PLANETARY YEARBOOK PHOTOS

STUDYING PLANET FORMATION IN SNAPSHOTS

Mackenna Wood

UNC Chapel Hill

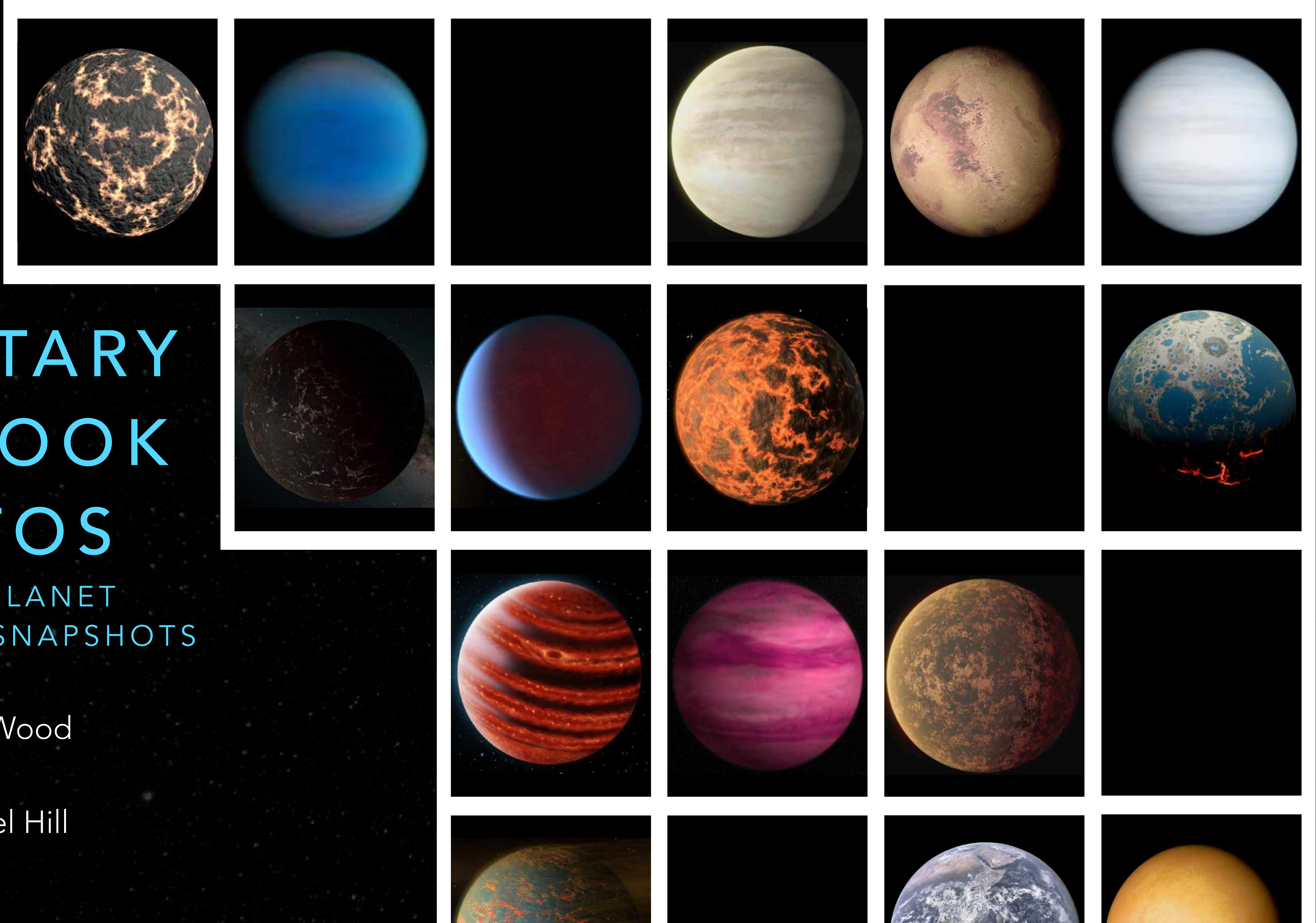


TABLE OF CONTENTS

- Background: What we already know
- Method: How to learn more
- New planets and what they tell us
- Questions?

THE BUILDING BLOCKS OF A PLANET

1

DUST

2

GRAVITY

- A star forms from a cloud of dust
- The leftover material from the cloud stays in a disk around the star
- Small particles in the disk collide and stick together
- They stick to more particles, until the clump is big enough to attract even more
- The planetismal picks up all the dust in it’s orbit
- The forming planets pick up all the dust in the disk

Video courtesy of NASA/JPL-Caltech

WHAT WE ALREADY KNOW

- Its hard for planets to form extremely close to the star, because there isn’t a lot of dust there
- But we find planets in that area, very close to their stars


51 Pegasi b Orbit
0.05 AU
Planet Radius:
1.6 RJ = 0.0007AU
Star Radius
1.2 R_sun = 0.006 AU
to scale


Mercury Orbit
51 Pegasi b Orbit
0.387 AU
0.05 AU
Planet Radius:
1.6 RJ = 0.0007AU
Star Radius
1.2 R_sun = 0.006 AU
to scale


51 Pegasi b
Radius: 0.00076 AU
Mercury
Radius: 0.000016 AU
to scale

PLANET MIGRATION

- Method 1: Friction with the disk
- Method 2: Interactions with other planets

CHANGING ATMOSPHERES

- Earth has gone through three atmospheres, only the last of which is capable of supporting human life
- Mars had an atmosphere and lost it
- Is it normal for planets to cycle through more than one atmosphere? When do they form and how?

OTHER PLANET FEATURES

- Planets can have rings and moons
- Do these form with the planet?
- Do they last the whole life or do they come and go?

REMAINING QUESTIONS

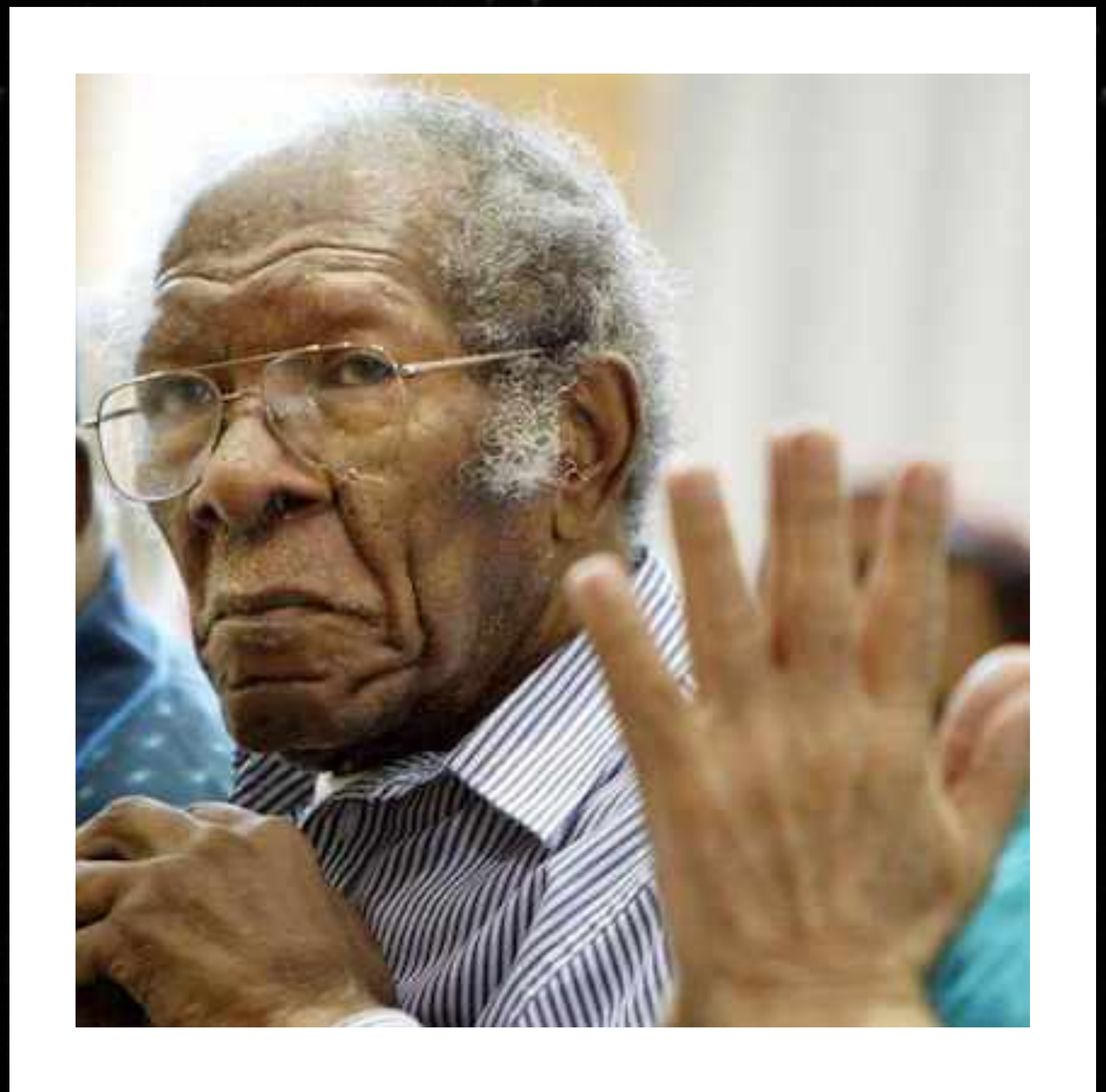
- How do planets change between their formation in the disk and their development into full 'mature' planets?
  - Do all planets migrate? What causes them to migrate?
  - Do all planets form atmospheres but lose them? Is it common for planets to have multiple atmosphere compositions during their lives?
  - How do other planetary features change?

THE GOAL

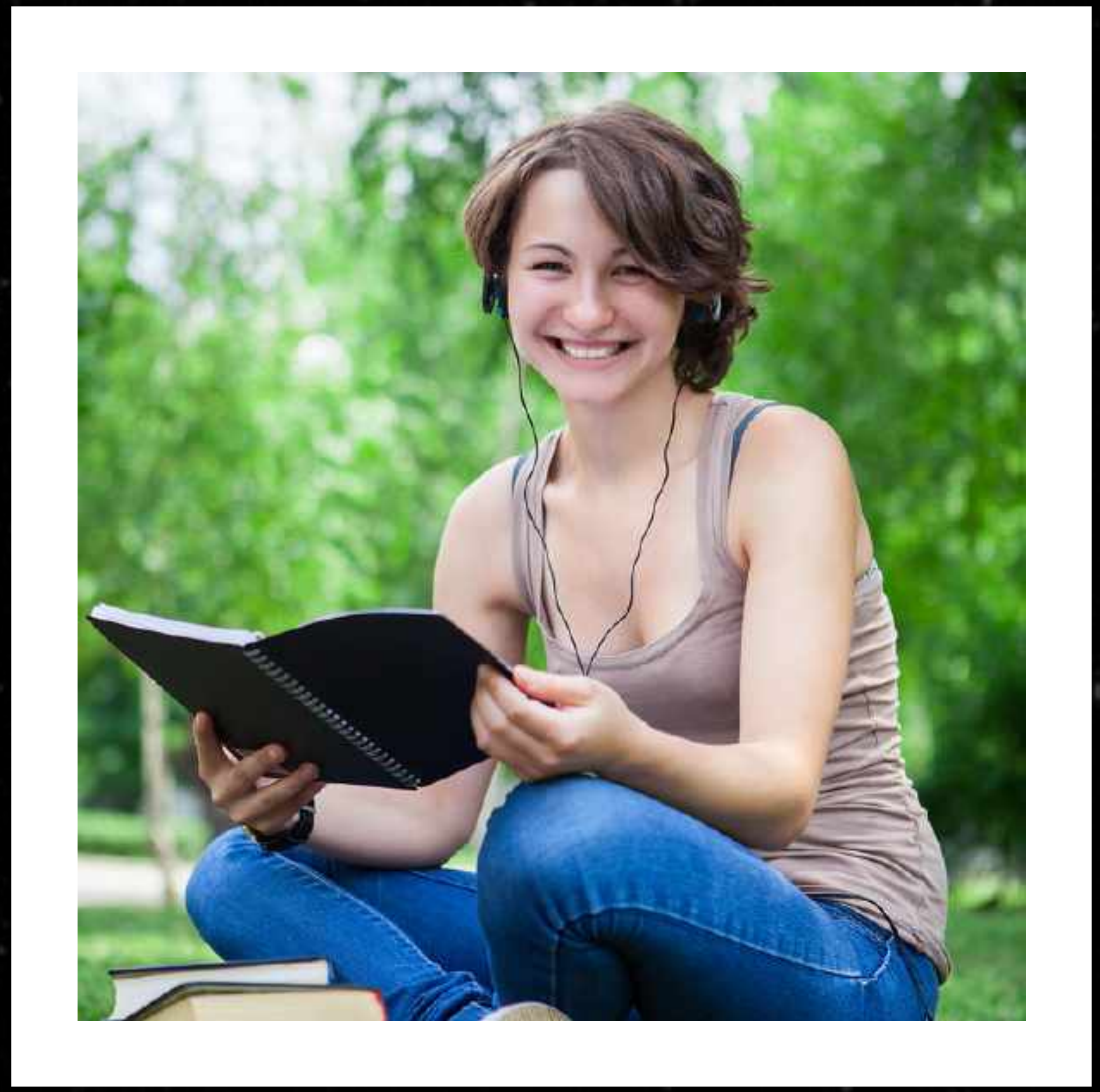
- We want to learn about how planets form and change over time.

- But the lifetime of a planet is much longer than the lifetime of all of modern astronomy, much less one astronomer

- So rather than watch one planet, we have to look at many planets and determine how they age from that

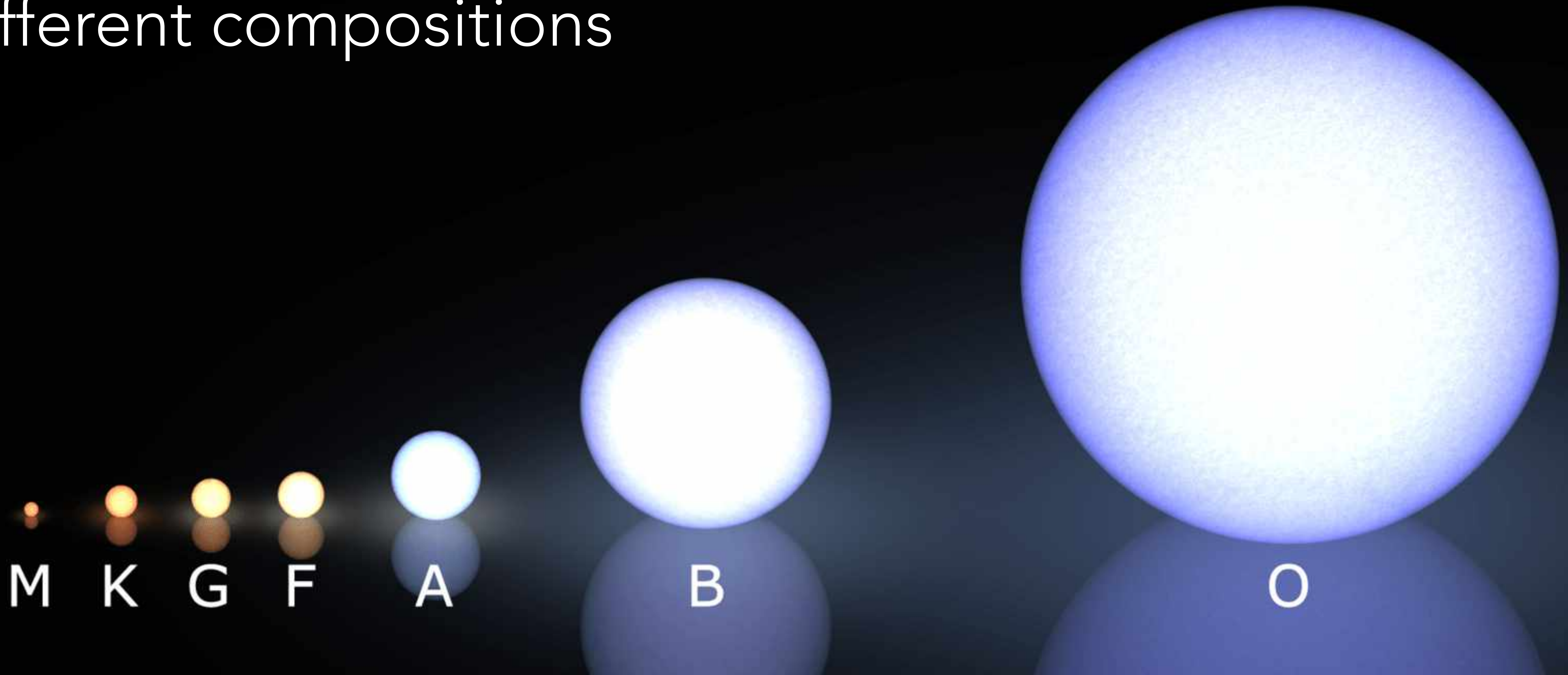




SO HOW DO WE TELL THE AGES OF PLANETS?

- Planets have roughly the same ages as the stars they orbit
- Measuring the age of a star still has most of the same problems as measuring the age of a planet

- They evolve differently depending on their size
- They form as singles or as binaries or triples
- The form in different environments, giving them different compositions



IT'S BETTER IN A GROUP

- Star clusters are groups of stars that all have the same age
- Because they have many stars age measurements of them are more accurate
- Then you know the age of any star or planet in the group

WHAT IS A YOUNG PLANET?

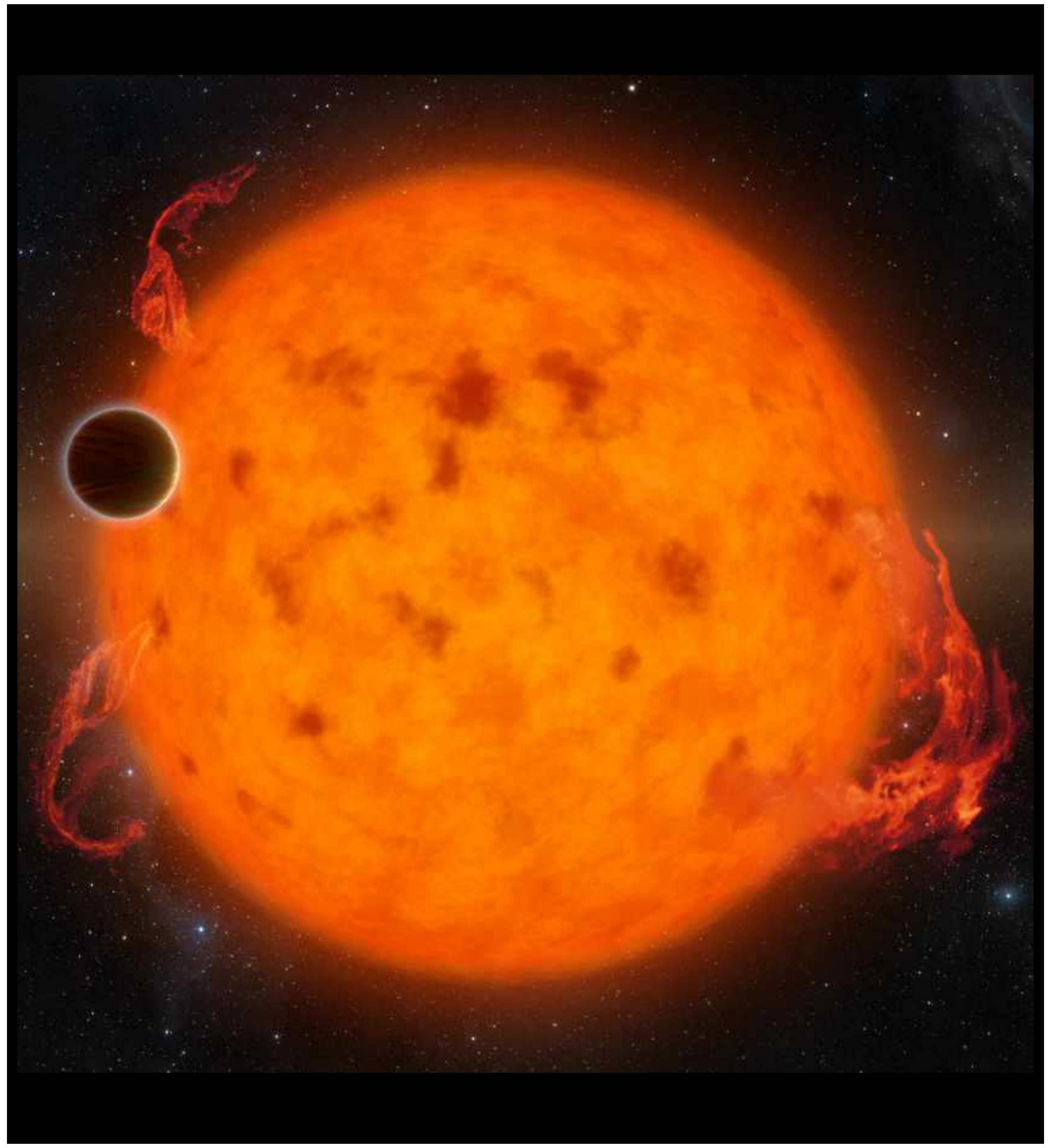
< 13 JUPITER MASSES

< 100 MILLION YEARS

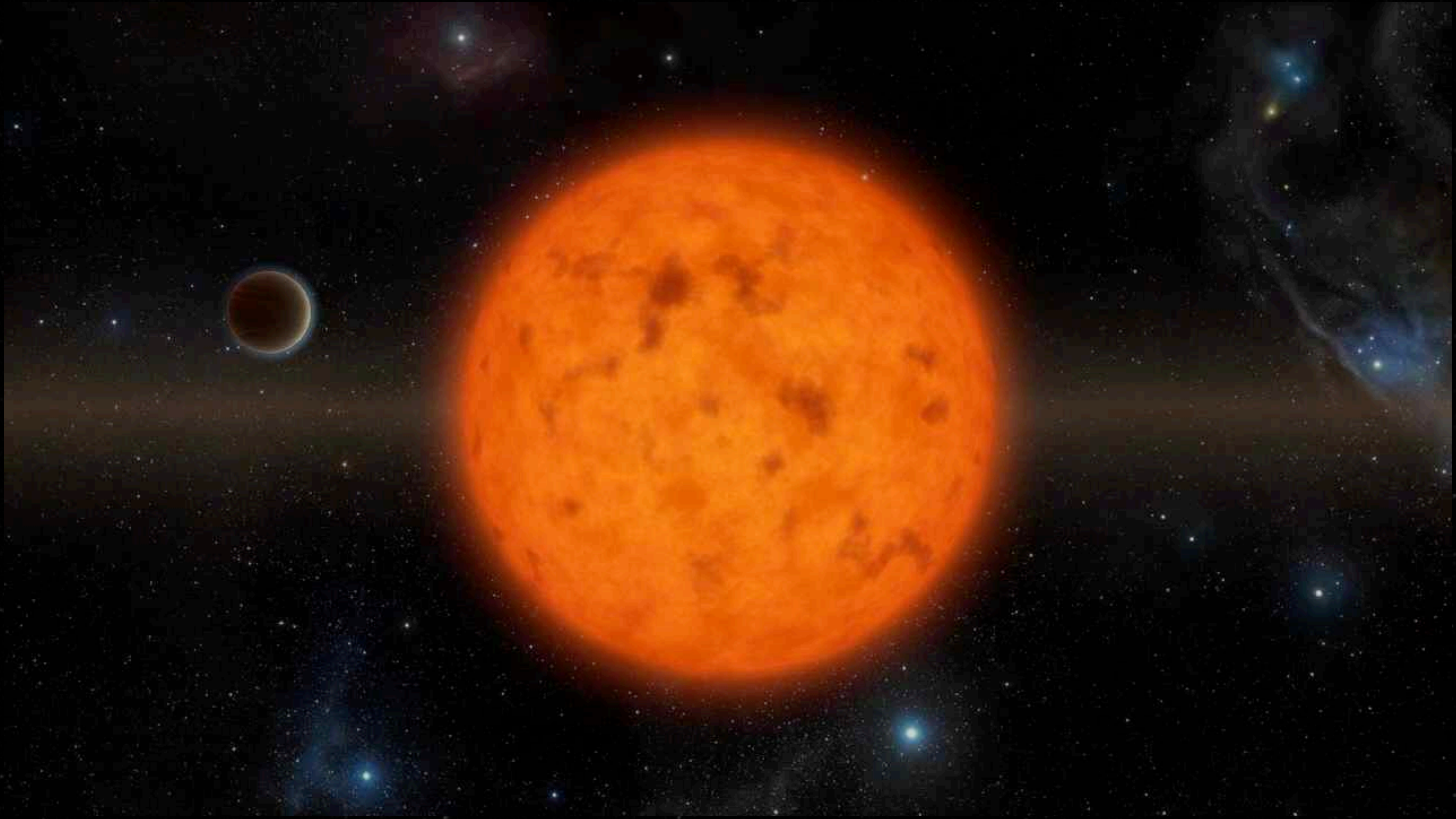
KNOWN YOUNG PLANETS

- K2-33b ~ 10 Million Yrs
- V830 Tau b ~ 2 Million Yrs
- DS Tuc Ab ~ 45 Million Yrs
- V1298 Tau b ~ 23 Million Yrs

K2-33B



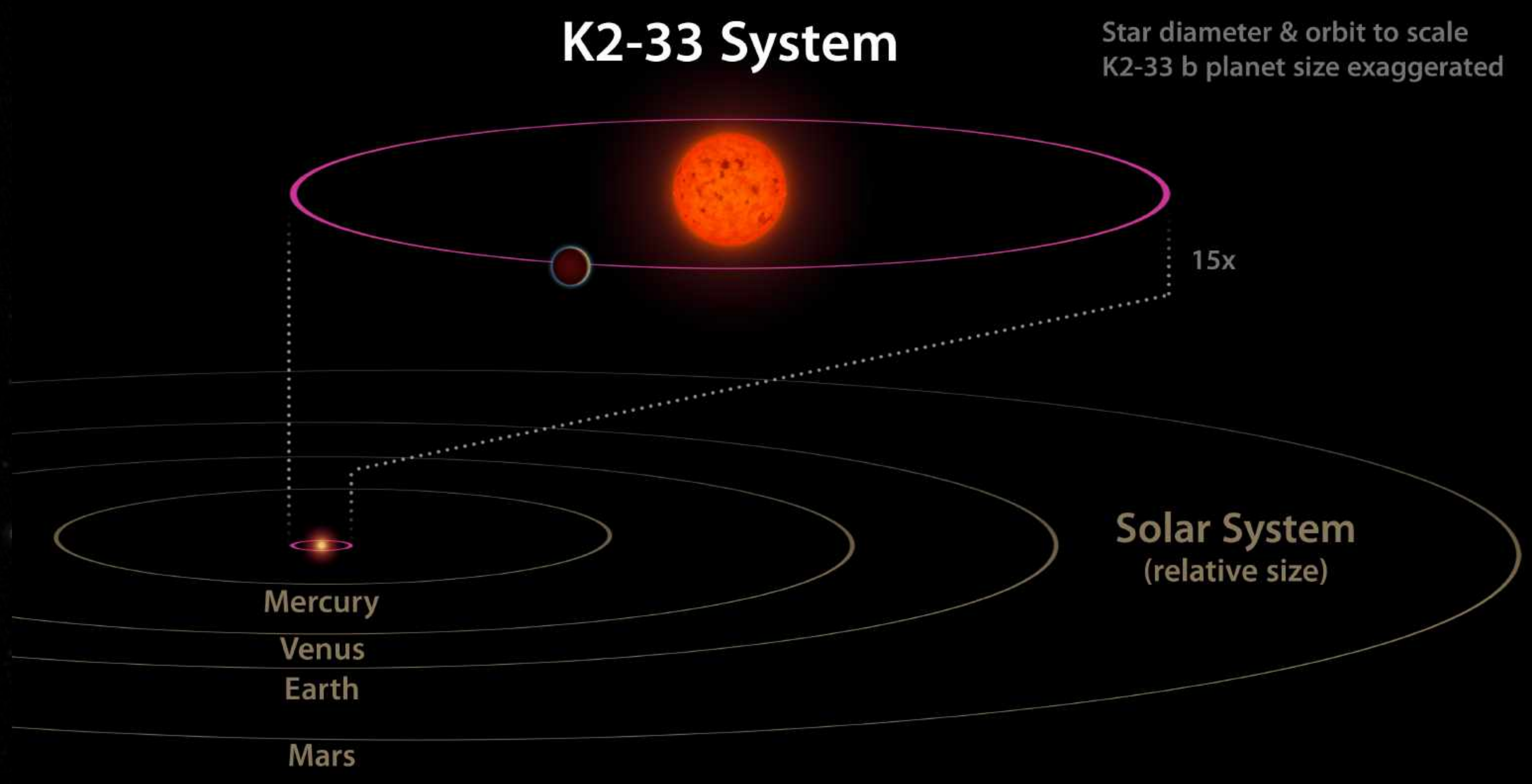
K2-33B



Movie Credit: NASA/JPL-Caltech

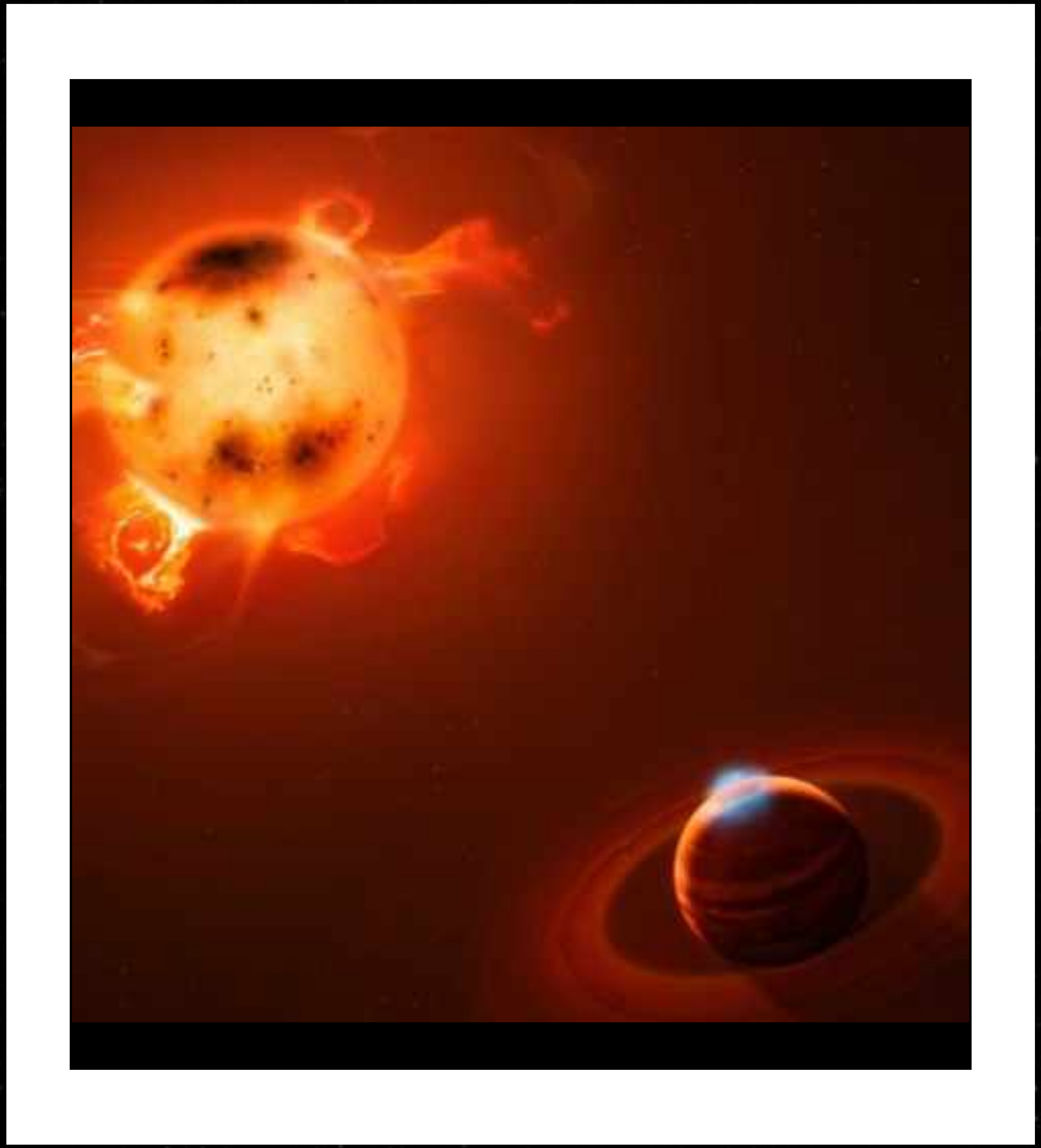
K2-33B

- K2-33b is very close to it's star
- It's only 11 million years old
- This means that the planet must have migrated inwards in the first 11 million years



Mann, Andrew W. et al. AJ 152.3 (2016): 61.
Image Credit: NASA/JPL-Caltech

V830 TAU B



V-830 TAU B

- V 830 Tau b is also very close to it's star
- It's only 2 million years old

Donati, J., Moutou, C., Malo, L. et al. Nature 534, 662–666 (2016)

DS TUC AB AND V 1298 TAU B

- Provide useful laboratories for studying young planets

David, Trevor J. et al. AJ 158.2 (2019): 79.
Newton, Elisabeth R. et al. APJ 880.1 (2019): L17

CONCLUSION

- There are many things we don't know about how planets form and change
- To understand this we have to find many young planets of various types and find how each one fits into the puzzle
-

Questions ?