

Technology



Technological Advances

- **Modern Age** marked a *surge* in *tech advances*

(eg) *telescopes, photography, instrumentation*

- **technology** became *widespread*
- quality improved *greatly*
- **new** instruments/approaches were developed

Q: Why was Modern Age so “rich” in technology?

- **science** encouraged *speculation & testing*

Visible Light Telescopes

- same *refracting & reflecting telescopes* but *larger*

- *largest refracting telescope*
- Yerkes Observatory (Chicago)
- lens 40 inches across (102 cm)

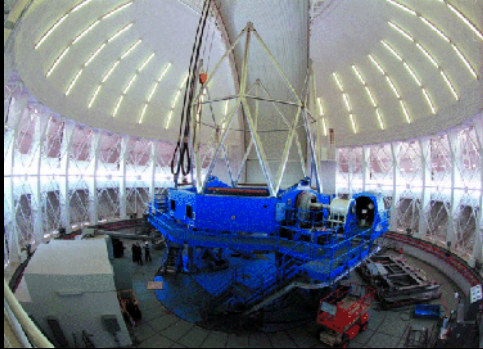
- *largest reflecting telescope*
- *was* Palomar, San Diego (5 m)
- today, *segmented mirrors* used



Yerkes Refractor (1921)



Gemini South Dome - Chile



Inside Keck (10 m)

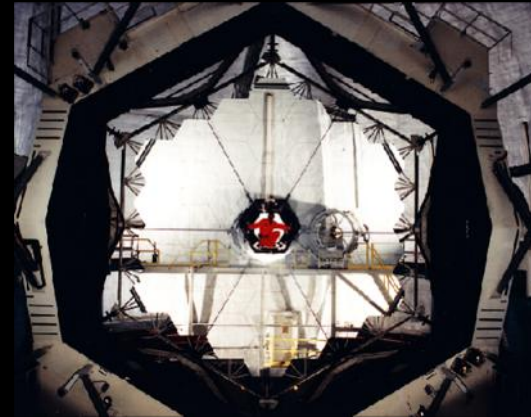


TABLE 6.1 Largest Optical (Visible-Light) Telescopes

Size	Name	Location	Opened*
10.4 m	Gran Telescopio Canarias	Canary Islands	2007
10.2 m	South African Large Telescope	South Africa	2005
10 m	Keck I and Keck II	Mauna Kea, HI	1993/1996
9.2 m	Hobby-Eberly	Mt. Locke, TX	1997
2 × 8.4 m	Large Binocular Telescope	Mt. Graham, AZ	2005
4 × 8.2 m	Very Large Telescope	Cerro Paranal, Chile	1998/1999/2000/2001
8.3 m	Subaru	Mauna Kea, HI	1999
8 m	Gemini North and South	Mauna Kea, HI (North); Cerro Pachon, Chile (South)	1999/2002
6.5 m	Magellan I and II	Las Campanas, Chile	2000/2002
6.5 m	MMT	Mt. Hopkins, AZ	2000

*The year of "first light," when the telescope began operating.

© 2011 Pearson Education, Inc.

Q: What made HST (1990) such a big deal?



- **HST** has a 2.5 m primary with resolution of 0.05" (eg) ~one hundred thousandth the width of a finger



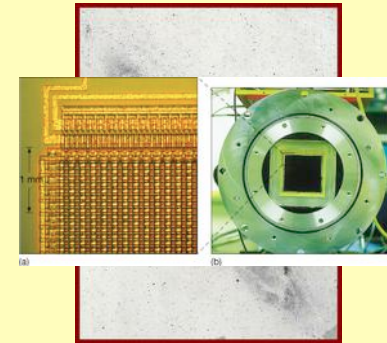
Imaging in Visible Light

- **photographic plate**: records **photograph** on treated glass; used since **mid 1800's**

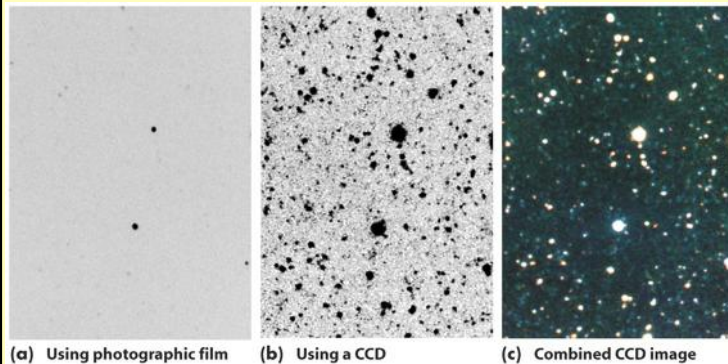
- **benefits**: large format, high resolution, extremely stable

- **CCD**: records **digital image**

Q: Besides astronomy, where are CCDs used?



- **CCDs revolutionized** astronomy
- **50x more sensitive to photons** (light) than **film**

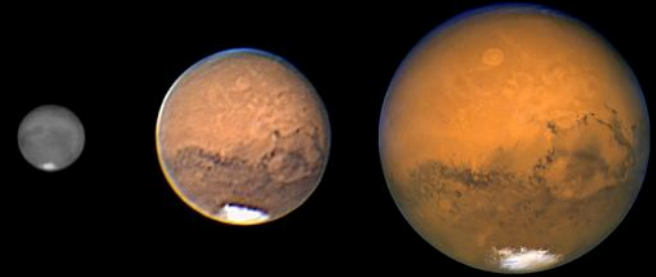


Q: What effects does this sensitivity have?

First photo of Moon (1865)



Modern telescopic image



- *Faworski & Parker (2003); 10" vs HST*
- *digital **imaging, stacking, corrections***



***CLICKER:** HST takes amazing images because...*

- (a) it is above **Earth's atmosphere***
- (b) it is the **largest reflecting telescope ever built***
- (c) it utilizes an array of **multiple CCD imagers***
- (d) of **advances in image processing software***

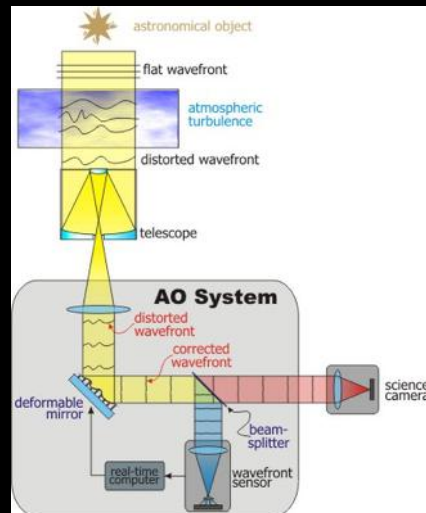
Adaptive Optics

- ***computers** determine amount of **blurring due to the atmosphere** and **reshape a deformable mirror** to counteract it*

- *only possible with **modern high speed computers***



Adaptive Optics



Adaptive Optics at work

Photo credit: Heidi B. Hammel, Imke de Pater, Keck Observatory

Uranus on 9 July 2004

The Power of Keck's Adaptive Optics

AO System OFF

AO System ON

2.2 μm

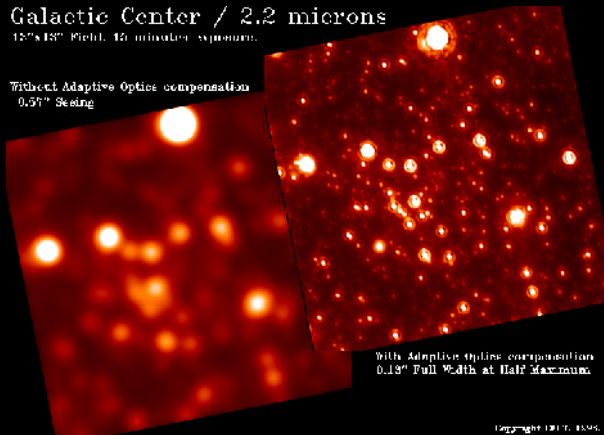
1.6 μm
zoom x2

Adaptive Optics at work

Galactic Center / 2.2 microns

15"x15" Field, 10 minute exposure

Without Adaptive Optics compensation
0.5" Seeing



Spectroscopy

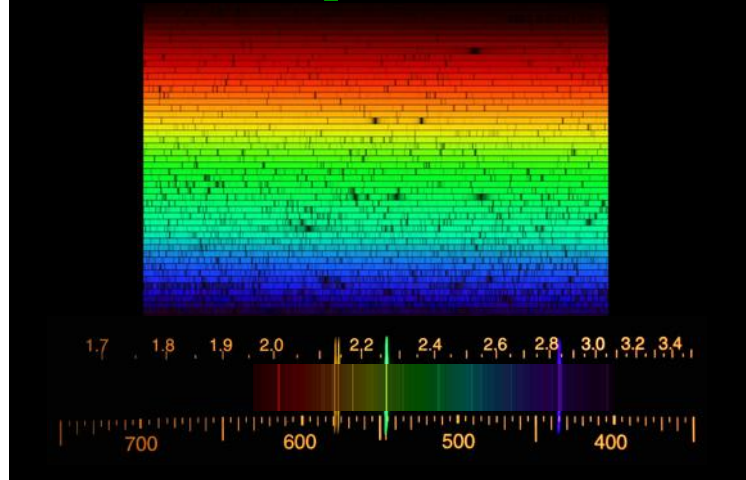
- **Newton** showed that **light** can be “broken down”
- **light** passing through **prism** breaks it into colours
- pattern of resulting colours: **spectra**
- can do this with **sunlight**... or **any star's light**



“On the subject of stars, ... we shall not at all be able to determine their chemical composition or even their density... I regard any notion concerning the true mean temperature of the various stars as forever denied to us.”

—philosopher Auguste Comte, 1835

Spectra



The “Big Bang”

- *Hubble* (1929) looked at *spectra* from galaxies
- *almost all* seemed to be *moving away*
- was our universe *expanding*????

Q: If it's getting bigger now, then in the past...?

- *Fred Hoyle* (1950) derisively coined “*Big Bang*”
- *proof* would have to wait until the 1960s...

Review: Modern Age

- *Newton* legitimized the *scientific method*
- *observation* & *experiment* directed *enquiry*
- *distance to Sun* gave our universe *scale*
- *discovery of planets* utilized & energized *science*
- *evidence* for *Earth's motions* a long time coming
- *astronomy* has leveraged *emerging technology*