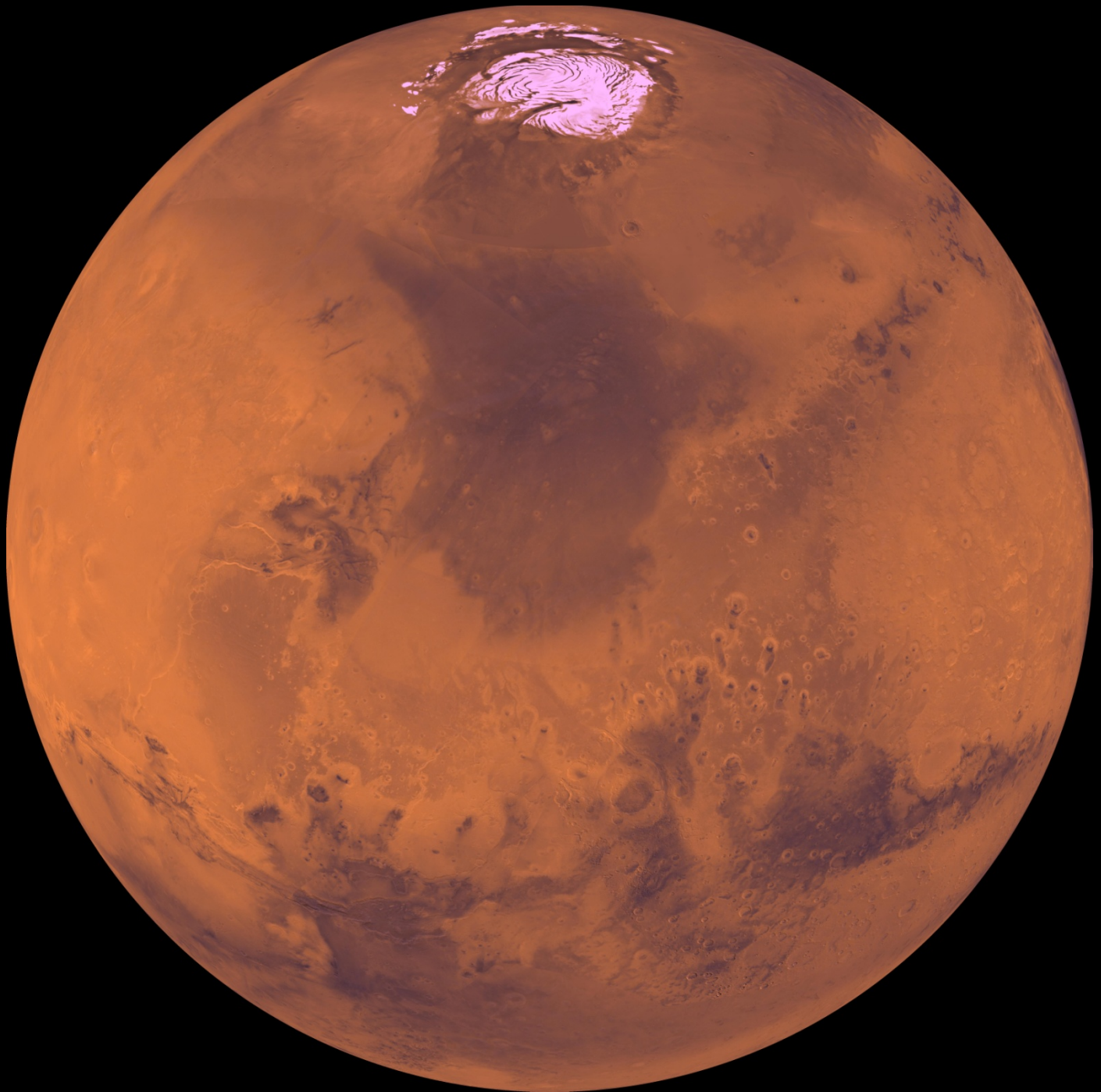
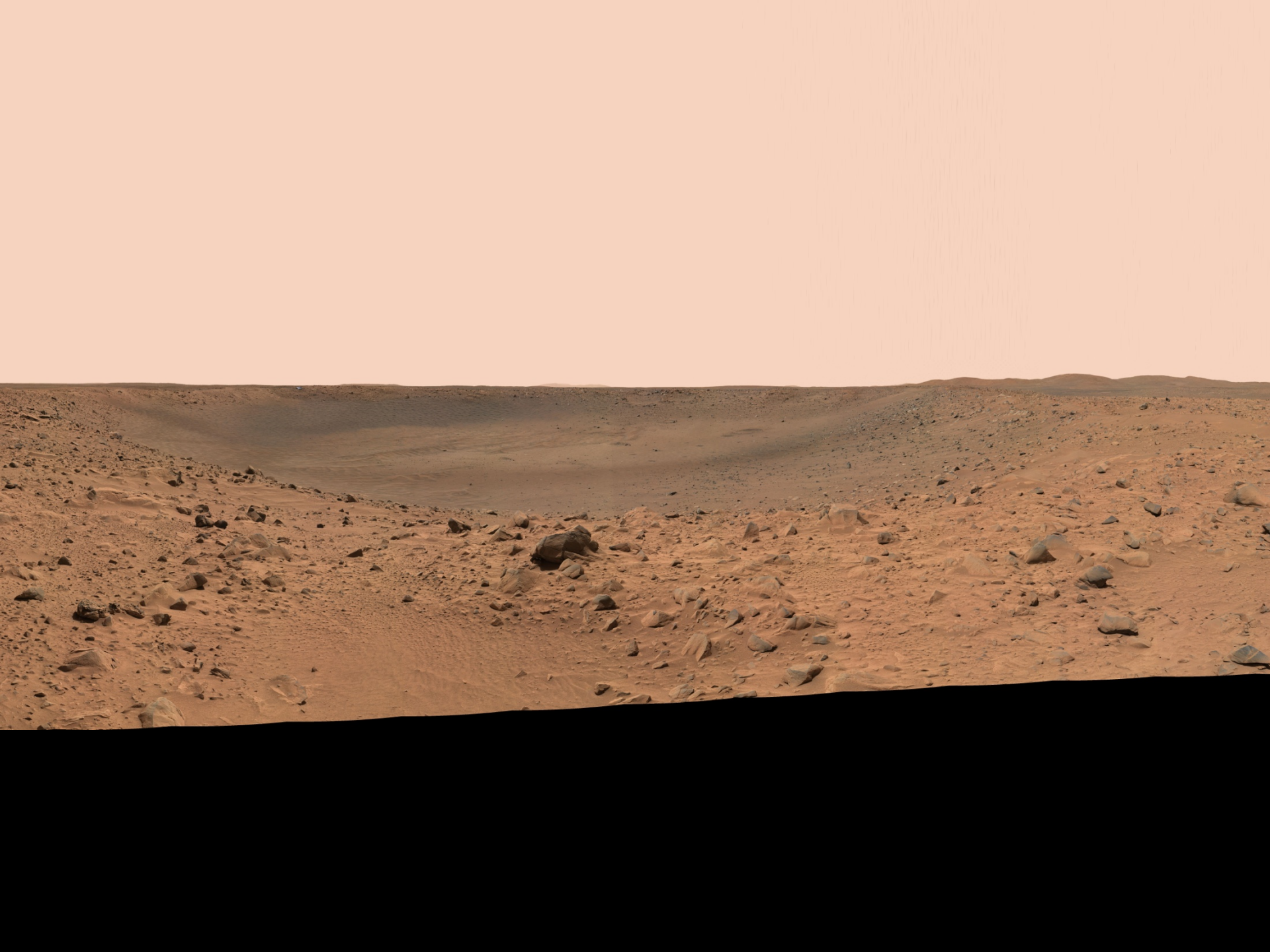
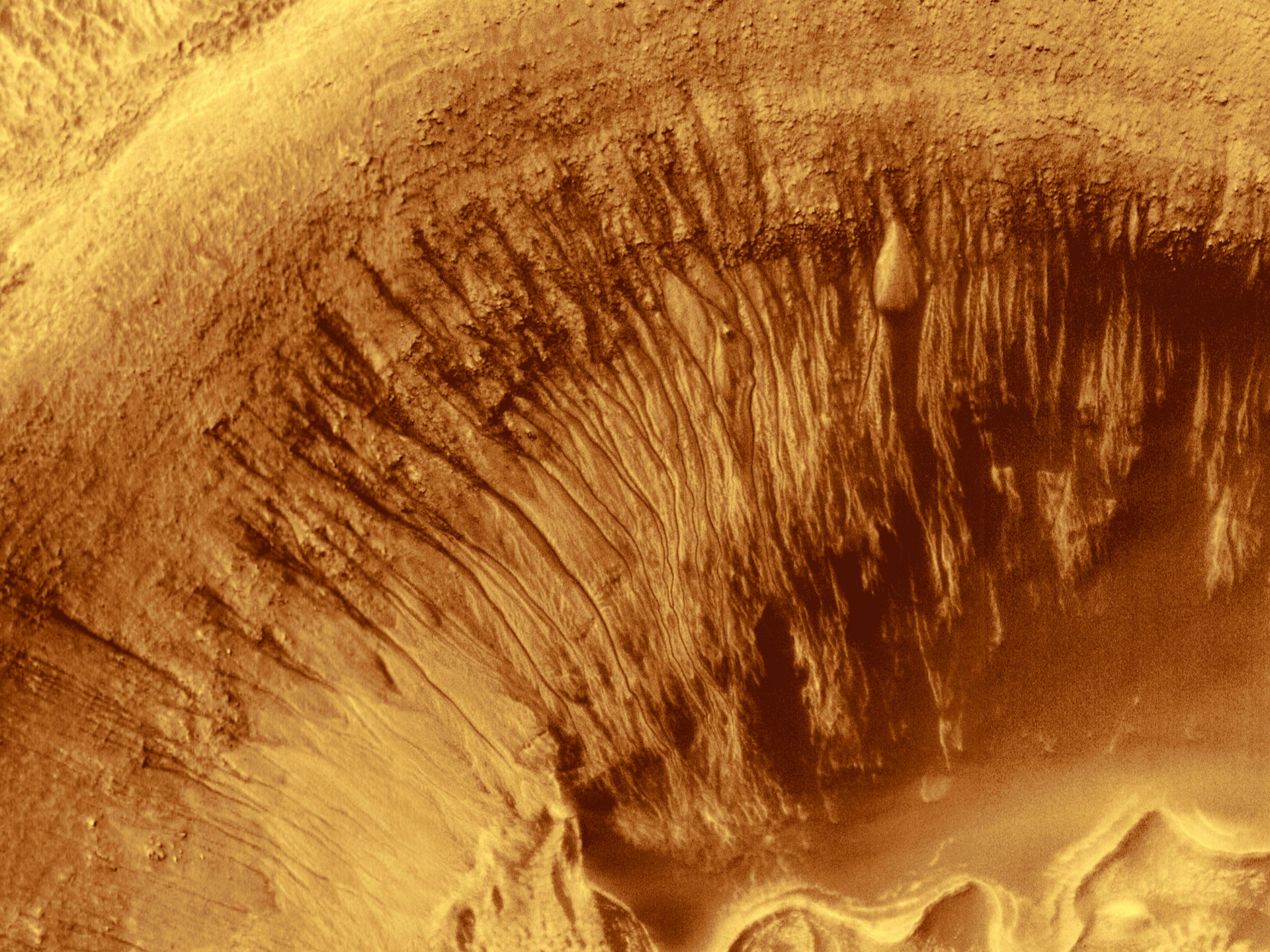
Prof Chris Done
Durham University

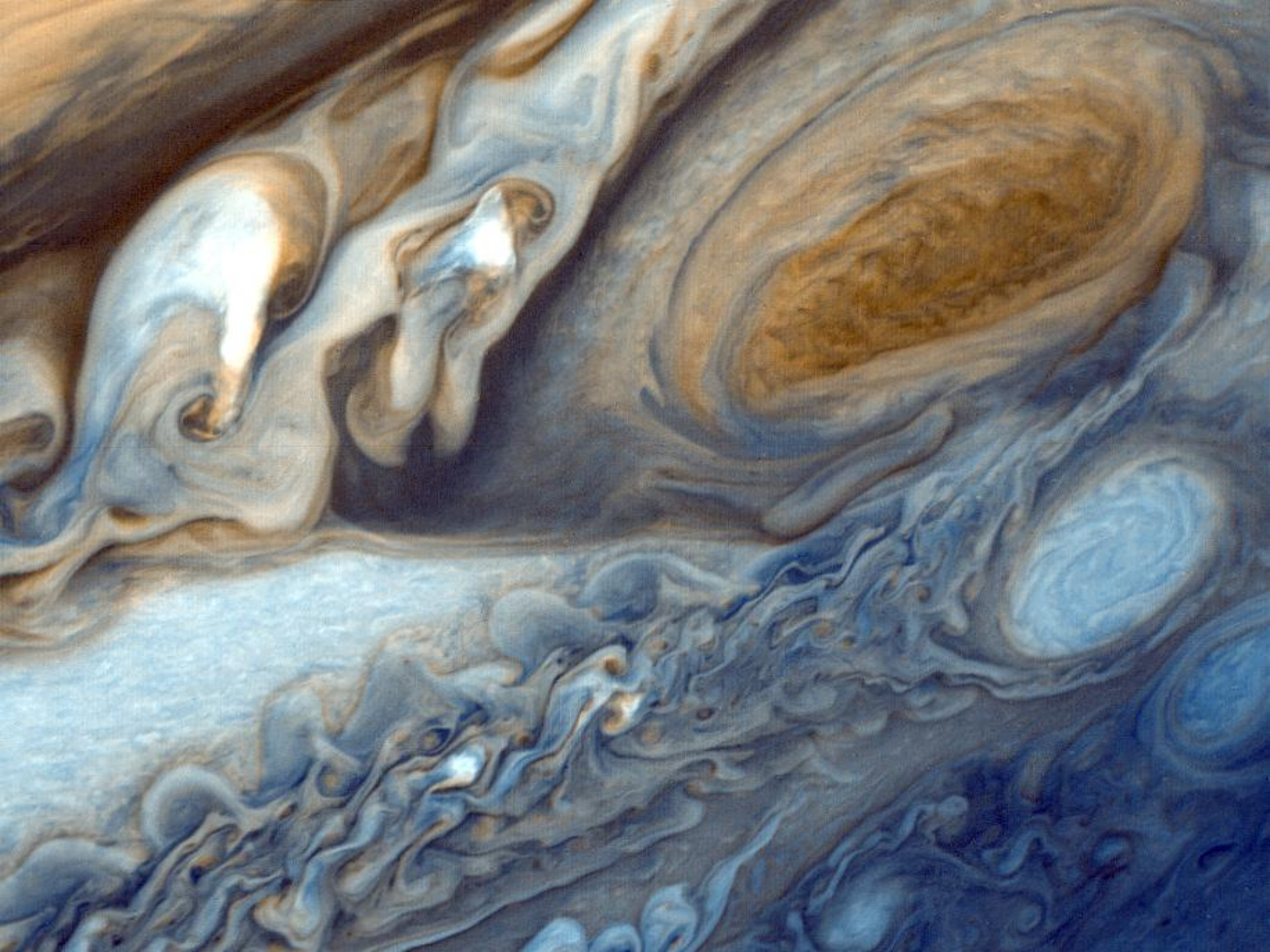
A guided tour of the Universe

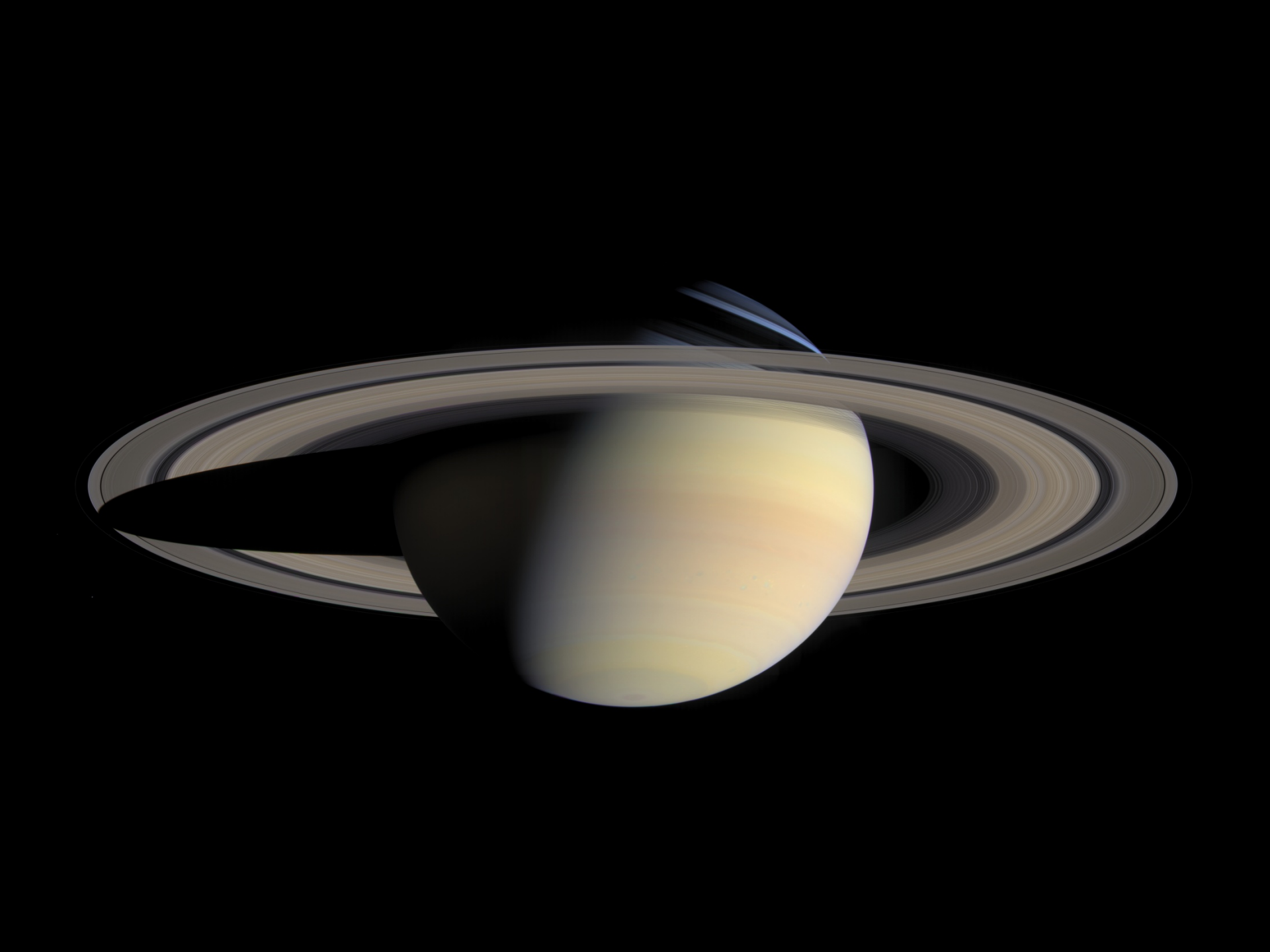


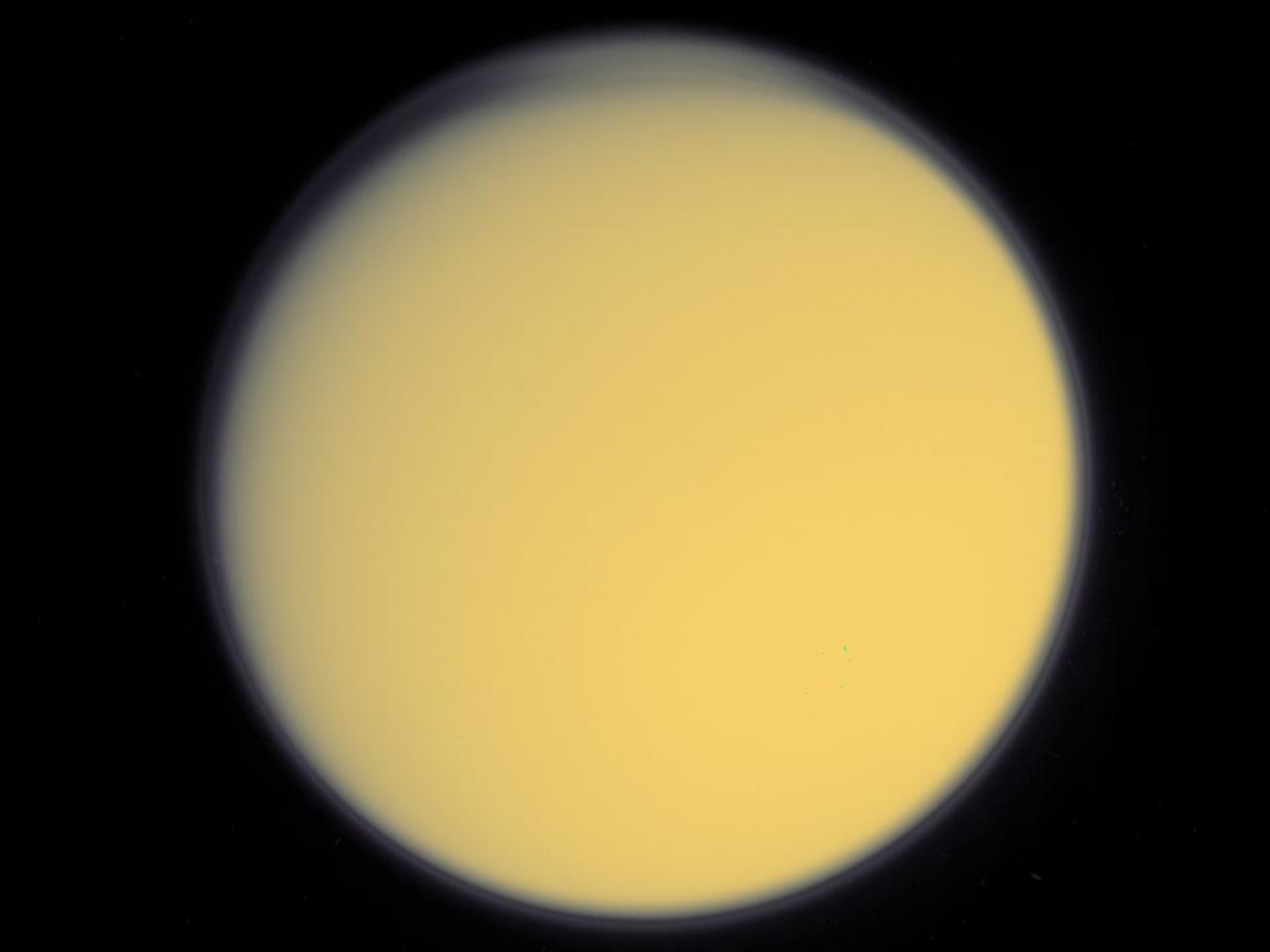


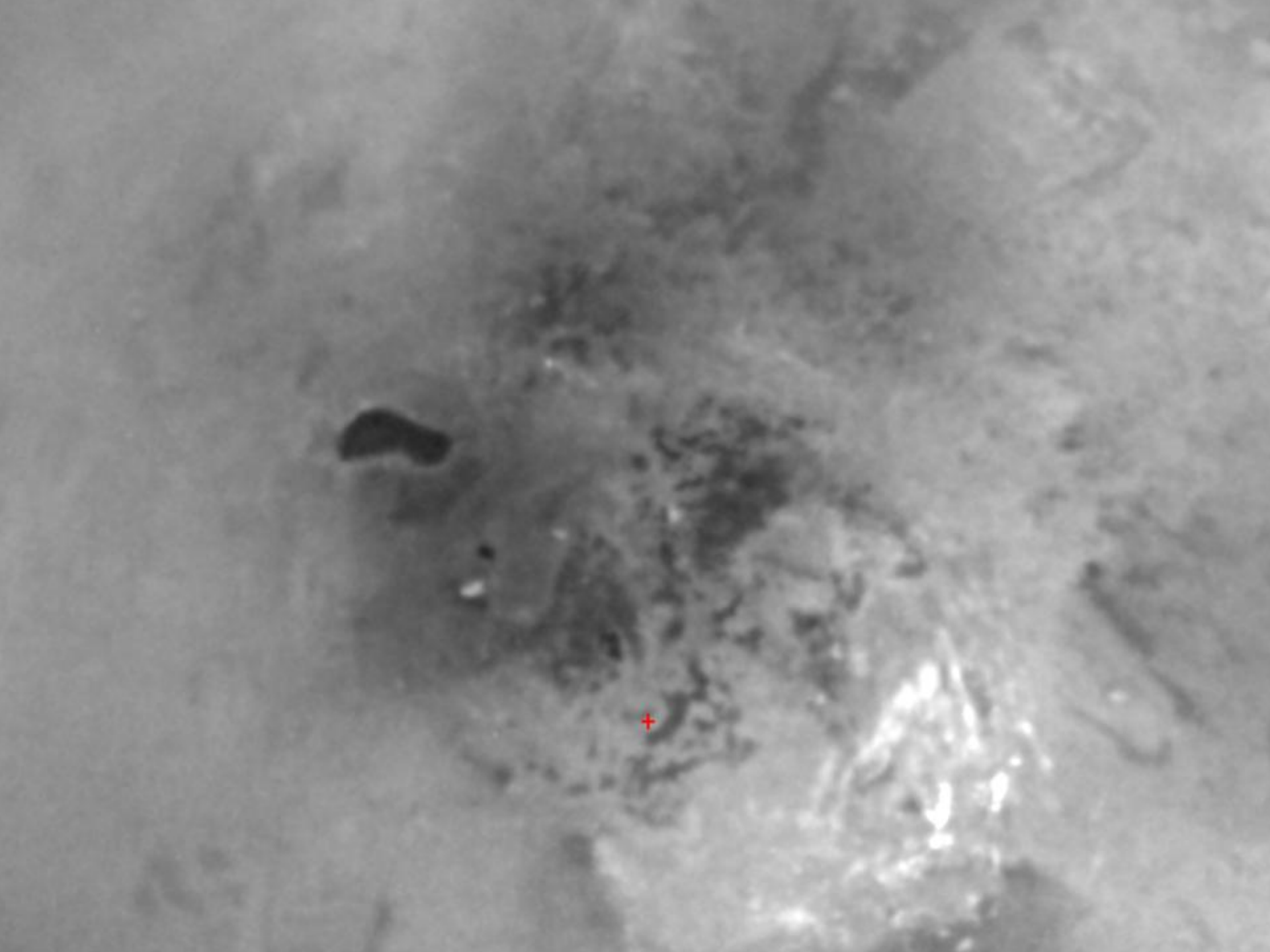


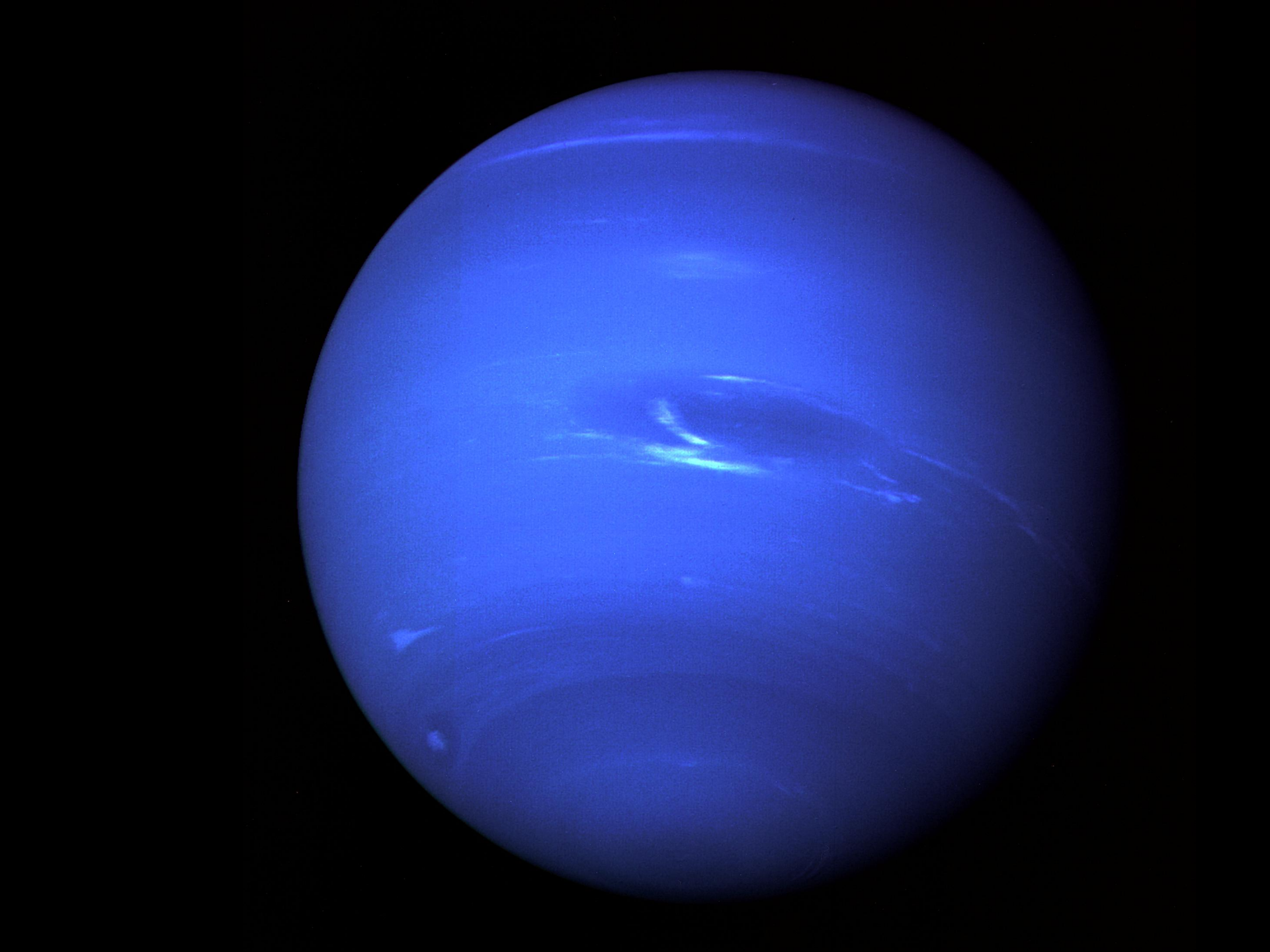


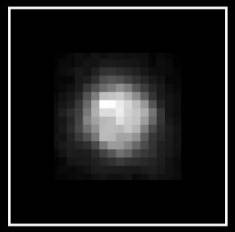


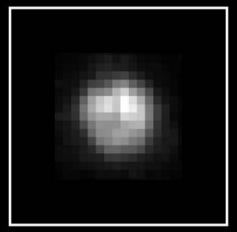


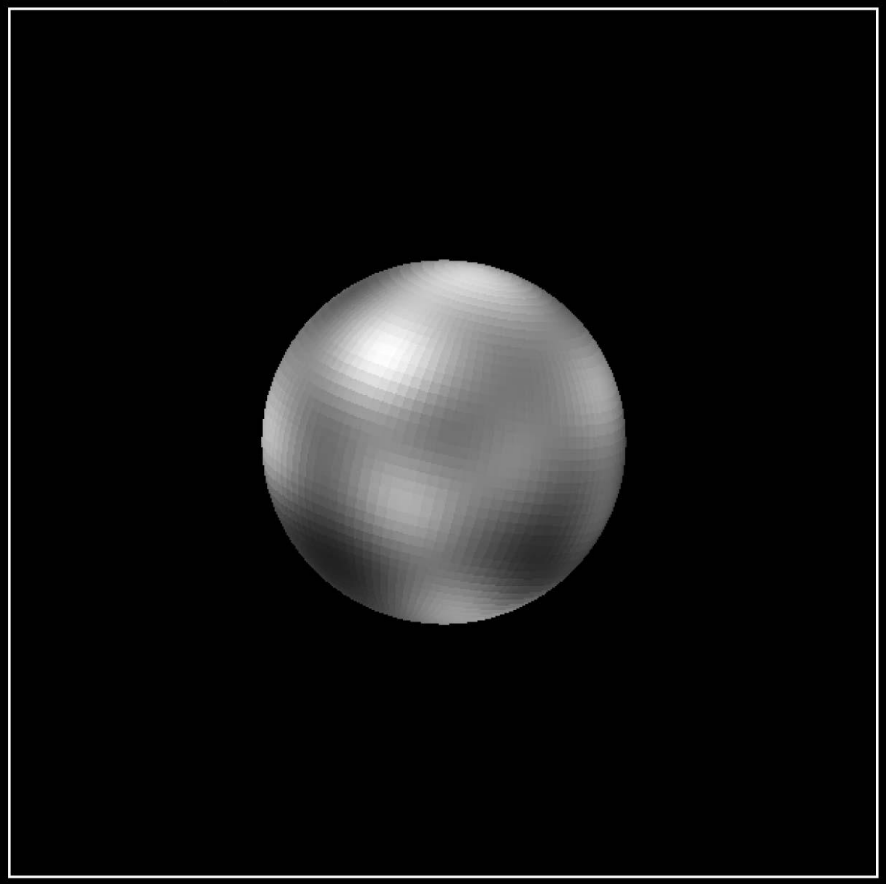


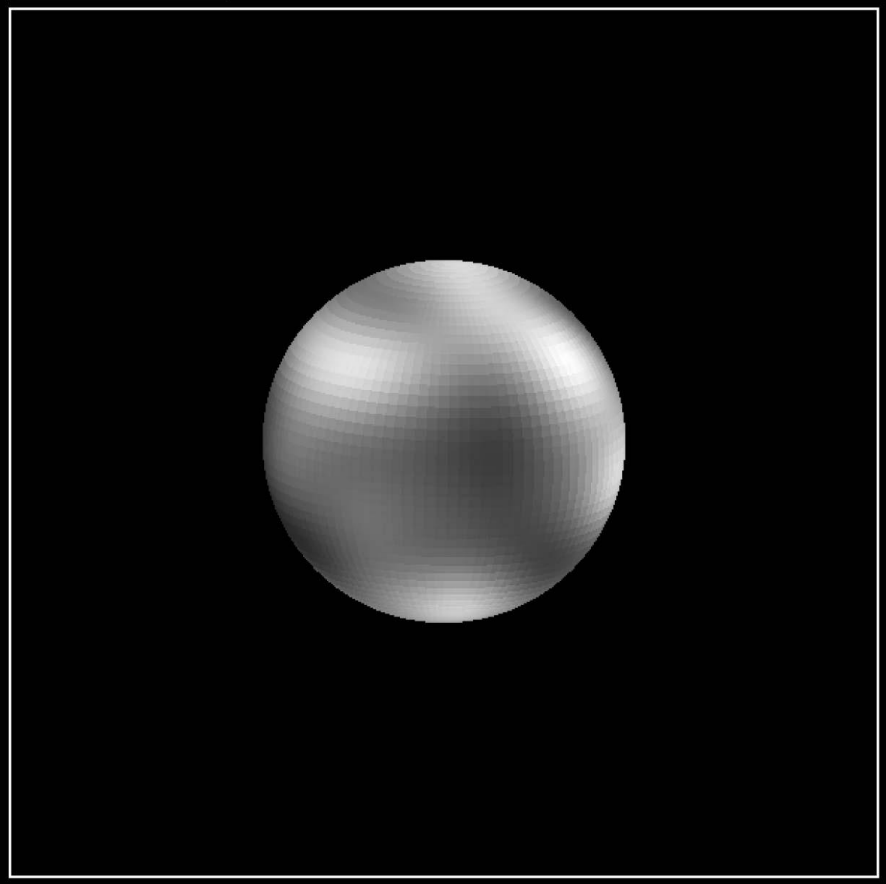








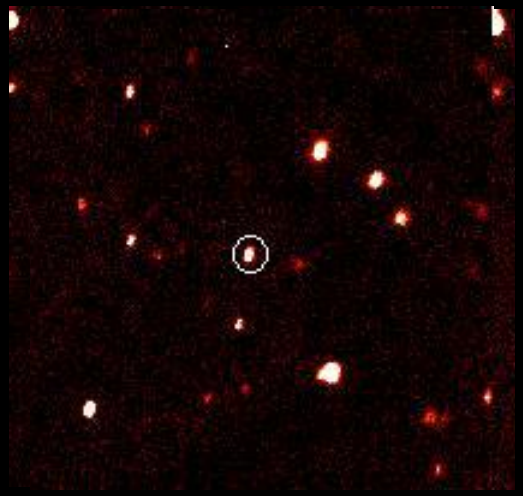


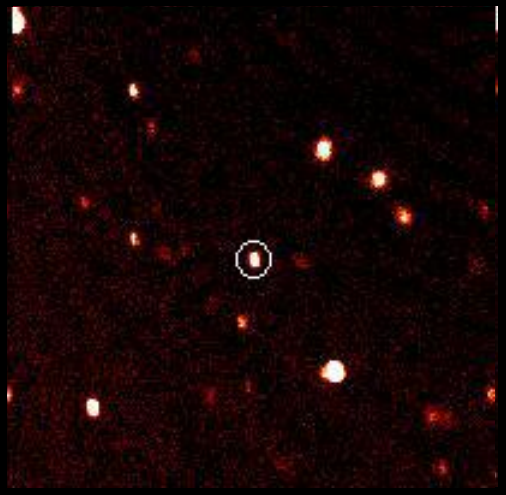


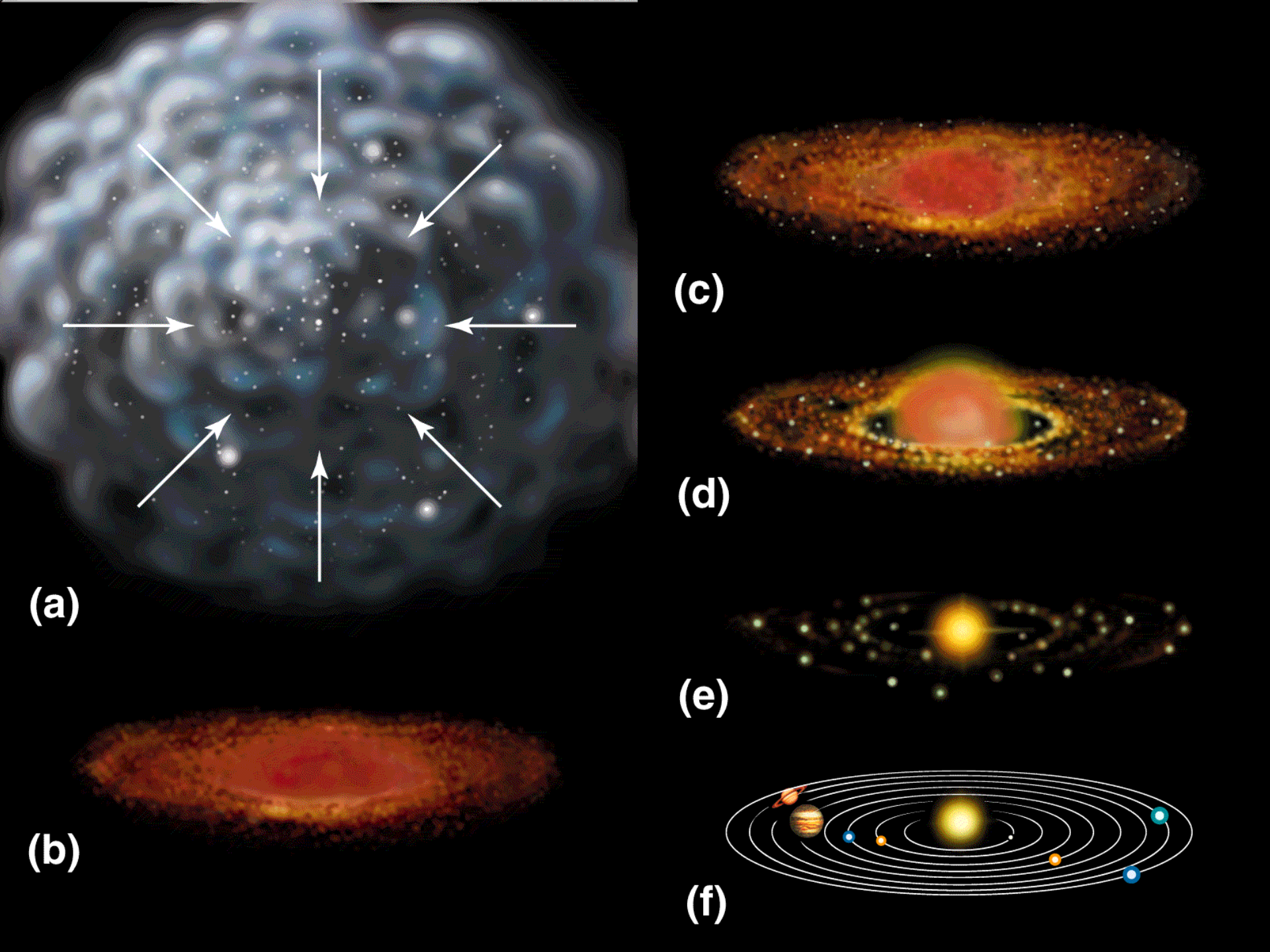
Pluto

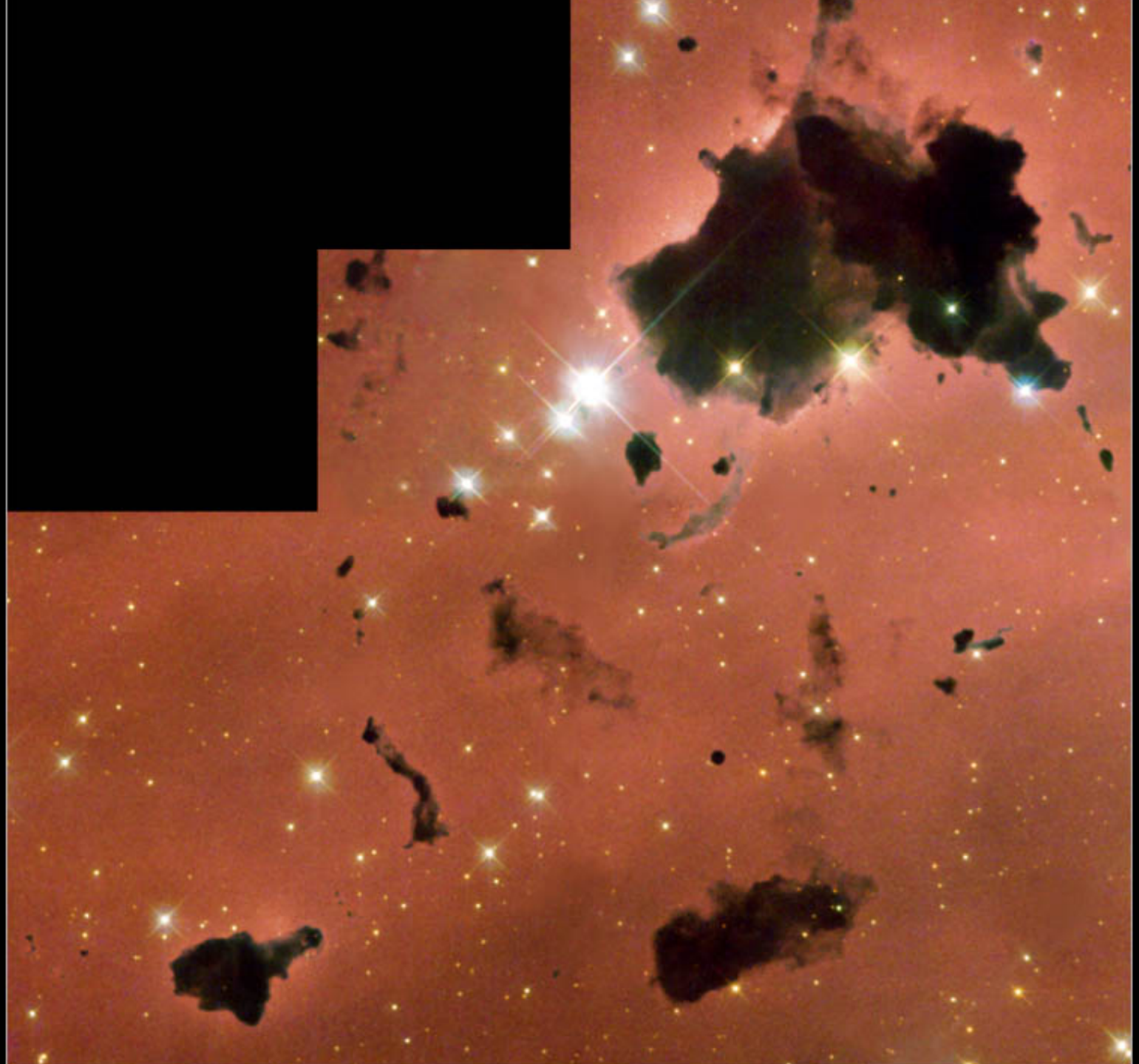
Hubble Space Telescope • Faint Object Camera

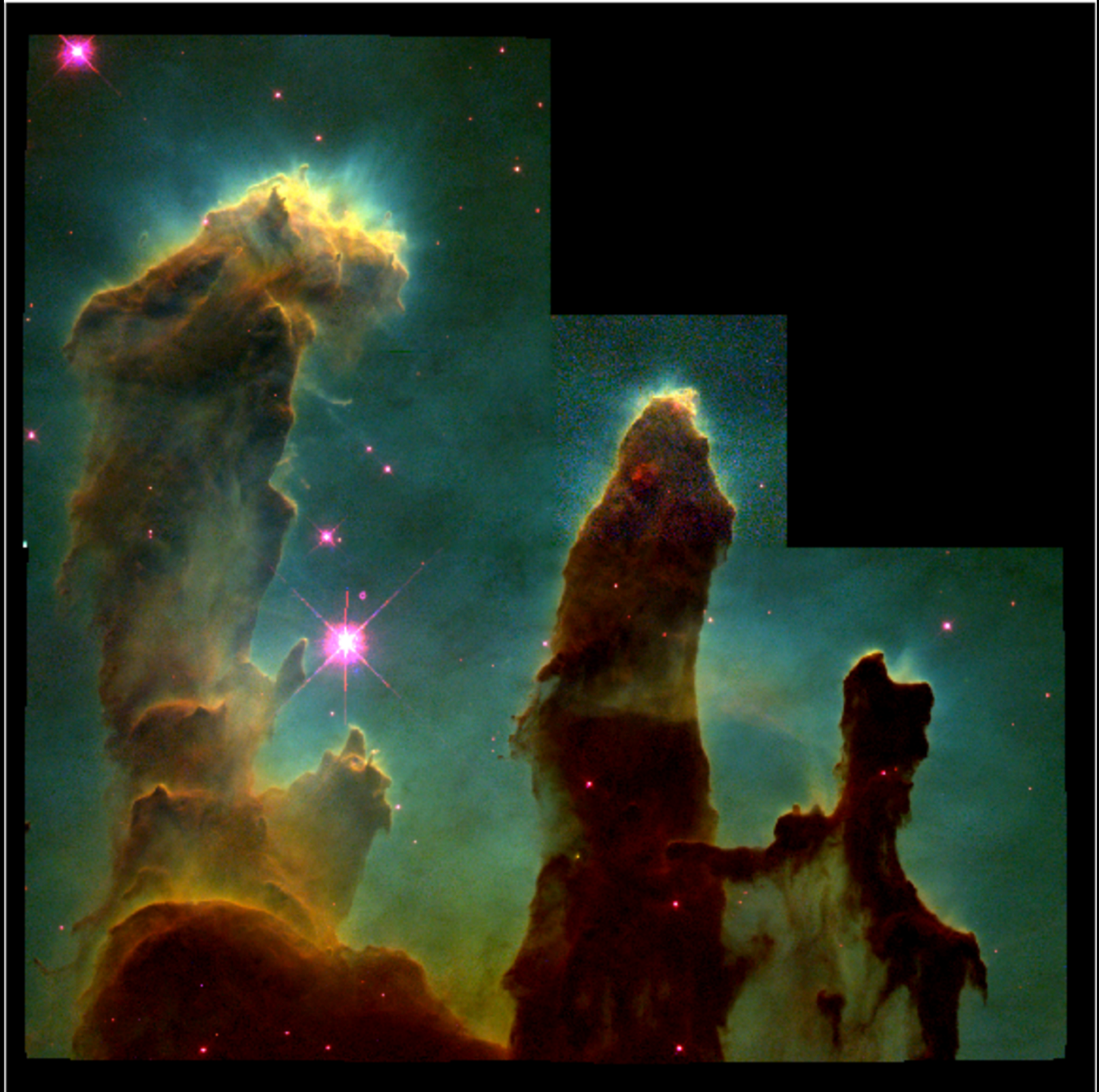
PRC96-09a • ST ScI OPO • March 7, 1996 • A. Stern (SwRI), M. Buie (Lowell Obs.), NASA, ESA

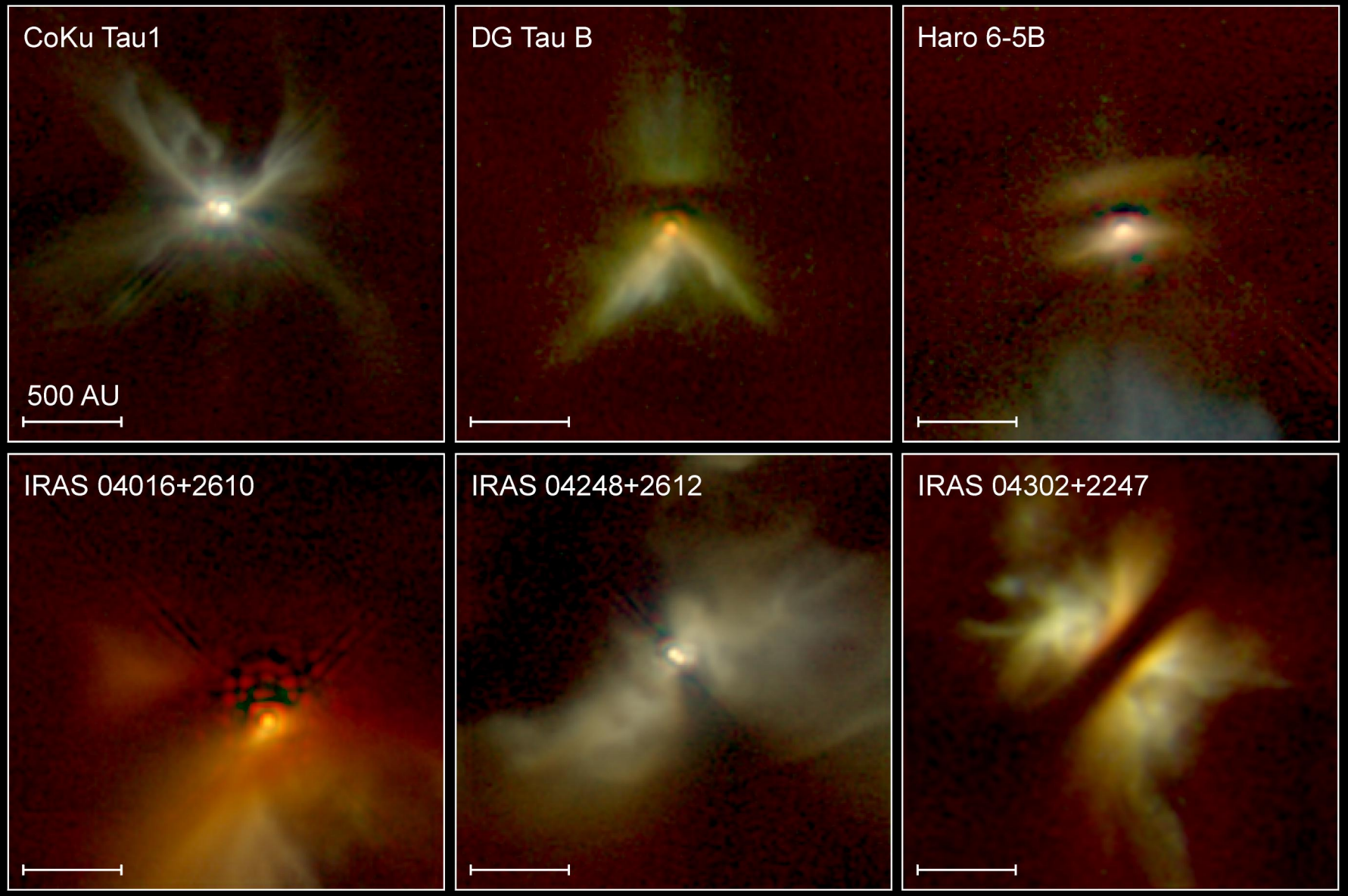





(a)
(b)
(c)
(d)
(e)
(f)



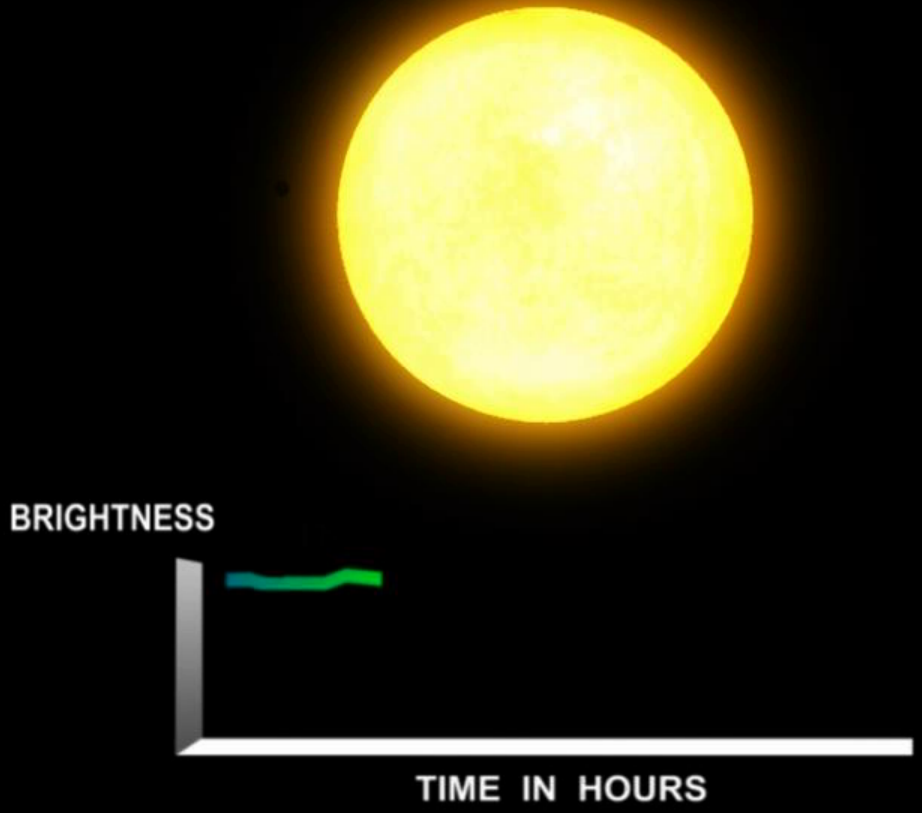


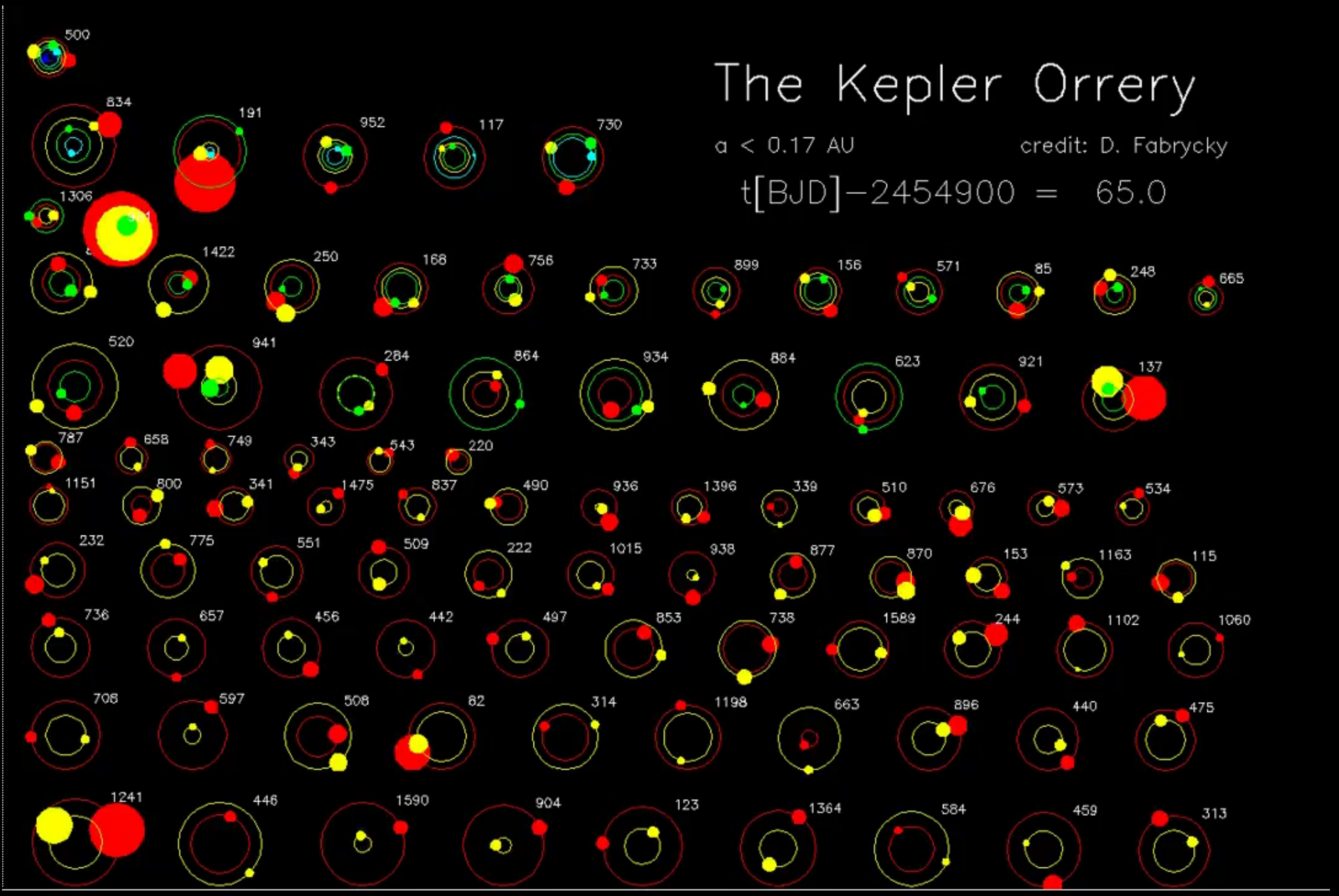


Young Stellar Disks in Infrared

Hubble Space Telescope • NICMOS

NASA Kepler mission to detect Earth sized planets March 7 2009


BRIGHTNESS
TIME IN HOURS


The Kepler Orrery
a < 0.17 AU
credit: D. Fabrycky
t[BJD]−2454900 = 65.0
500
834
191
952
117
730
1306
1422
250
168
756
733
899
156
571
85
248
665
520
941
284
864
934
884
623
921
137
787
658
749
343
543
220
1151
800
341
1475
837
490
936
1396
339
510
676
573
534
232
775
551
509
222
1015
938
877
870
153
1163
115
736
657
456
442
497
853
738
1589
244
1102
1060
708
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1590
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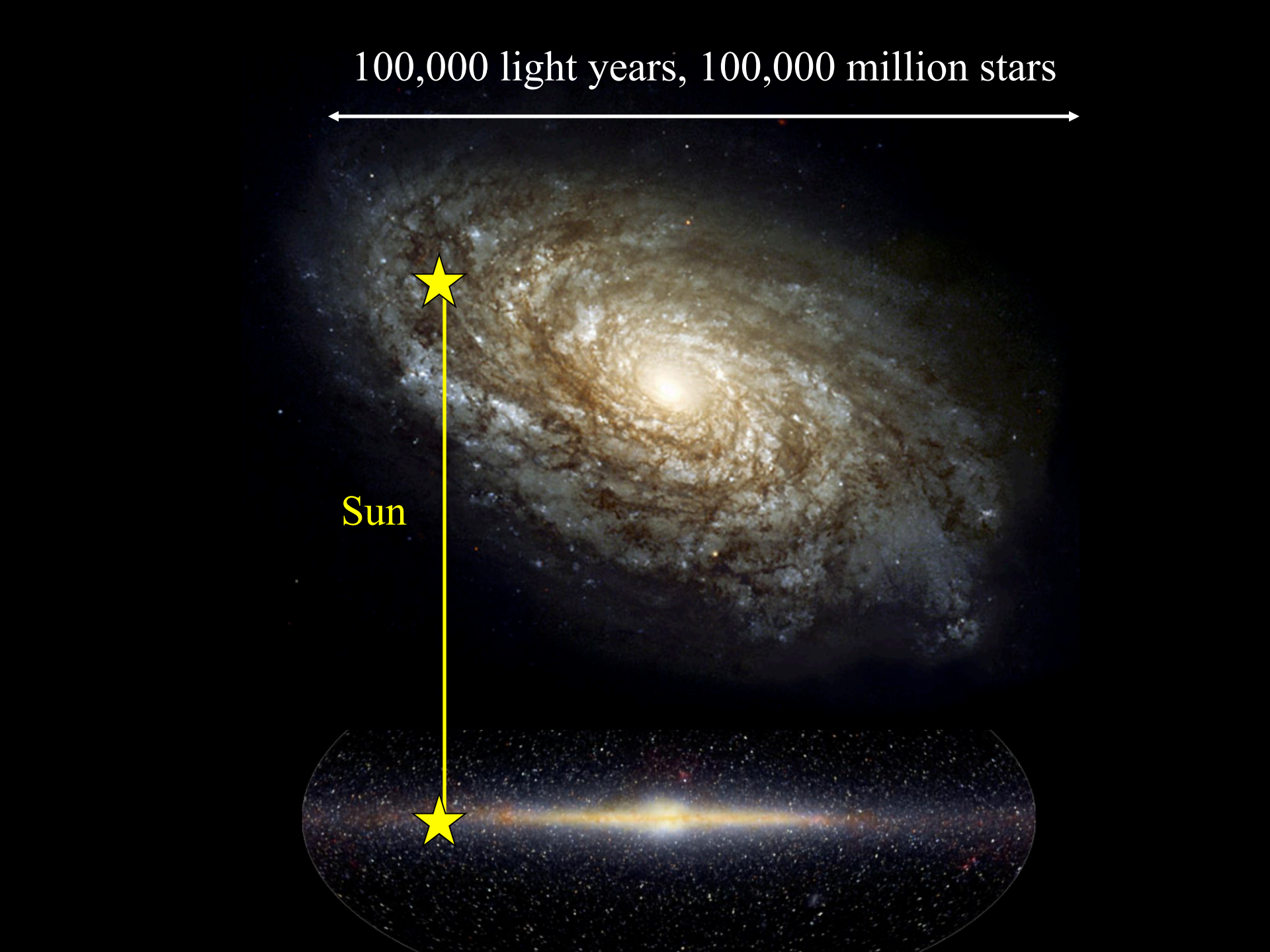
459
313

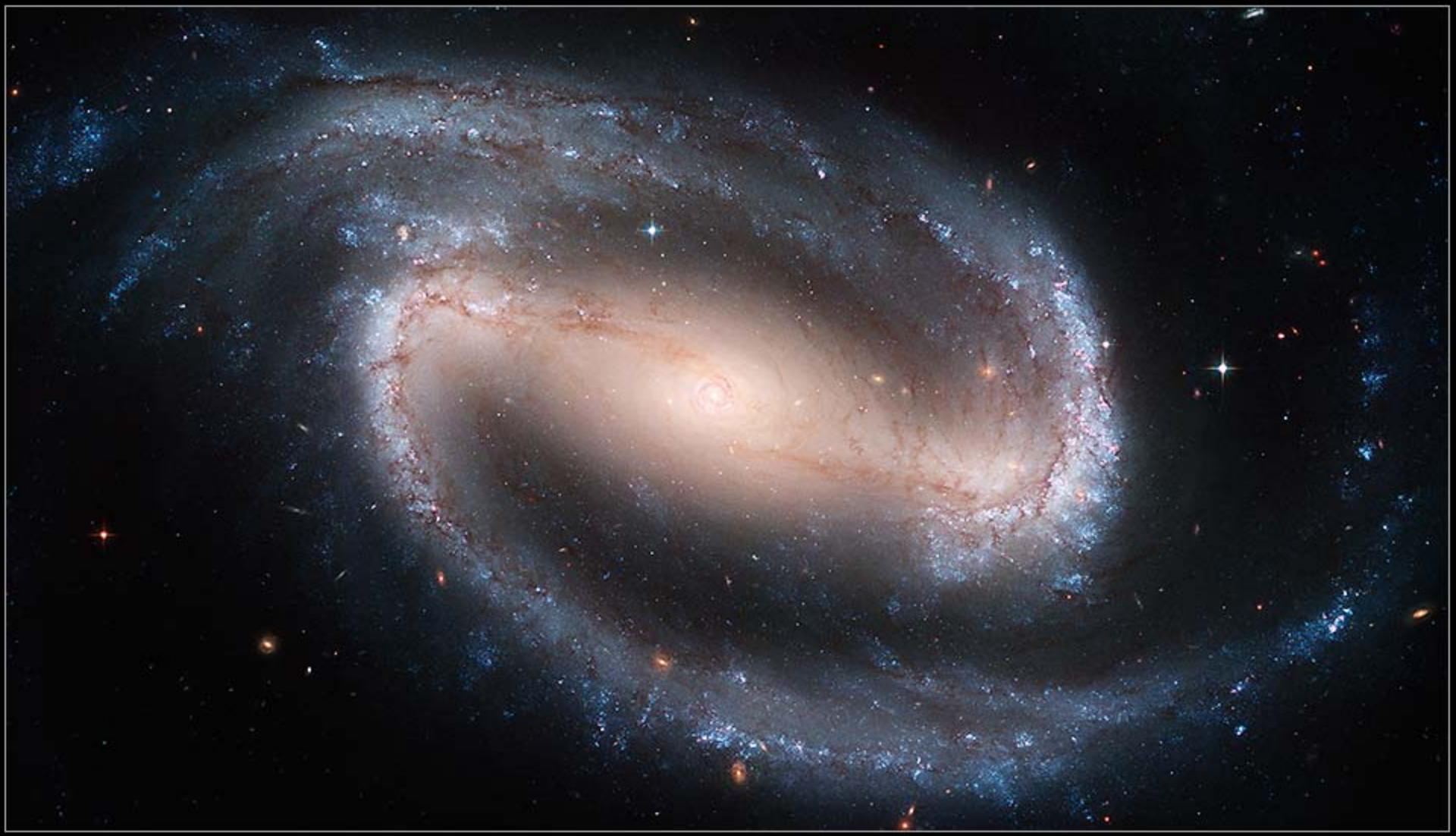

100,000 light years, 100,000 million stars
Sun

Edge-On Galaxy NGC 4013

Spiral Galaxy NGC 3370

Hubble Heritage

Barred Spiral Galaxy NGC 1300

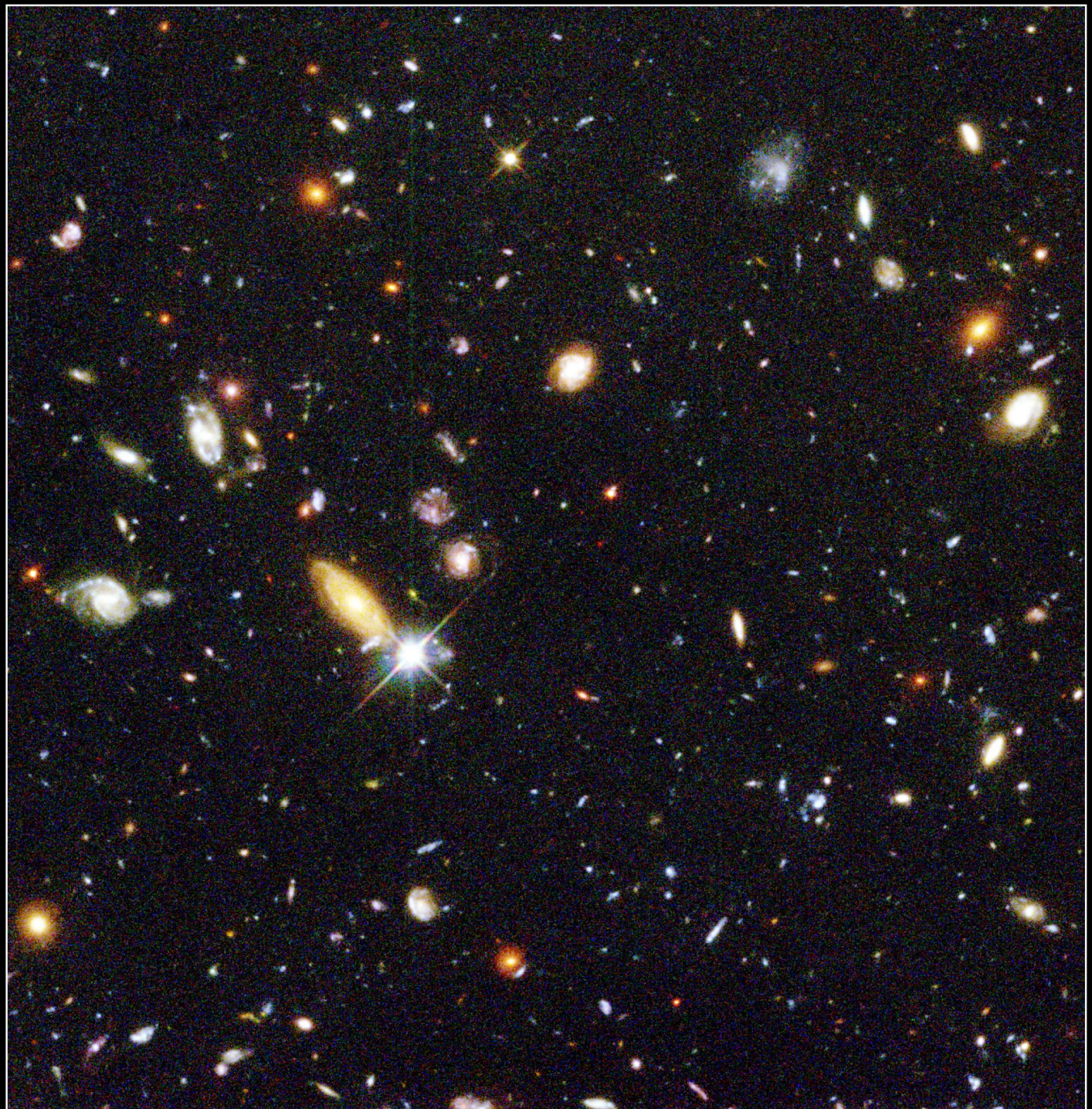


Hubble Heritage

Sombrero Galaxy • M104

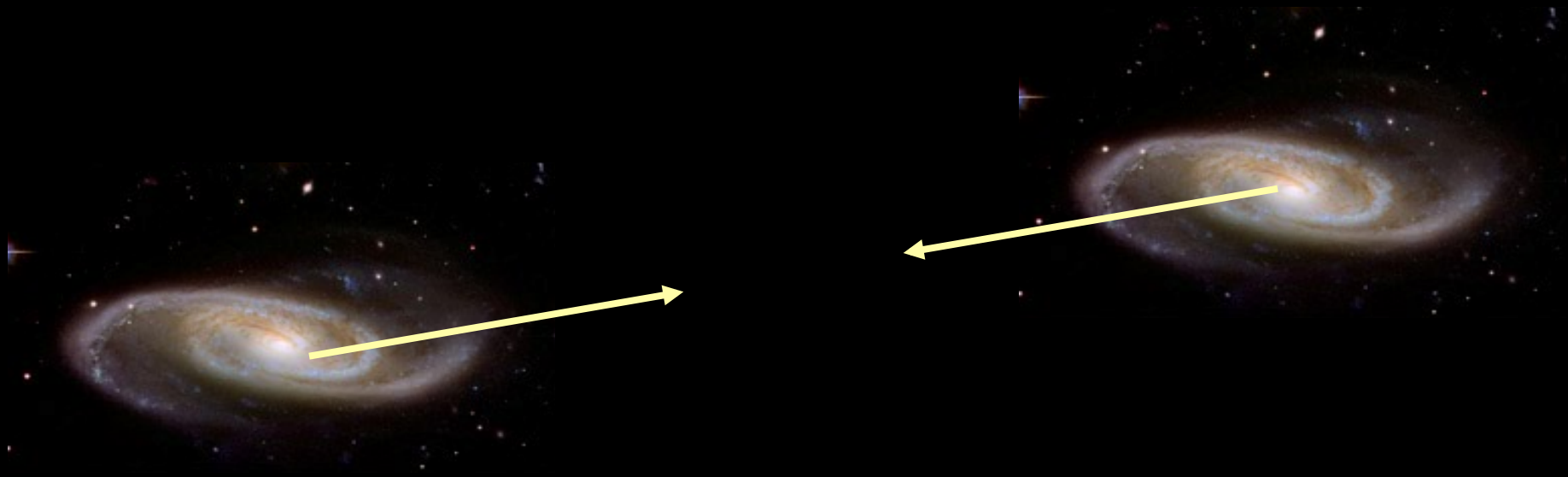
Hubble Heritage


© Agrabi Australian Observatories



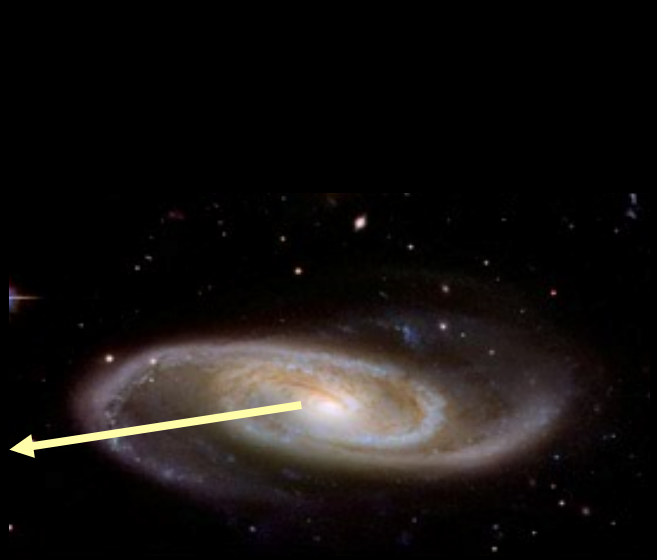
An expanding Universe

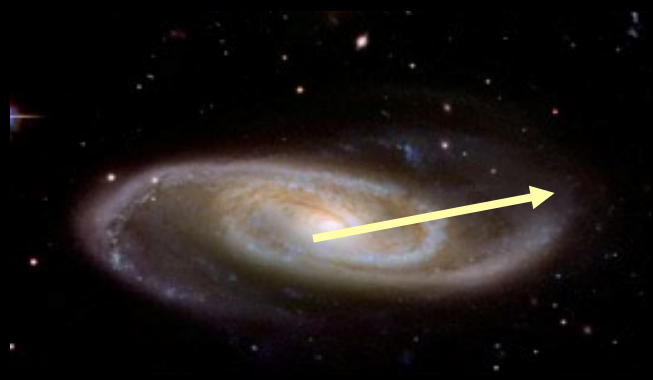
- Can’t be static, unchanging, eternal universe if gravity!
- Galaxies have gravity so attract each other
- So should be all moving towards each other



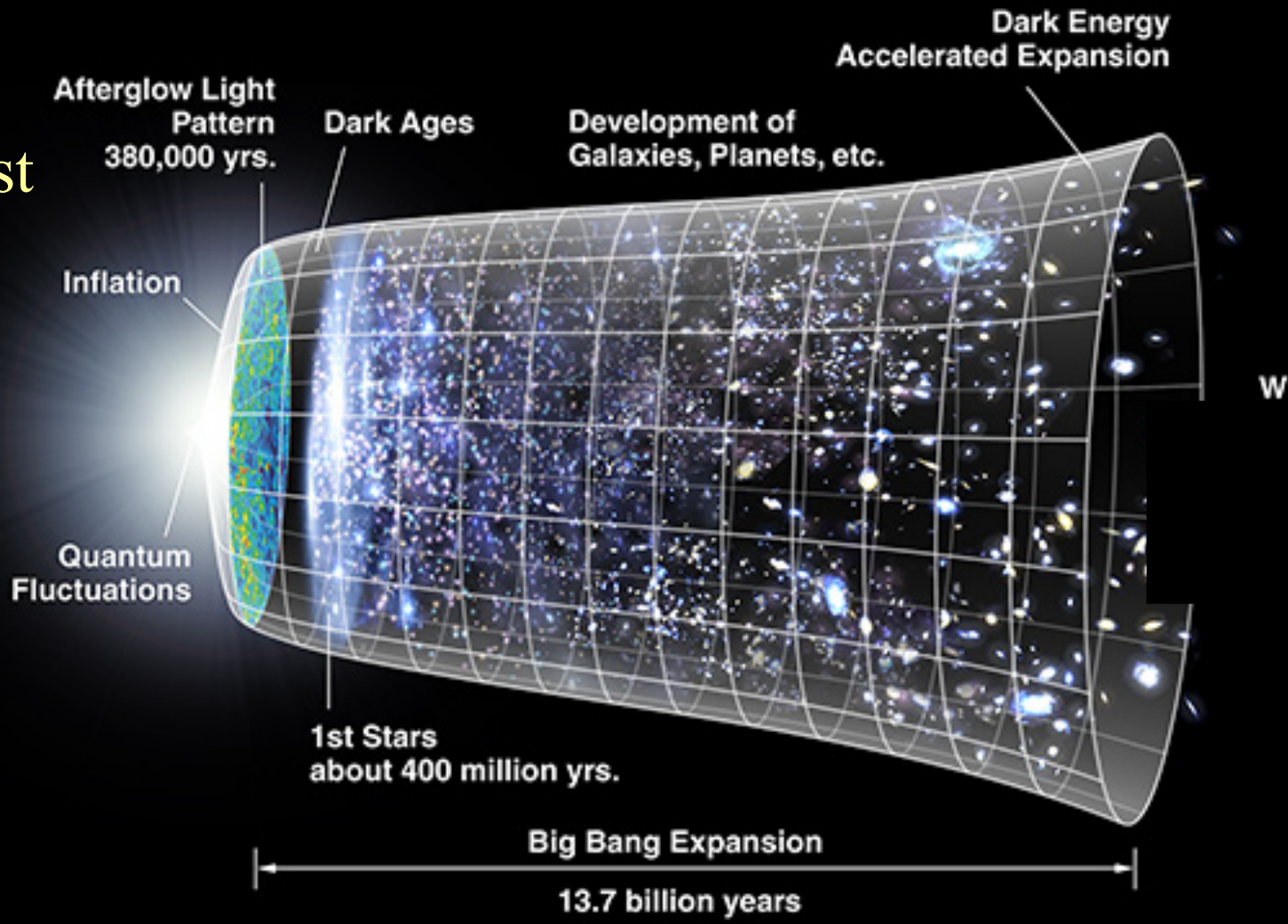
An expanding Universe

- Can’t be static, unchanging, eternal universe if gravity!
- Galaxies have gravity so attract each other
- So should be all moving towards each other
- But actually they are overwhelmingly moving away!





- Galaxies closer in past
- Very dense, universe in past - hot
- Very different from what we see now



Life on Mars?

- Martian meteorite?
- Mars gets hit by asteroid, rocks escape, eventually hit Earth
- Find in Antarctica (rock on snow!)
- MAYBE fossil bacteria: but ambiguous

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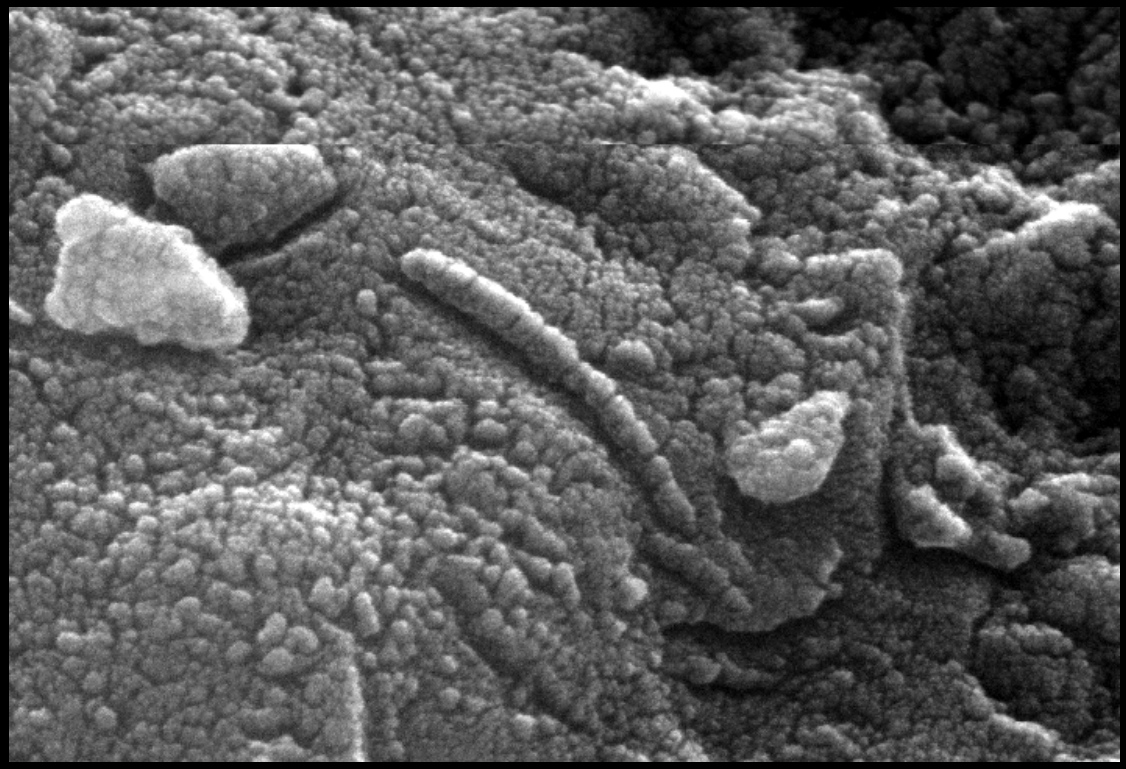

How the sun shines!

- Stars fuse 4H to He
- Lose mass, gain energy via Einstein's $E=mc^2$
- Hydrogen bomb! in its stable life – outward pressure of hot gas (fusion) balanced by inward pull of gravity

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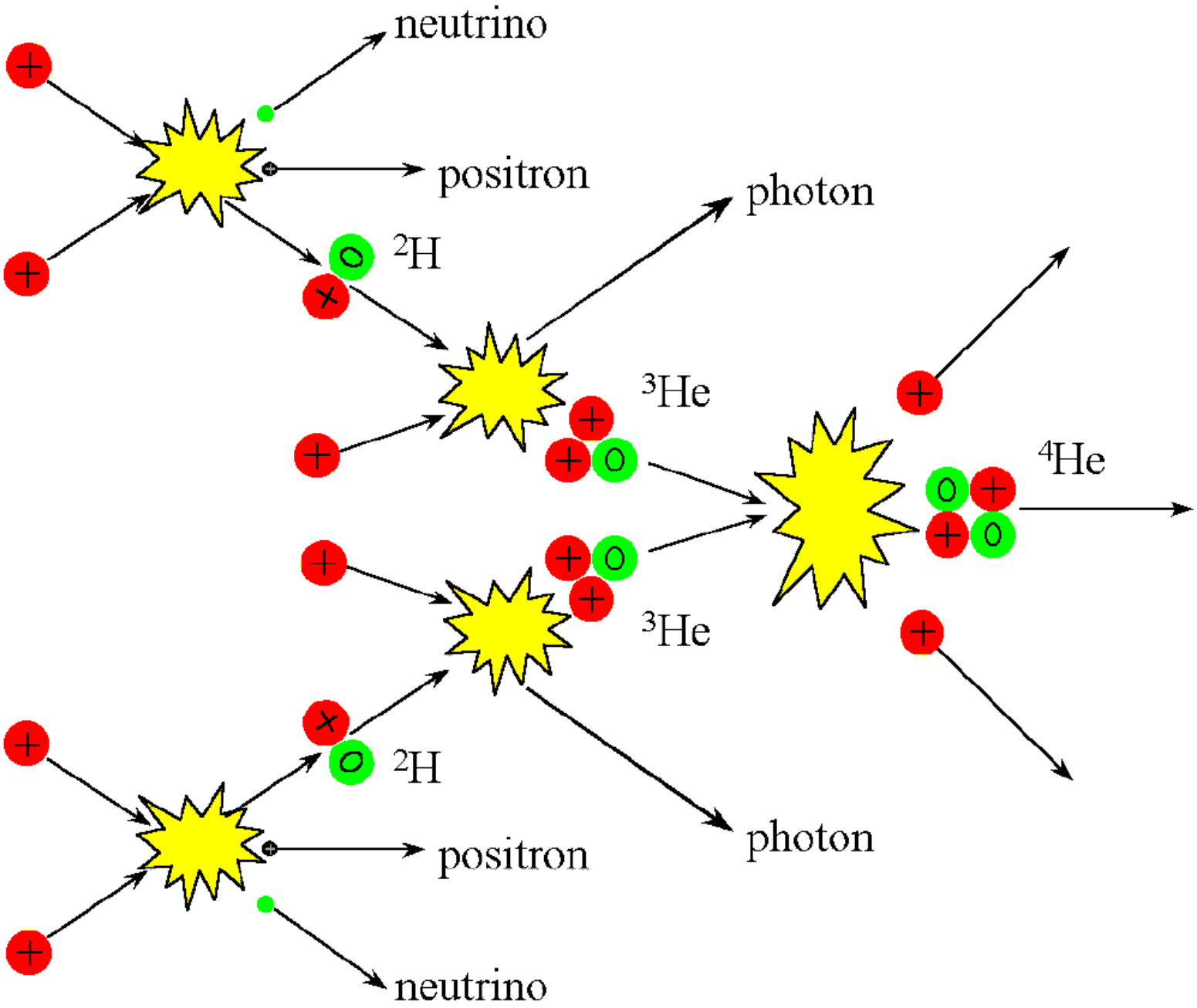
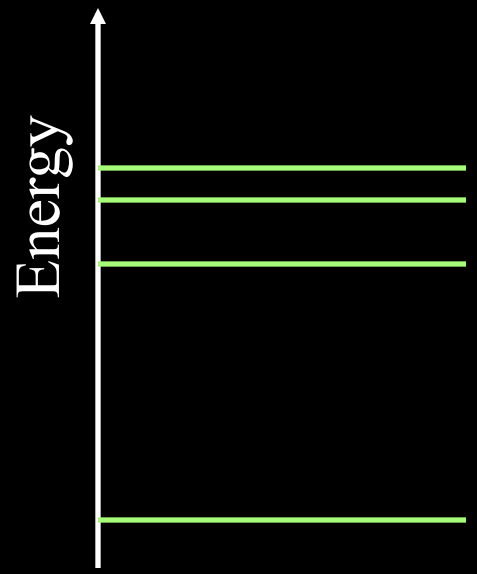
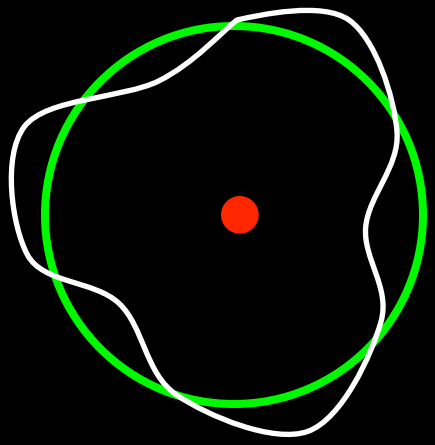
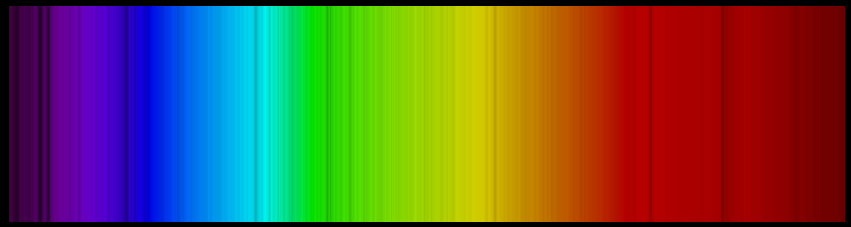

neutrino
positron
photon
^{2}H
^{3}He
^{4}He
^{3}He
^{2}H
positron
photon
neutrino

Atomic lines

- Characteristic spectral lines
- Electron wave fits exactly only at certain distance=energy

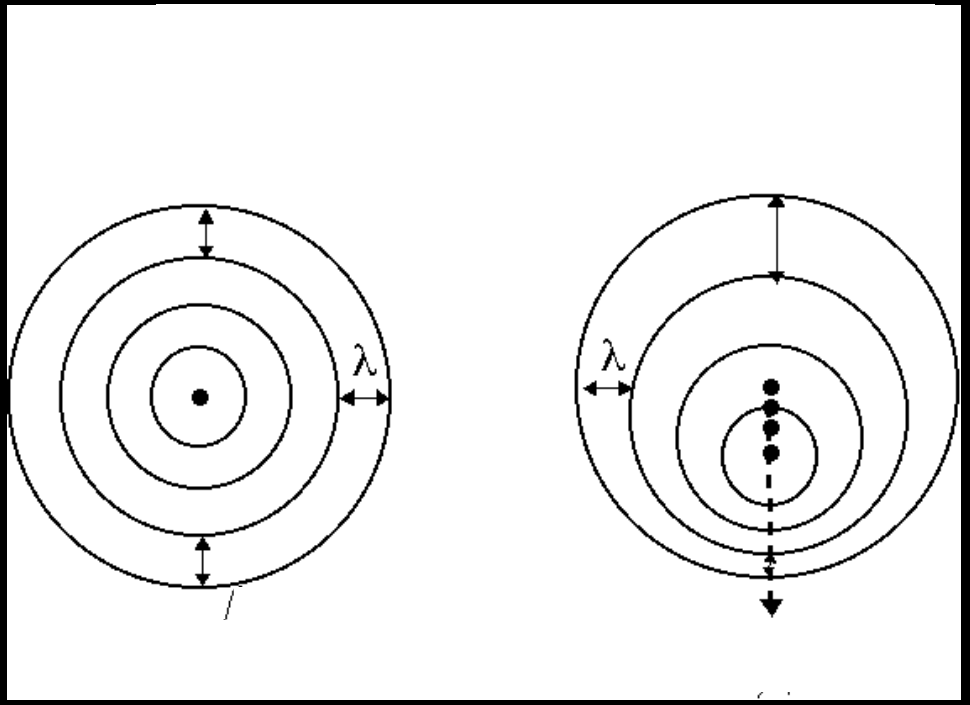






Doppler shift

- Doppler shift!
- Period and velocity give distance and gravity strength



Doppler shift

Hubble law

- Spectra of star in galaxy gives type and so distance
- Spectrum of whole galaxy gives Doppler shift velocity
- Galaxies overwhelmingly moving away!!!