# Feb 28 2025



# Planet Formation

Eugene Chiang Berkeley Astronomy & EPS







# 2017 Total Solar Eclipse

# 2012 Venus Transit



# Transit method for detecting exoplanets



# "light curve"

AQUILA

DELPHINUS

177

CYGNUS

Deneb

BRIGHTNESS

Photometer Sun shade Solar Array Reaction Wheels (4) Radiator High Gain Antenna Solid State Omni-antenna Recorde (1 of 2) Avionics Star Trackers (2) (redundant)

TIME IN HOURS

NASA Kepler Space Telescope 2009-2018





# permanent night 50 °K (-370 °F)

## permanent day 1800 °K (2800 °F)

tidally locked



Magma ocean exoplanet = Early Earth?





"Eta Earth"

## Fraction of Sun-like stars with Earth-like planets on Earth-like orbits

# 10-20% (Bergsten+22) cf. 6-22% (Petigura+13)

technically an extrapolation from Kepler data



Milky Way Galaxy

Number of stars ~ 200 billion and more planets

Rotation period at Sun's location  $\approx 250$  million yr

# ~24000 light-years

Sun

# WE ARE HERE

# The Milky Way Galaxy (actually)

#### Max Planck Institute for Chemistry



Stars form in interstellar clouds (~I-I00 light-years in size)

Daniel Price and Christoph Federrath (2010)

Stars form in interstellar clouds (~I-I00 light-years in size)

Daniel Price and Christoph Federrath (2010)

Panorama of the Carina Nebula 🕑 HUB

~0.5 light-year









## Circumstellar disks

# ~100 AU (~10 light-hours) Protoplanetary Disks Orion Nebula HST · WFPC2

PRC95-45b · ST Scl OPO · November 20, 1995 M. J. McCaughrean (MPIA), C. R. O'Dell (Rice University), NASA



## Atacama Large Millimeter Array







# Sticky particles



## Energy balance + Hertz's law of contact

$$v_{
m stick} \sim rac{\gamma^{5/6}}{E^{1/3} 
ho^{1/2} s^{5/6}}$$

 $\sim 0.1 \text{ cm/s}$ for  $s \sim 1 \text{ mm}$ 

Sticking up to, but not beyond, cm sizes

## CHONDRITIC METEORITES

- 0.1-1 mm igneous spheres
- > 30% volume fraction
- near-solar composition
- 4.562-4.567 Gyr old







COMPLETE SLICE OF THE SINGULAR GUJBA METEORITE

### I Myr

## 100 Myr







10 Gyr

# Formation of the Moon: the last giant impact



SwRI/Canup

# Moon is 4.51 Gyr old CAIs (oldest meteorites) are 4.56 Gyr old ("t=0")

... Moon-forming impact occurred 4.56 - 4.51 Gyr  $\simeq$  0.05 Gyr  $\simeq$  50 Myr after CAIs

