Physics 134

Philip Lubin
www.researchgate.net/profile/Philip_Lubin

www.deepspace.ucsb.edu/classes

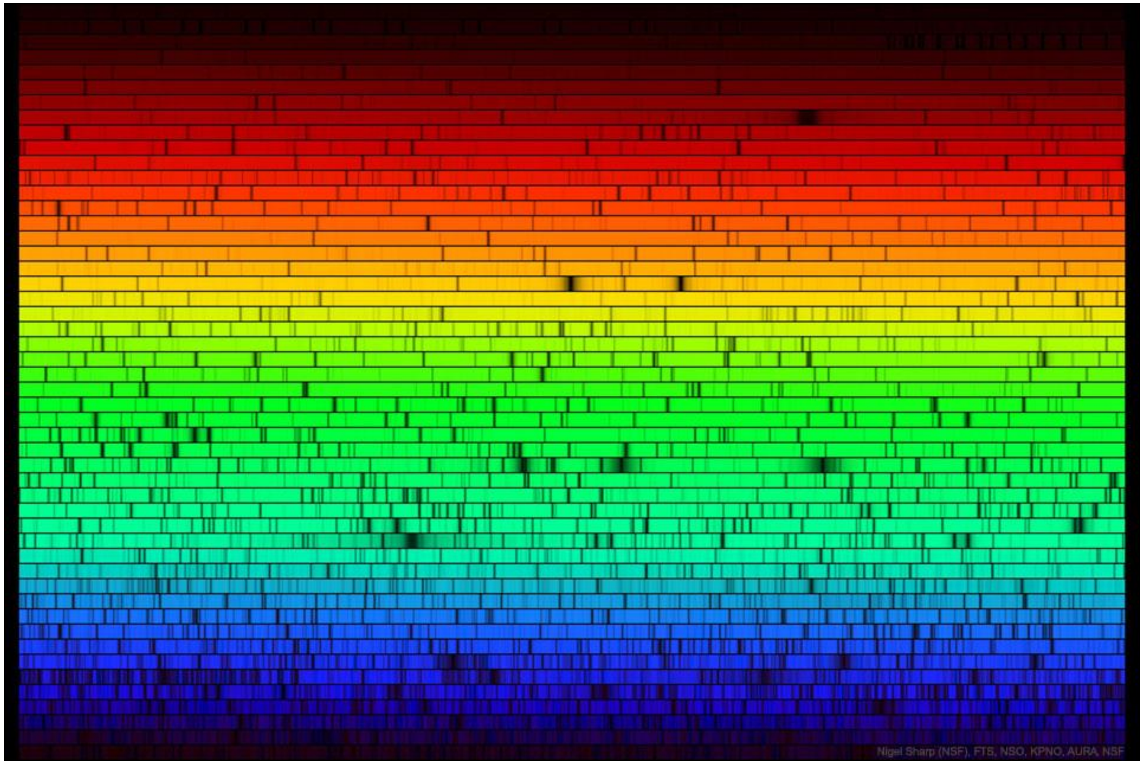
Introduction Lecture 1

Class Structure

- Observational Astrophysics using visible bands
- Use LCO (Las Cumbres Observatory) telescope network
  - https://lco.global/
  - Typ weekly LCO and UCSB astro colloquia – please attend if possible – some remote colloq this quarter
  - http://web.physics.ucsb.edu/~astrogroup/events/
  - LCO - Thur 3:30–4:30pm, at LCO.
- Useful textbooks:
  - To Measure the Sky - Chromey
  - Can get paperback
  - **Observational Astrophysics, P. Lena (expensive but much more comprehensive)**
  - **Class notes on website**
  - **The Search for Directed Intelligence** arxiv.org/abs/1604.02108
- You will work on ~ 3 observing projects
- **→Form teams and teams present project next Wed←**
  - 5 Power Point slides presentation from each team next Wed
  - **→Weekly paper on Obs Astro – 1- 2 pages – find something interesting ←**
  - Begin object requests next Thur ideally
  - Coordinate with TA
  - Ari has LCO observing experience
- Grading will be based on effort, presentation, project results + HW
- Learn AstroArt (http://www.msb-astroart.com/) and Astroplanner (remote access)

Astronomy Picture of the Day - APOD

- **Look at APOD each day** of the week
- Try to understand what It is and why it looks the way it does
- What does it represent?
- https://apod.nasa.gov/apod/astropix.html



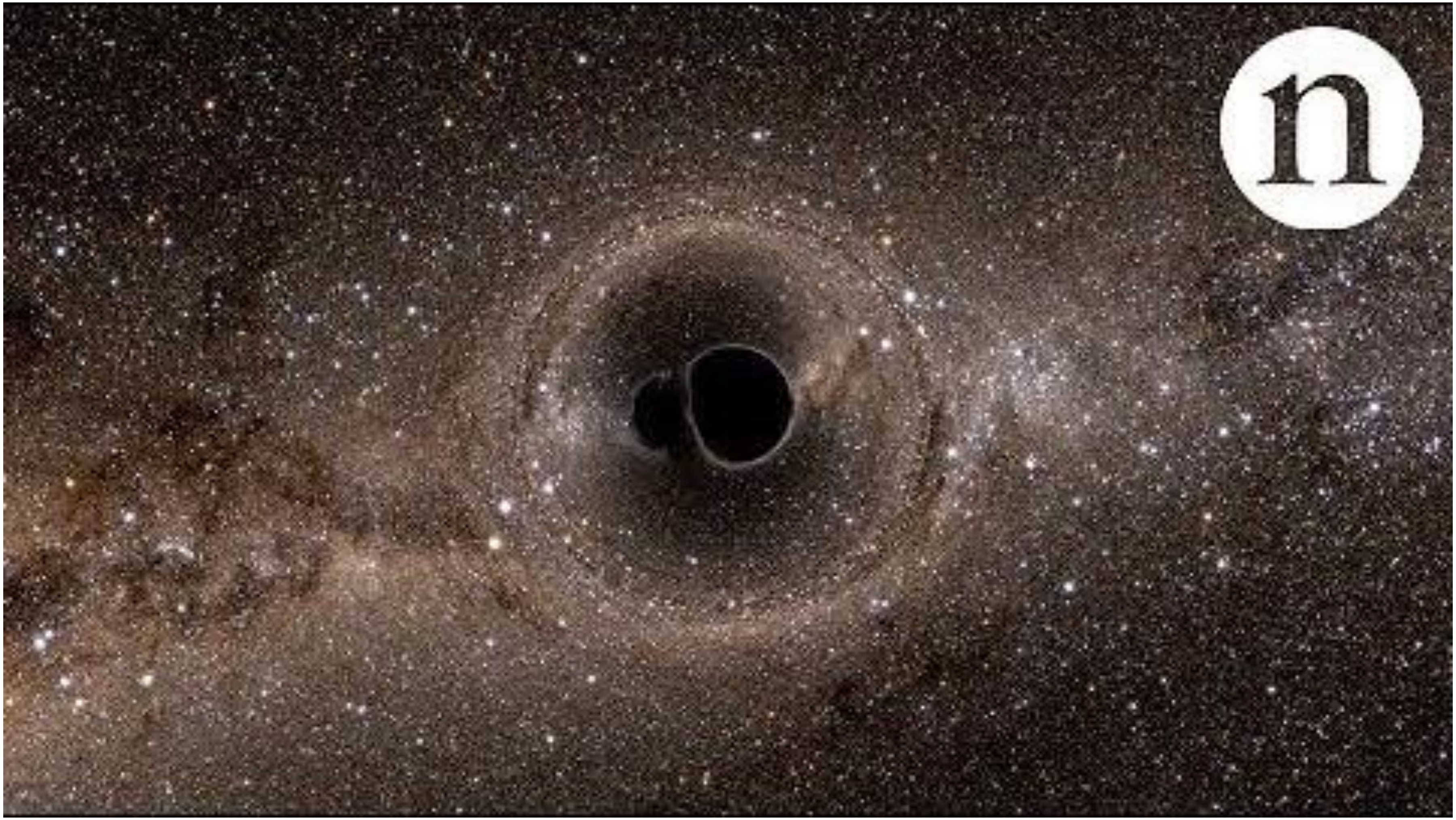
September 26, 2018 – The spectrum of the Sun. Why the dark lines?

September 30 APOD – Sonification of Eagle Nebula Pillars

Gravity waves from Merger of Two Blackholes

https://youtu.be/I_88S8DWbcU

https://www.nature.com/news/the-black-hole-collision-that-reshaped-physics-1.19612



Observing Projects and Teaming

- Class will be focused largely on observing projects
- Typically you will complete 3 observing projects
- Small teams are allowed (2-3 people typ)
- **Many** projects possible – some ideas:
  - Supernova search
  - Planet occultation
  - HR (color-magnitude) diagram of star clusters
  - Photometric redshift survey
  - Variable stars (mag vs time)
  - Optical SETI
  - Suggest your own – look at LCO site and papers/ posters
  - Be creative
- Projects can carry on after Phys 134 for indep research
  - Phys 199 for example

Data Analysis

- AstroArt is on all Phys 134 and PSR computers
  - Image processing software
  - Remote access to computers this quarter
  - www.msb-astroart.com/ (demo free)
- DS9 is free for download and on 134 and PSR
  - Image processing
  - www.cfa.harvard.edu/resources/software.html
  - sites.google.com/cfa.harvard.edu/saoimageds9
- Astroplanner is on all Phys 134 machines
  - Observational planning
  - www.astroplanner.net/
- Data pipeline for TPS and related SETI
  - Might be modifiable for SN and other transients
  - Uses crowded field source extractor code
  - web.deepspace.ucsb.edu/projects/implications-of-directed-energy-for-seti

Some Really Big Questions

- Why does the universe exist?
- Is there more than one universe (Multiverse)?
- When and how did the universe come to be?
  - We believe it started 13.8 Gyr ago – why do we believe this?
- What came before our universe or was time also created?
- Is our reality the only one?
  - Modern physics →4 dimension exist , there are other options
  - For example time does not exit for photons (light)
- Are we alone in the universe (SETI)? We are we on the intelligence scale? If we are alone – what should we do?

Length Scales

Length (cm)	Comments
10^{-33}	Planck Length
10^{-13}	Proton (nucleus) size
10^{-8}	Atomic radius
10^{-4}	“Large” molecules
10^{0}	Common experience (1 cm)
10^{3}	Largest known living things
10^{5}	Asteroid; neutron star
10^{9}	Planet
10^{11}	Star (sun)
10^{14}	Red giant
10^{15}	Solar System
10^{18}	1 light year (ly)
10^{21}	Globular cluster (bound stars)
10^{23}	Galaxies
10^{25}	Cluster of Galaxies (Virgo)
10^{28}	Size of Universe

Time Scales

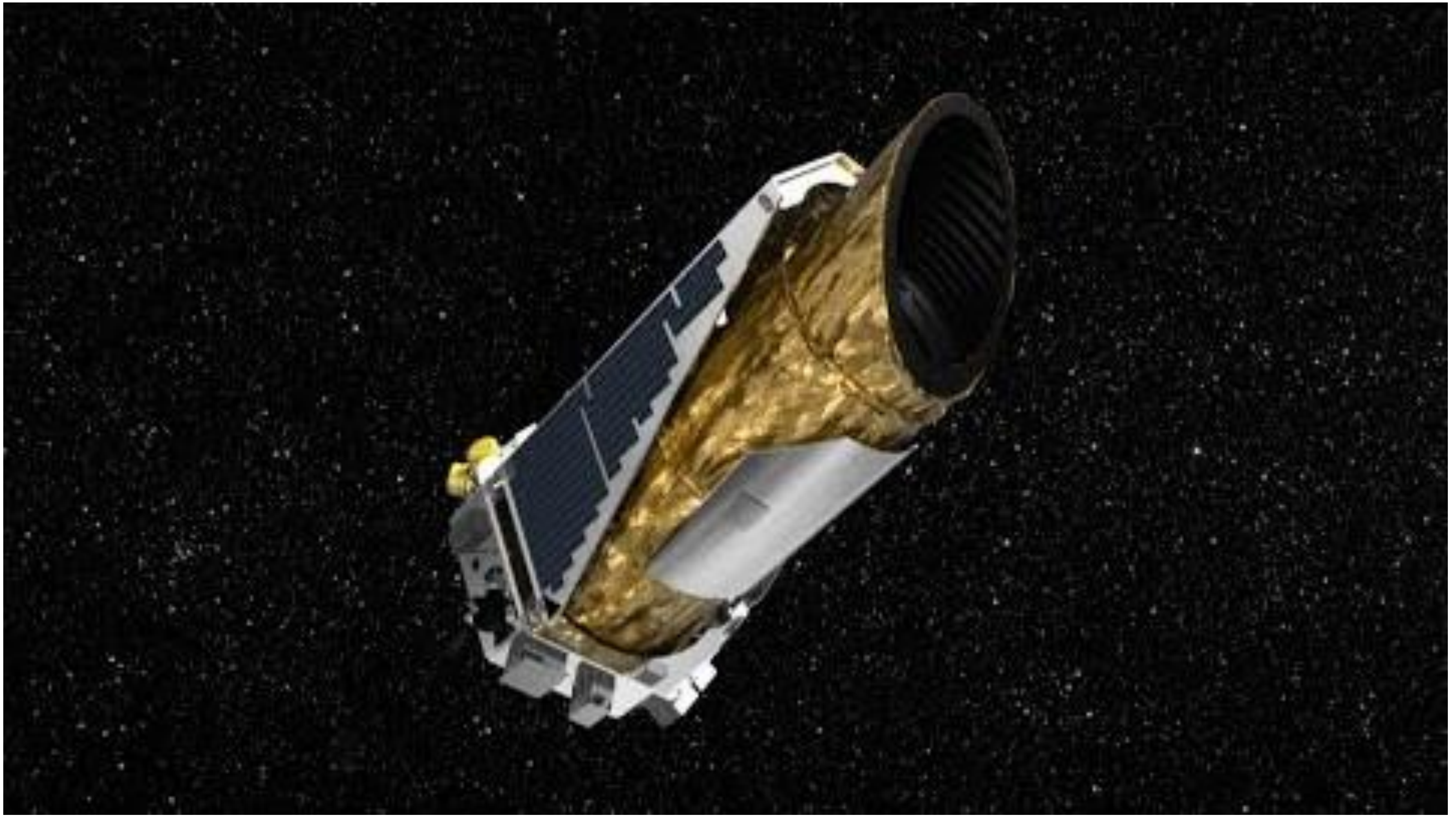
Time (s)	Comments
10^{-43}	Planck Time $\left(\frac{\hbar G}{c^5}\right)$
10^{-34}	Period of highest energy cosmic ray
10^{-21}	Period of typical nuclear gamma ray
10^{-15}	Typical electron orbital period
10^{-9}	H spin flip transition photon period
10^{-3}	Audio
10^{0}	Common time perception
10^{5}	Bacteria, virus lifetimes
10^{9-10}	Large mammals
10^{13}	Largest star lifetimes
10^{17-18}	Age of universe

Kepler Mission has Found Thousands of Exoplanets for Far – Some in habitable Zones

www.nasa.gov/mission_pages/kepler/overview/index.html

4284 as of Sept 30, 2020

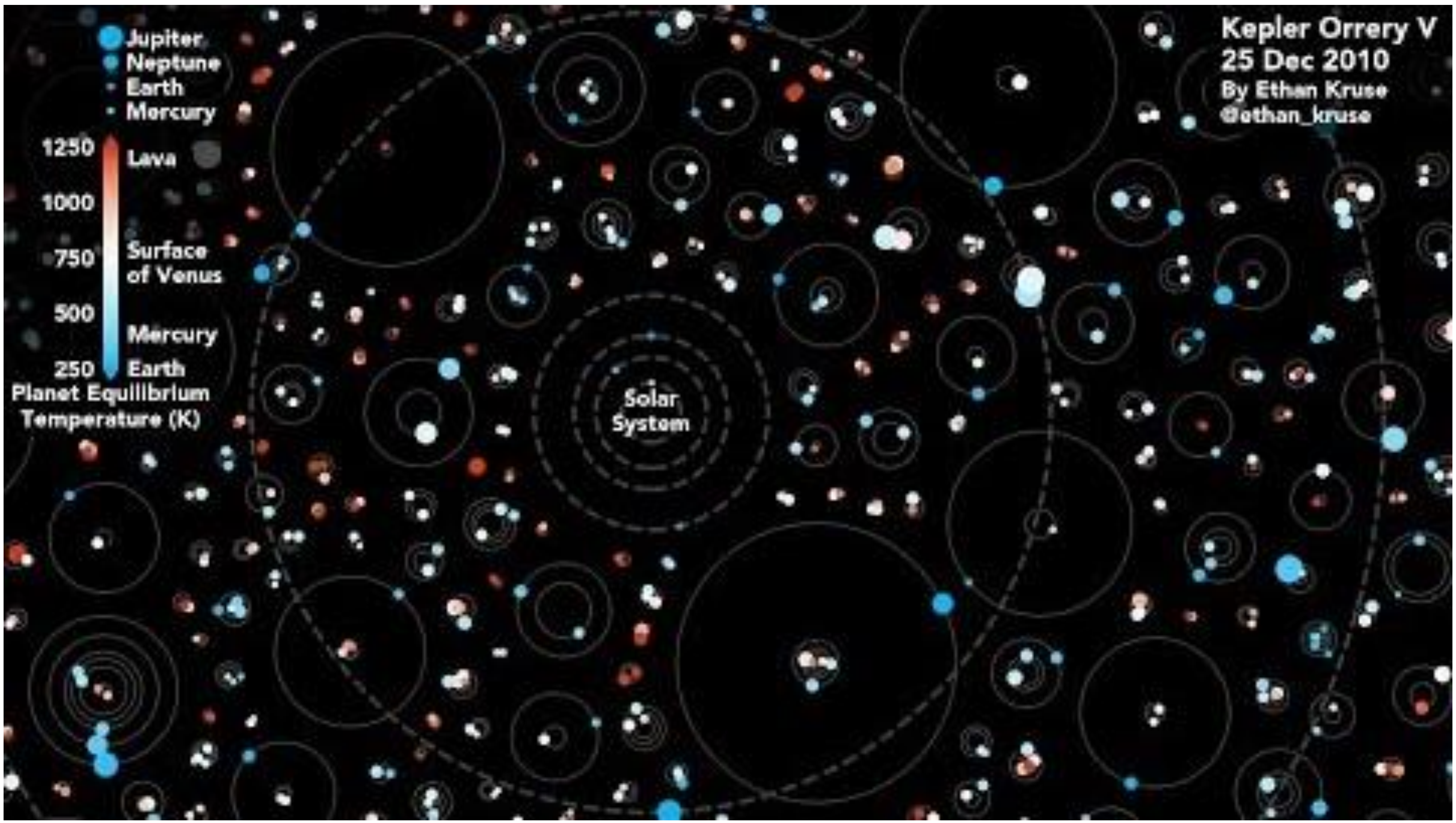
https://exoplanets.nasa.gov/



From Kepler Mission we know ~ 1 planet/star

www.nasa.gov/mission_pages/kepler/overview/index.html

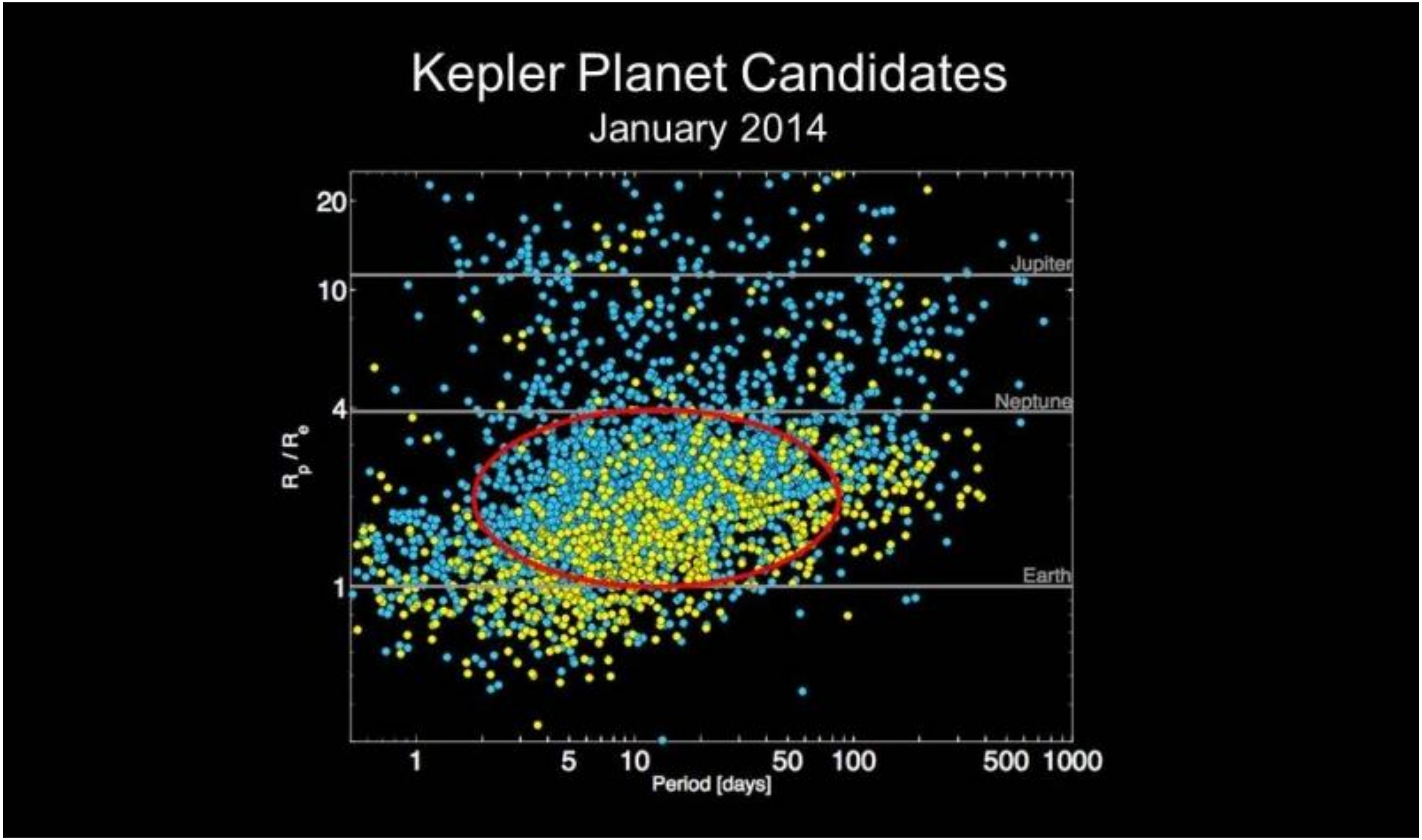
https://www.alanzucconi.com/2016/01/20/exoplanetary-orrery-v/



So many planets – so little time!

Even our nearest stellar neighbor (Proxima Centauri) has a planet

Planet is called Proxima b



SETI Implications - ~ 1 mole of planets in universe

Single 1 sq deg Image - ~ 10^{18} planets

→Look at the sky tonight – you see ~O(10^{21} planets)←

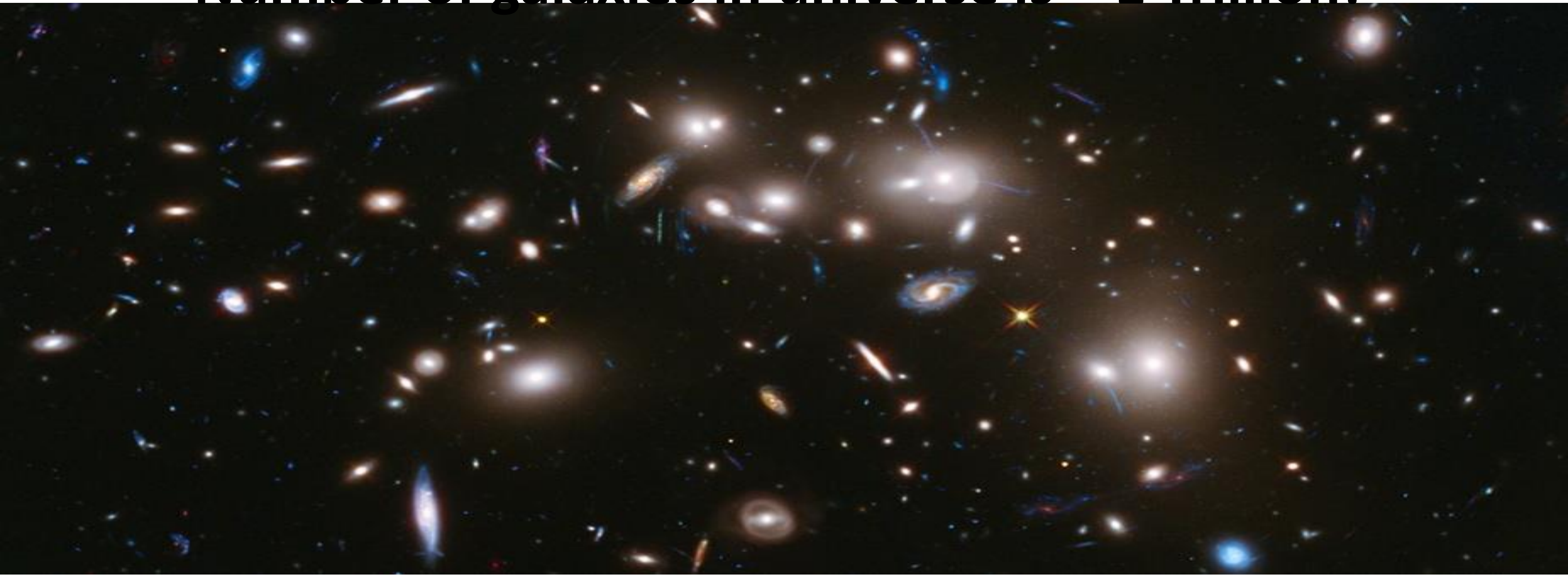
Does intelligence need a planet?

Hubble Space Telescope – Part of Deep Field below 2.6'

1/12 angular width of Moon

Thousands of galaxies – Each galaxy ~ 0.1-1 trillion stars

Number of galaxies in universe is ~ 1 Trillion!

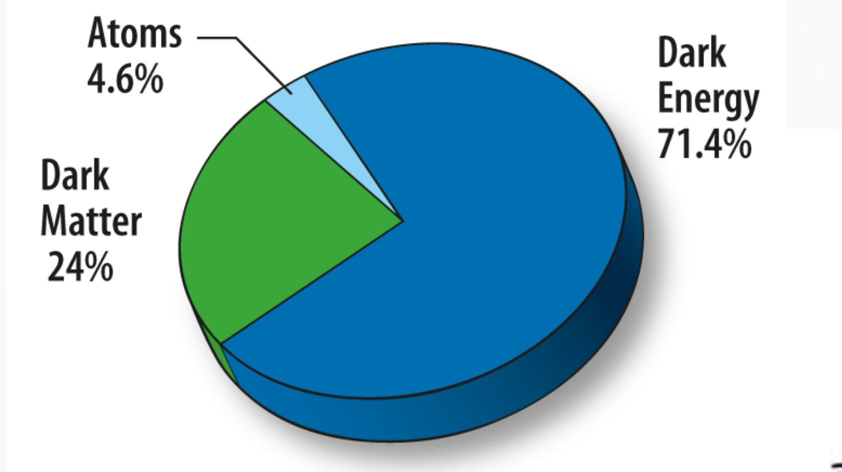


By observing the universe in supernovae, the Cosmic Microwave Background and galaxy distributions, we learn about the origin and fate of the universe. We believe it is dominated by Dark Energy and Dark Matter.

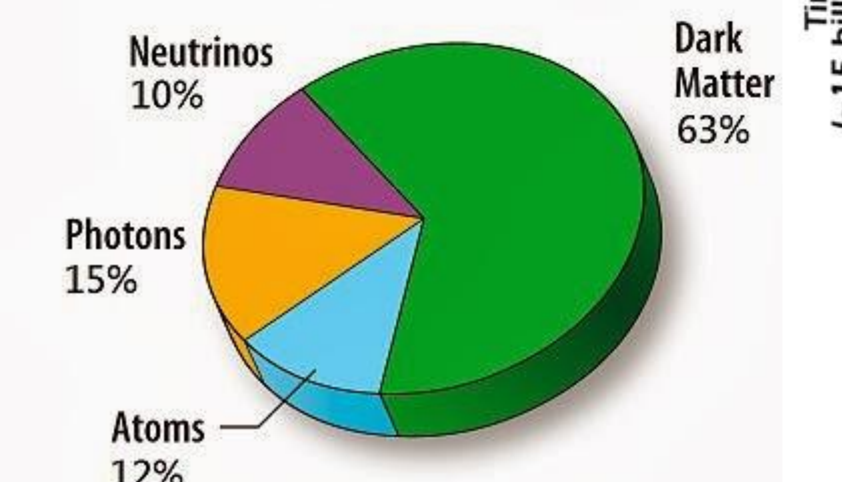
Figure 1-9
Universe, Tenth Edition
2004–2013 R. Jay GaBany, Cosmotography.com

A Large Spiral Galaxy

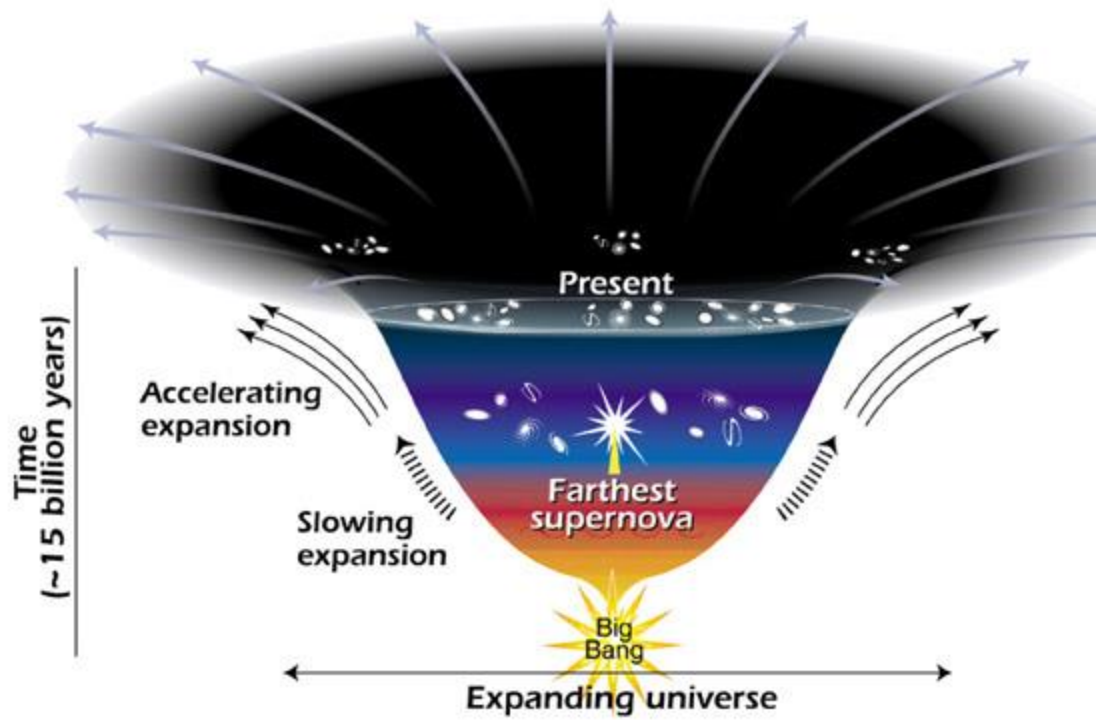
Only a small fraction (~ 5%) of mass/energy in universe is "ordinary matter" (periodic table) – The rest is Dark Energy and Dark Matter



TODAY



13.7 BILLION YEARS AGO
(Universe 380,000 years old)



This diagram reveals changes in the rate of expansion since the universe's birth 15 billion years ago. The more shallow the curve, the faster the rate of expansion. The curve changes noticeably about 7.5 billion years ago, when objects in the universe began flying apart at a faster rate. Astronomers theorize that the faster expansion rate is due to a mysterious, dark force that is pushing galaxies apart.