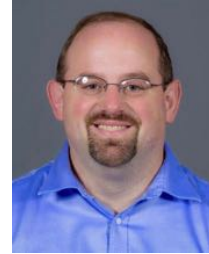


# Welcome to **Astro 150:** **Stars, Galaxies and Cosmology**

Prof.  
Steve  
Kawaler



Prof.  
Jake  
Simon

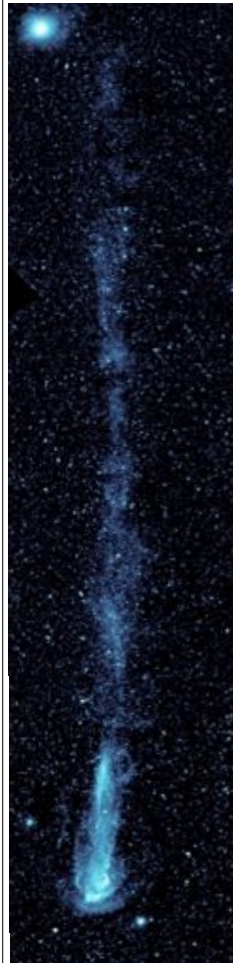
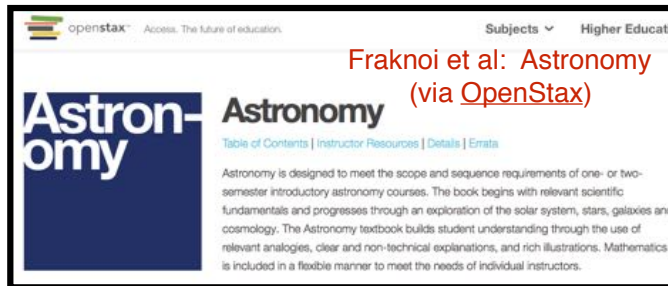


TA:  
Suvadip  
Mandal



Recitations begin *this* Wednesday, August 19

Textbook  
required,  
**free** online




“There are only two worthwhile professions: medicine and astronomy. Medicine, because you are sure to help someone, and astronomy, because you are sure you won’t hurt anyone.”

-Aldous Huxley

- Astronomy concerns things that are
  - too large to imagine
  - too far to fathom
  - too old to comprehend, and
  - too small to see

# The Universe is a BIG Place

Object	Distance [km]	One Way Travel Time		
		55 mph	100,000 mph	LIGHT*
Moon	384,000	174 d	2.4 hr	1.25 s
Venus	42,000,000	54.5 yr	11 d	2.33 min
Sun	150,000,000	193 yr	2 months	8.33 min
Pluto	6,000,000,000	7,800 yr	4.25 yr	5.25 hr
$\alpha$ Centauri	40,000,000,000,000		30,000 yr	4.25 yr

Nearest star to the Sun 

\*speed of light = 300,000 km/s  
677,000,000 mph  
 $6.77 \times 10^8$  mph

## Astronomical Distance Units:

- an “a.u.” = mean distance between Earth and Sun
- a light-year = distance light travels in 1 year (=67,000 a.u.)
- 1 l.y. = 10,000,000,000,000 km =  $10^{13}$  km = 10 trillion km

## A Scale Model: Solar System Distances

1 a.u. = 10 meters

the Sun = a softball  
Jupiter = a grape  
Earth = a poppyseed

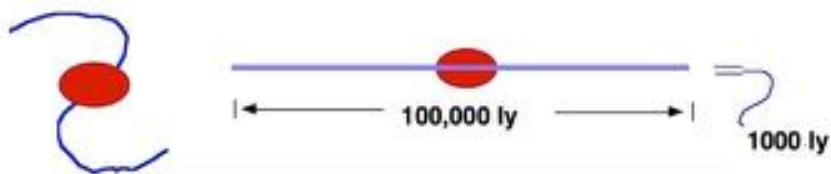


each step you take - 10 million miles!

# The Rest of our Solar System



The Sun is one of ~400 **billion** stars in the **Milky Way Galaxy**



• **Nearest similar galaxy: M31 (Andromeda)**



• **Most distant galaxies known: 13 billion ly away !**

• **There are as many as galaxies in the Universe as stars in our Galaxy !**



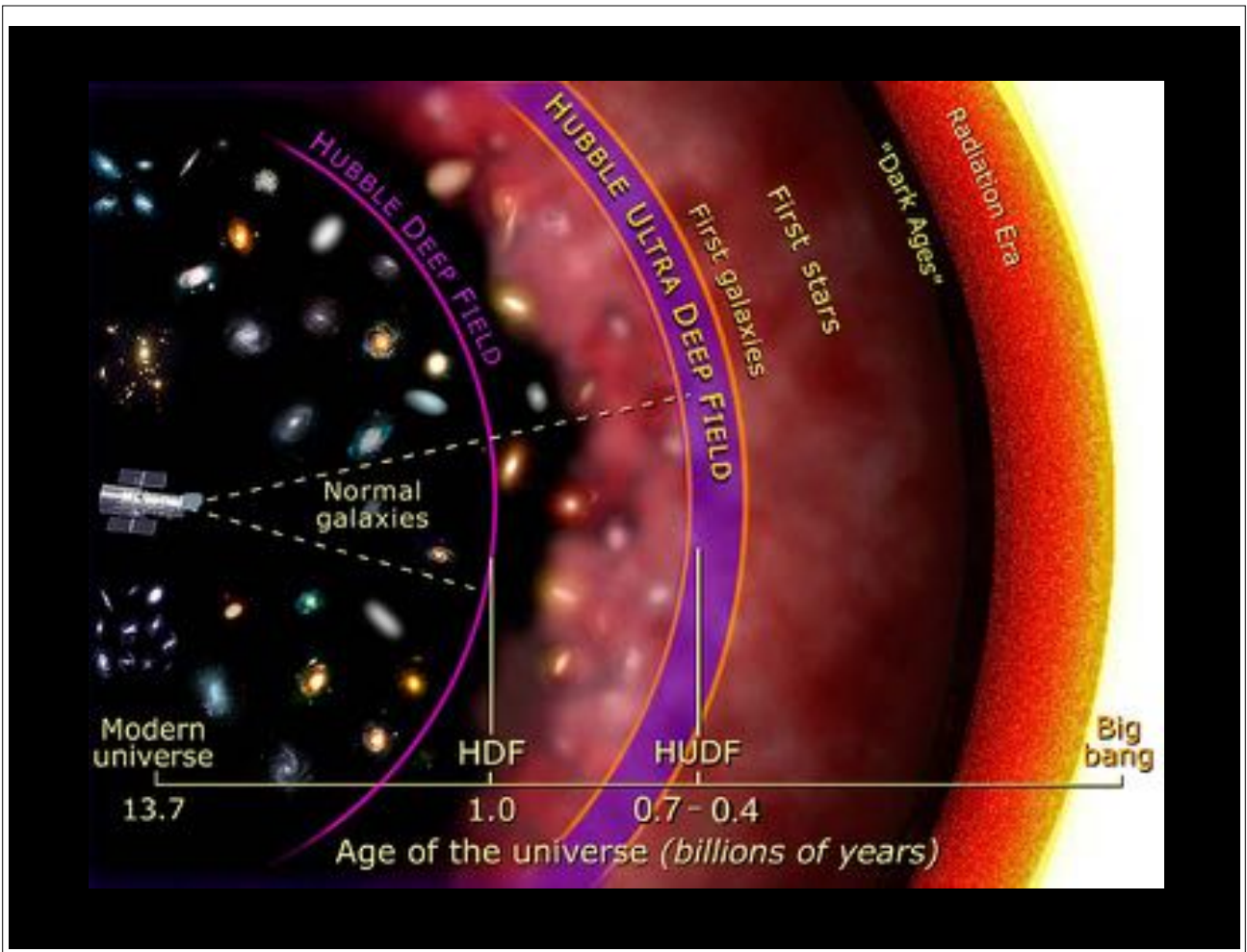




Astro 150 Fall 2020: Lecture 1 pag42

## **The Universe is now expanding, following a **Big Bang****

- **Age of the Sun: 4.5 billion years**
- **Age of the Universe: ~13.6 billion years**





## The Universe is (almost) empty

- Density of water: **1 gram/cc**
- Density of Earth: **5 grams/cc**
- Density of the **Universe:**

$$= 0.000000000000000000000001 \text{ g/cc} = 10^{-23} \text{ g/cc}$$

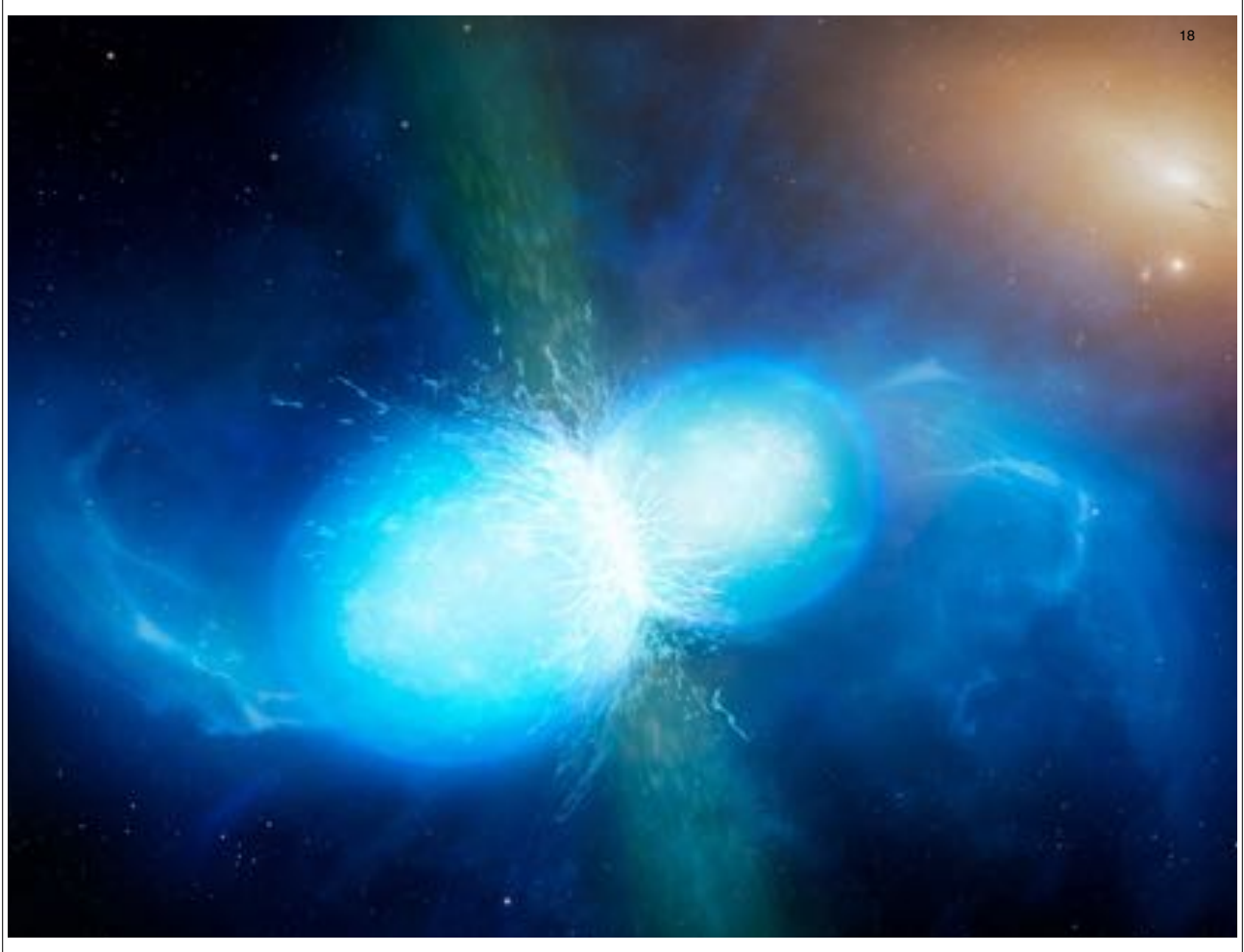
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### Chemical composition:

**75% Hydrogen**  
**~ 24% Helium**  
**< 1% everything else**

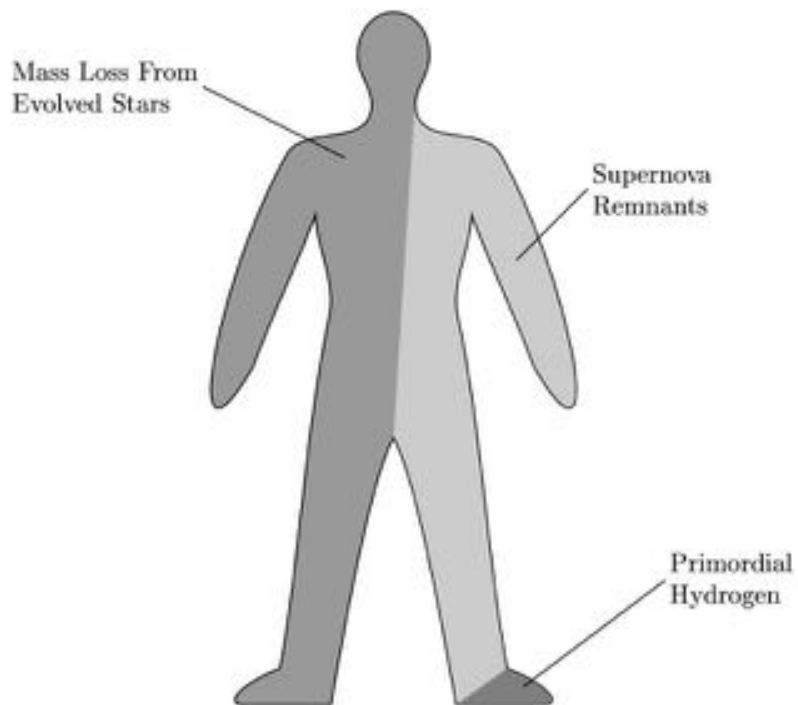
**All Earthly matter heavier than helium (carbon, oxygen, calcium, gold, ...) was transformed in the centers of long-dead stars billions of years ago**



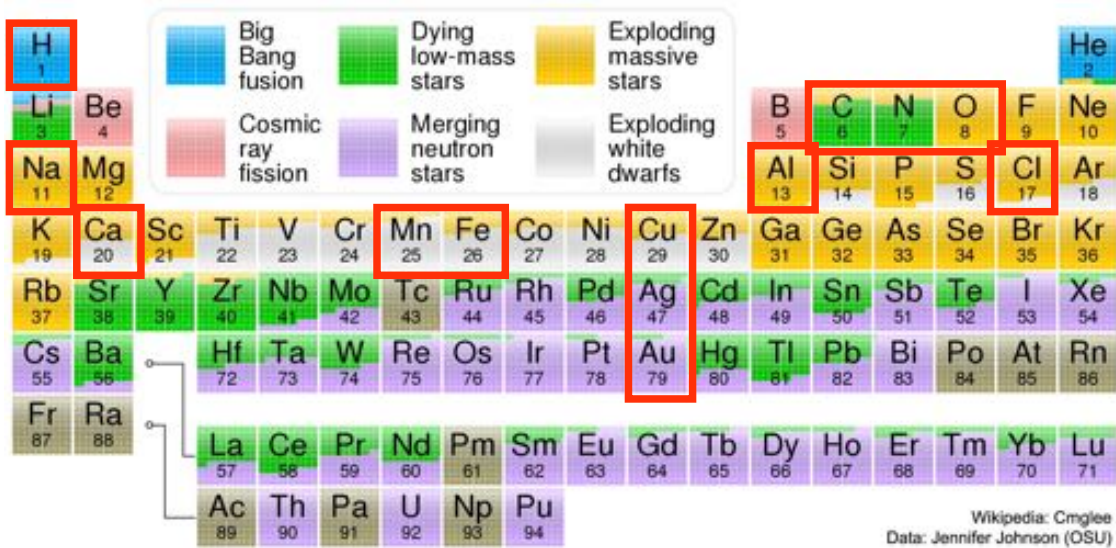




# we are stardust...



# we are stardust...



## How did that stuff become us?

- **That is what Astro 150 is all about!**
  - structure and motions of planets, stars, and galaxies
  - content of our Universe
    - why stars shine
    - galaxies everywhere (?)
    - large scale structure of the Universe
  - origin, history, and future of the Universe
  - development of life in our solar system... and other solar systems
- **Along the way we will explore**
  - processes linking our Earth and Sun with distant and exotic places
    - light - visible and invisible
    - gravity and energy in all their manifestations
  - stars and their environments both familiar and utterly alien
  - catastrophes bigger than Hollywood has dreamed of
  - elusive and exotic Dark Matter and Dark Energy, and
  - whether we are the only civilization in the Galaxy

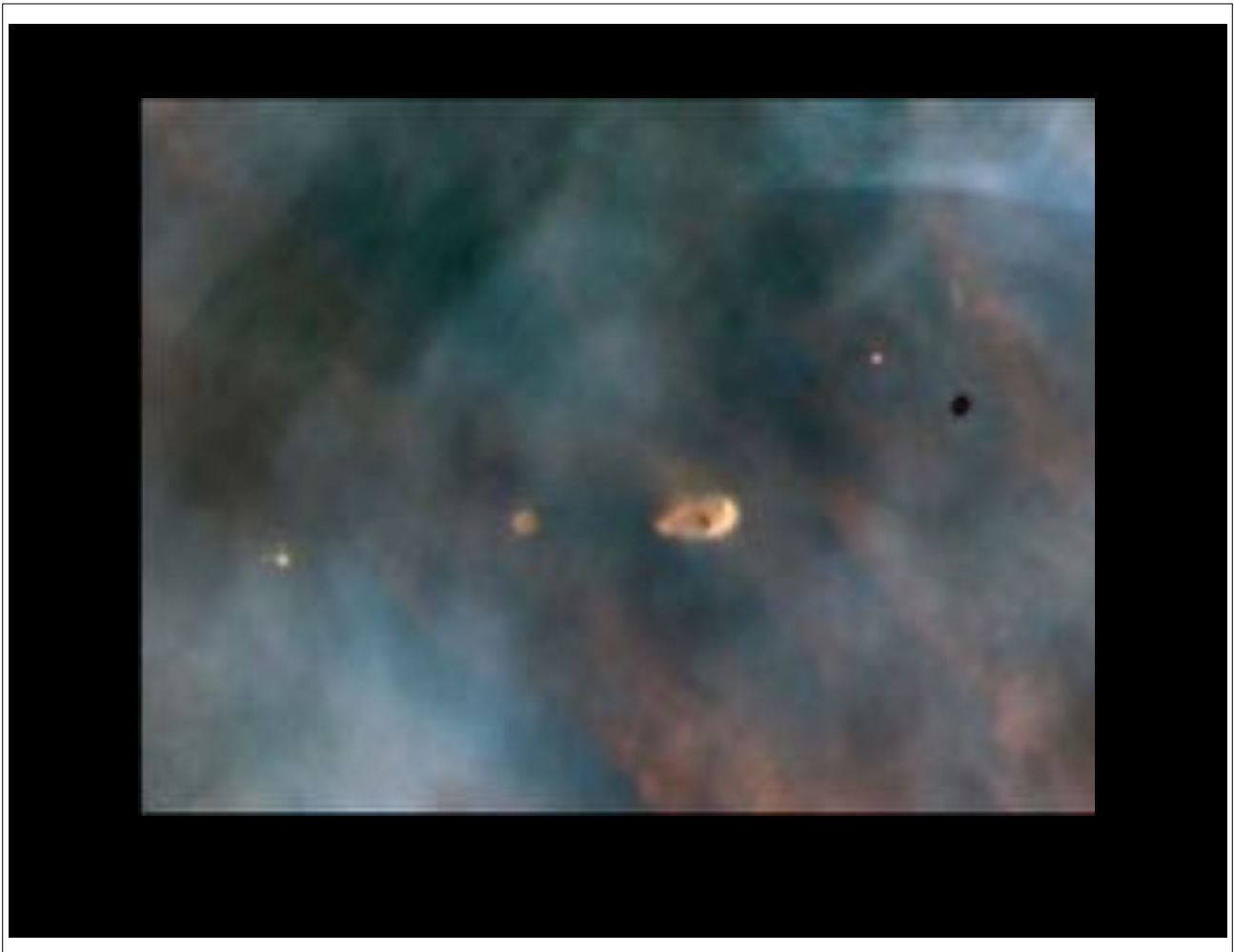
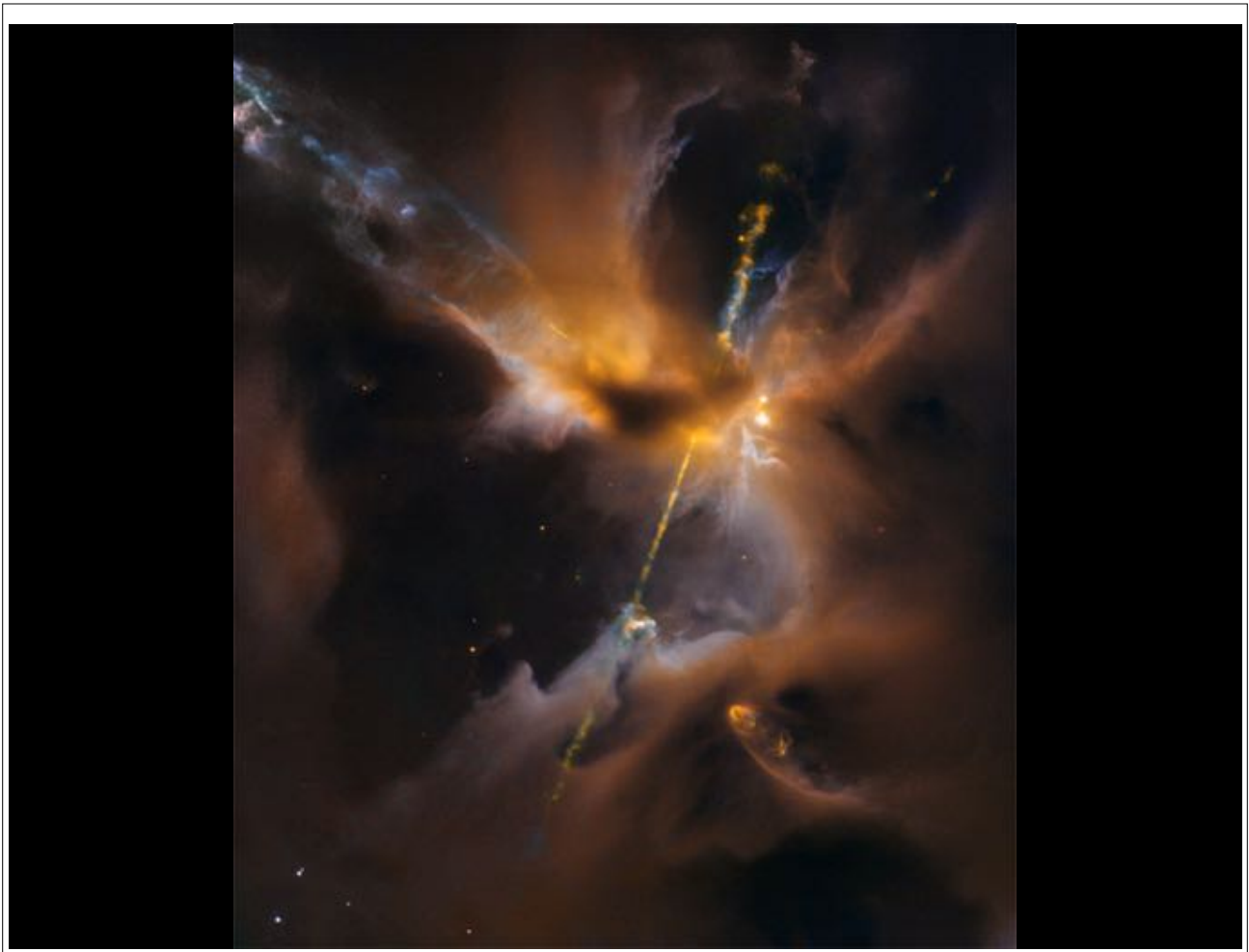


**Star-Birth Clouds · M16**

**HST · WFPC2**

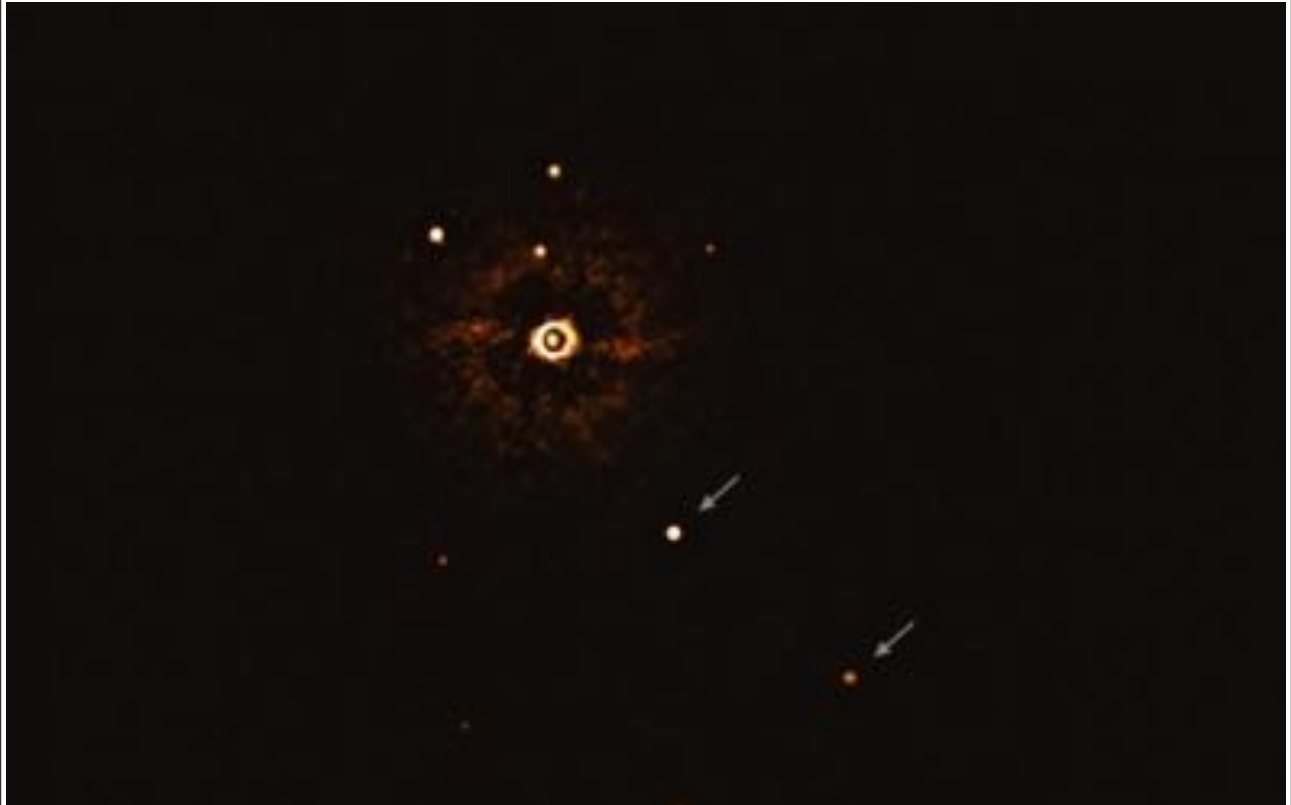
PRC95-44b · ST ScI OPO · November 2, 1995  
J. Hester and P. Scowen (AZ State Univ.), NASA



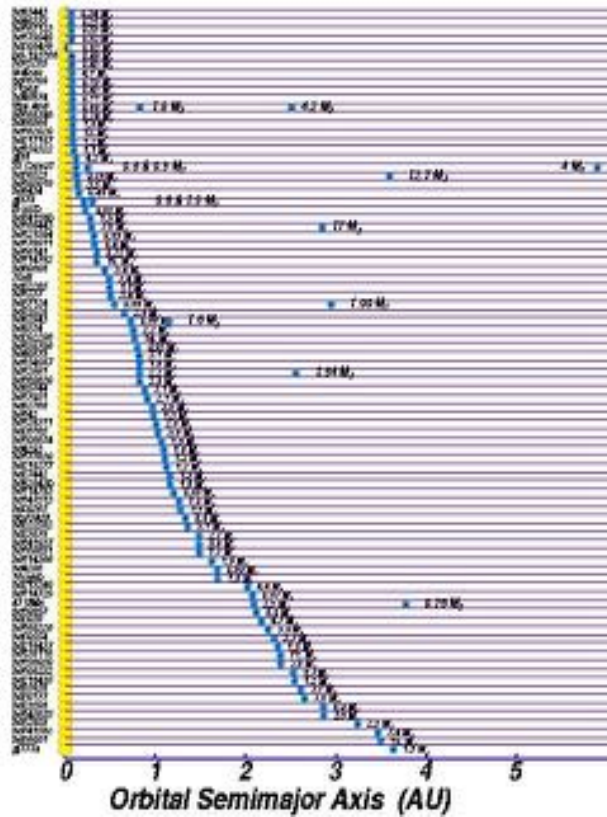


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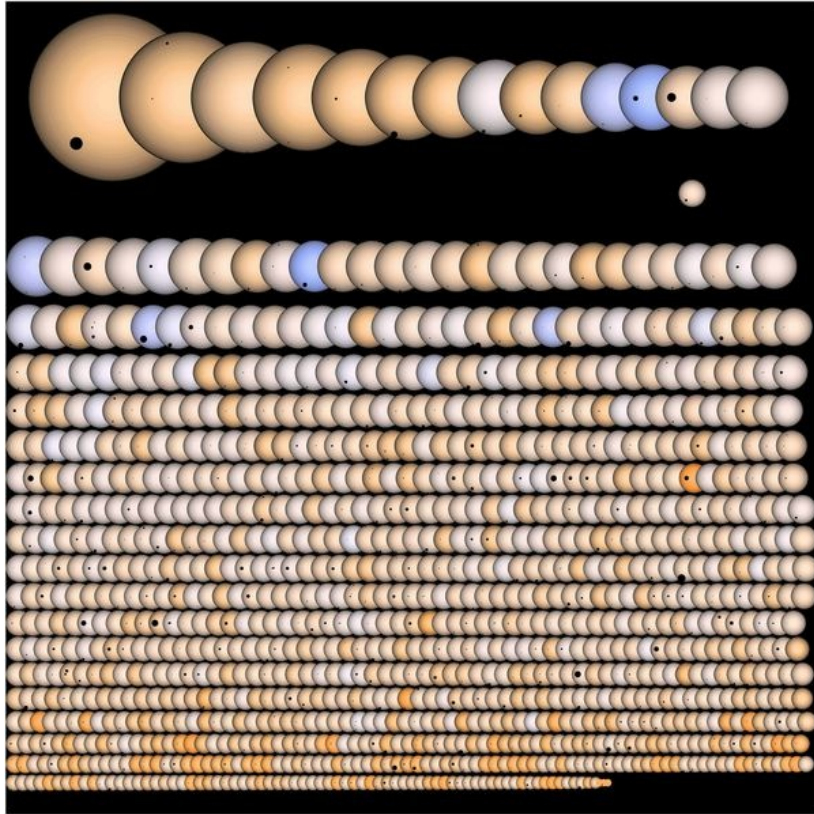
a sunlike star w/ 2 imaged giant planets Bohn et al. (2020)



## Some Other Solar Systems (over 4000 known)



## Some Other Solar Systems (over 4000 known)



*Credit: Jason Rowe, NASA Ames Research Center and SETI Institute*

## A Scale Model of Time

*From: The Evolution of Life, by Frank H. T. Rhodes*

Event	Date	Time	Years ago
Big Bang	Jan. 1	12:00:00 AM	13,600,000,000 yr
Galaxies form	Jan. 24	12:00:00 AM	12,000,000,000 yr
Sun forms	Sept. 13	noon	4,500,000,000 yr
Earth forms	Sept. 13	12:17 PM	4,470,000,000 yr
1st life appears	Oct. 24	8:48 PM	2,800,000,000 yr
1st higher forms	Dec. 19	3:07 AM	570,000,000 yr
1st land animals	Dec. 25	4:29 AM	280,000,000 yr
1st dinosaurs	Dec. 26	12:36 PM	225,000,000 yr
DINOs RULE	Dec. 28	4:34 PM	136,000,000 yr
DINOs DIE	Dec. 29	10:02 PM	65,000,000 yr
Earliest "human"	Dec. 31	9:05 PM	5,000,000 yr
Neanderthal - C.M.	Dec. 31	11:50 PM	300,000 yr
Last Ice Age	Dec. 31	11:59:37 PM	11,000 yr
Pyramids	Dec. 31	11:59:53 PM	3,500 yr
USA	Dec. 31	11:59:59.6 PM	244 yr
YOU	Dec. 31	11:59:59.96 PM	20 yr