

Planets and Galaxies and Stuff

Jonathan McDowell

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- **WHAT** objects do we study? - Stars, Planets, Quasars, etc., ...
- **HOW** do we study them? - ordinary light, radio waves, X-rays, etc.
- **WHY** do we study them? - to know what's in a particular part of space and time, to study the properties of an individual object ('Astronomy', which is like an extension of history and geography to outer space); or - to study the properties of entire classes of objects, find out the rules that make them work ('Astrophysics').

Big Numbers

How far away are things?

Place	Distance from the Hub
The Big Apple	One-thousandth of a second
The South Pole	One-tenth of a second
The Hubble Telescope	One-tenth of a second
The Moon	One second
Planet Mars	A few minutes
The Sun	8 minutes
Planet Neptune	4 hours
Voyager 1	$8\frac{1}{4}$ hours
Comet 1973 E1 Kohoutek	2 days
Star Alpha Centauri	4 years
Pleiades Star Cluster	400 years
Star Betelgeuse	600 years
Orion Nebula	1500 years
Crab Pulsar	6000 years
Messier 13 Globular Cluster	20,000 years
Galactic Center	30,000 years
LMC Dwarf Galaxy	150,000 years
Andromeda Galaxy (M31)	2 million years
Whirlpool Galaxy (M51)	10 million years
M81 Galaxy Group	10 million years
NGC 1068 Seyfert Galaxy	33 million years

Center of Virgo Supercluster	40 million years
Hercules Cluster	500 million years
Quasar 3C 273	3 billion years
Galaxy FSC 10214+4724	8 billion years
Quasar OQ 172	10 billion years
Cosmic Horizon	20 billion years

Basic Things

- Star - Ball of gas, shines by nuclear fusion, a million miles across. Typical example: the Sun. Lots of special types.
- Planet - small debris around a star. Several types:
 - Gas giant planets - ball of gas and liquid, but no nuclear fusion. Ten to fifty thousand miles across. Example - Jupiter.
 - Terrestrial planets - small round stones, a few thousand miles across. Example - Earth.
 - Ice worlds - small round snowballs, a few hundred to a few thousand miles across. Example - Mimas
 - Asteroids - smaller stones, irregularly shaped, one to a hundred miles across. Example: (1940) Whipple.
 - Comets - smaller snowballs, irregular shapes. Example: 1P/Halley.
- Star system - group of one, two or three stars orbiting each other, possibly with assorted planets. Example: Solar System.
- Nebula - cloud of gas and dust in our galaxy.
- Star Cluster - group of stars close together. Example: Pleiades
- Constellation - group of stars all in the same direction as seen from Earth, but really nothing to do with each other.
- Active Galactic Nucleus (AGN) or Quasar - strong, compact source of radiation in the center of a galaxy.

- Galaxy - large system of stars, star systems, nebulae, and star clusters, and possibly an AGN. Example: Andromeda, Milky Way.
- Galaxy Cluster - group of galaxies, possibly with X-ray 'intra-cluster gas' cloud.
- Supercluster - group of galaxy clusters.
- Types of star: Dwarf, Giant, Supergiant, Binary, Nova, Supernova, Wolf-Rayet, Cepheid, etc., etc.,
- Types of solid collapsed star: White Dwarf, Neutron Star, Pulsar.
- Black Hole - collapsed region of spacetime.

CfA Interests - Planetary Division

- What is there in the solar system? Catalog new discoveries, communicate to others.
- Discovery of trans-Plutonians
- How are the planets different from Earth? Study of Moonrock, radar images of Venus.
- How did the Earth and the planets form? Studies of star and planet formation.

CfA Interests - Solar Physics

Solar and Stellar, also High Energy (L. Golub) and Theory. Spartan and SOHO satellites.

- What are the fusion reactions going on in the Sun?
- What's happening on the surface of the Sun? Sunspots, corona, flares.
- How does the Sun affect the Earth? Study of the solar wind.
- What is the interior structure of the Sun?
- How did the Sun form and how will it evolve?

CfA Interests - Stars

Solar and Stellar, High Energy, etc.

- Variable stars
- Stellar evolution
- Close Binary Stars
- Weird Stars and small Black Holes
- Supernovae

CfA Interests - Nebulae

Radio, OIR, Atomic and Molecular

- Star Formation
- Spiral Arms
- Supernova Remnants
- Galactic Center

CfA Interests - Galaxies and Quasars

OIR, High Energy

- Mapping the Universe (Geller, Huchra)
- Properties of Galaxies
- Starburst Galaxies
- Clusters of Galaxies
- Quasars

CfA Interests - The Universe

Theory, OIR

- The Distance Scale (Kirshner, Schild, etc.)
- Physical Cosmology (Field, etc.)
- The Early Universe