AST 301: ***Update on Telescopes (Chapter 5)***

Your textbook is four years old, so there are a few updates about telescopes that I am including in this brief summary. Use these to test whether you are comfortable with wavelength regions, why some have to be in space, which have the best resolution, …. Don't memorize them, except for the few listed on the review sheet.
And look for the homework questions that are contained within the text—they may appear on the exam.

Optical Observatories (in visual part of the spectrum)
A few of the most important optical space observatories
Hipparcos – distances to stars were horribly inaccurate before Hipparcos.
Homework: Why did a space telescope make so much difference for this?
Hubble (HST) – Most important part was UV, but it broke.
Still, fantastic optical sensitivity and resolution showed picture of structure of the distant (early) universe.
COROT – European planet searcher, now finding weird planets.
Kepler --presently searching for Earth-like planets. Could happen this semester!
SIM (future) = Space Interferometry Mission– successor to Hipparcos.
(More non-optical listed below)

Homework question: *The Earth's atmosphere lets in optical (visual) radiation, unlike all other wavelength regions except the radio. So why go to space?*

Ground-based optical telescopes:
Today's top optical telescopes are 8-10 meter optical/near IR telescopes.
Keck = W. M. Keck Observatory – 1993, 1995, Mauna Kea (altitude 4100m), two 10 meter mirrors , 76 sq. meters each. Each telescope can obtain resolution of ~ 5 arcsec in the near IR because of advanced active optics based on each mirror's 36 segments. (Also adaptive optics)
VLT = Very Large Telescope (four 8.2 m mirrors, can operate as VLTI—see textbook; also uses adaptive optics for ~ 1-5 millisec resolution)

The Future:
E-ELT = Extremely Large Telescope (984x1.45m segments, 42m equiv. aperture, 1300 sq. meters)
TMT = Thirty Meter Telescope (492x1.45m segments, 30m equiv. aperture, 650 sq. meters)
GMT = Giant Magellan Telescope (7x8.4m mirrors, 24.5m equiv. aperture, 368 m^2)
LBT = Large Binocular telescope (2x8.4 m mirrors, 22.8m equiv. aperture, 111 m^2)
Notice these are all (or will be) at altitudes above 2000-3000 m, and obtain angular resolutions of better than 1 millisecond. ***Homework: What is the connection between altitude and resolution?***

More distant future—astronomers drooling…
ALMA = Atacama Large Millimeter/submillimeter Array. Interferometer of 66 gian t 12 meter and 7 meter radio telescopes observing in millimeter and submillimeter (just past far IR) wavelengths. Being built at 5000 meters altitude in northern Chile. First light: 2012. Cost > 1 billion US dollars.

SIM = Space Interferometry Mission (2 0.5m mirrors; 2015 at earliest; *optical* interferometer in space)
JWST = James Webb Space Telescope (2014; near IR; 6.5 m, 25 m^2); why must JWST be in space?
Others of great interest:
AT-LAST (far future): 8-18 meter *ultraviolet* space telescope. Aimed for ~ 2025-2030.
Terrestrial Planet Finder --search for signs of life in spectra of planets ~ 2015; no longer funded. Sad.

IR observatories:

Following the success of **IRAS** in the 1980s, the **Spitzer** infrared space observatory (launched 2003, $800million) has been the major instrument for a decade (see text). Now nearly dead (lasted years longer than expected).

Herschel: The current top IR space telescope is called **Herschel** (ESO, launched 2009, will last until 2012; 3.5 m diam). Fantastic sensitivity and resolution →

On the ground:.

JCMT = James Clerk Maxwell Telescope: 15 m diam., largest submillimeter telescope. On Mauna Kea at 5000 m (like Keck).

Two future instruments many astronomers drool over:

JWST = James Webb Space Telescope (6.5 m diam). A planned IR space telescope for 2014 With nearly twice the diameter as the present **Herschel**, how much more light can JWST collect? That would hardly be reason to spend five years and hundreds of millions of dollars. What is the big difference between Herschel and JWST? (wavelength region).

ALMA – 66 x 12 meter telescopes in space. This is submillimeter and millimeter wavelengths (short radio, or very far IR).

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Gamma-ray observatories:

Swift (2004; as of May 2010, had detected > 500 gamma ray bursts) and **Fermi** (launched 2008) are the current space gamma ray telescopes. →

MAGIC, and **VERITAS** are ground-based gamma-ray telescopes.

***Homework question:* Why does a ground-based gamma-ray observatory seem dumb, if not impossible? Why is it possible? *What are MAGIC and VERITAS really observing* (not collecting—they collect gamma-rays)?**

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Gravitational Wave observatories: [Don't worry about what this means—they aren't photons]

LIGO = Laser Interferometer Gravitational Wave Observatory. First light 2002. Size = 4000 meters (compare with largest optical telescopes).

Theorists predict chance of unambiguous detection ~ 20 percent up to 2010, but increasing ssteadily. Now in collaboration with GEO 600 in Germany. August 2010: First unambiguous detection? Was made through home computer distributed network Einstein@Home (like SETI@home, FOLDING@home, ….)

Future: **LISA** = Laser Interferometer Space Antenna. Gravitational wave detector, an orbiting LIGO, but at different frequencies.

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Neutrino observatories: (again, don't worry what these are, they aren't "light")

Currently: Super-Kamiokande (older), **IceCube** Neutrino Observatory (Antarctica; now complete and observing).