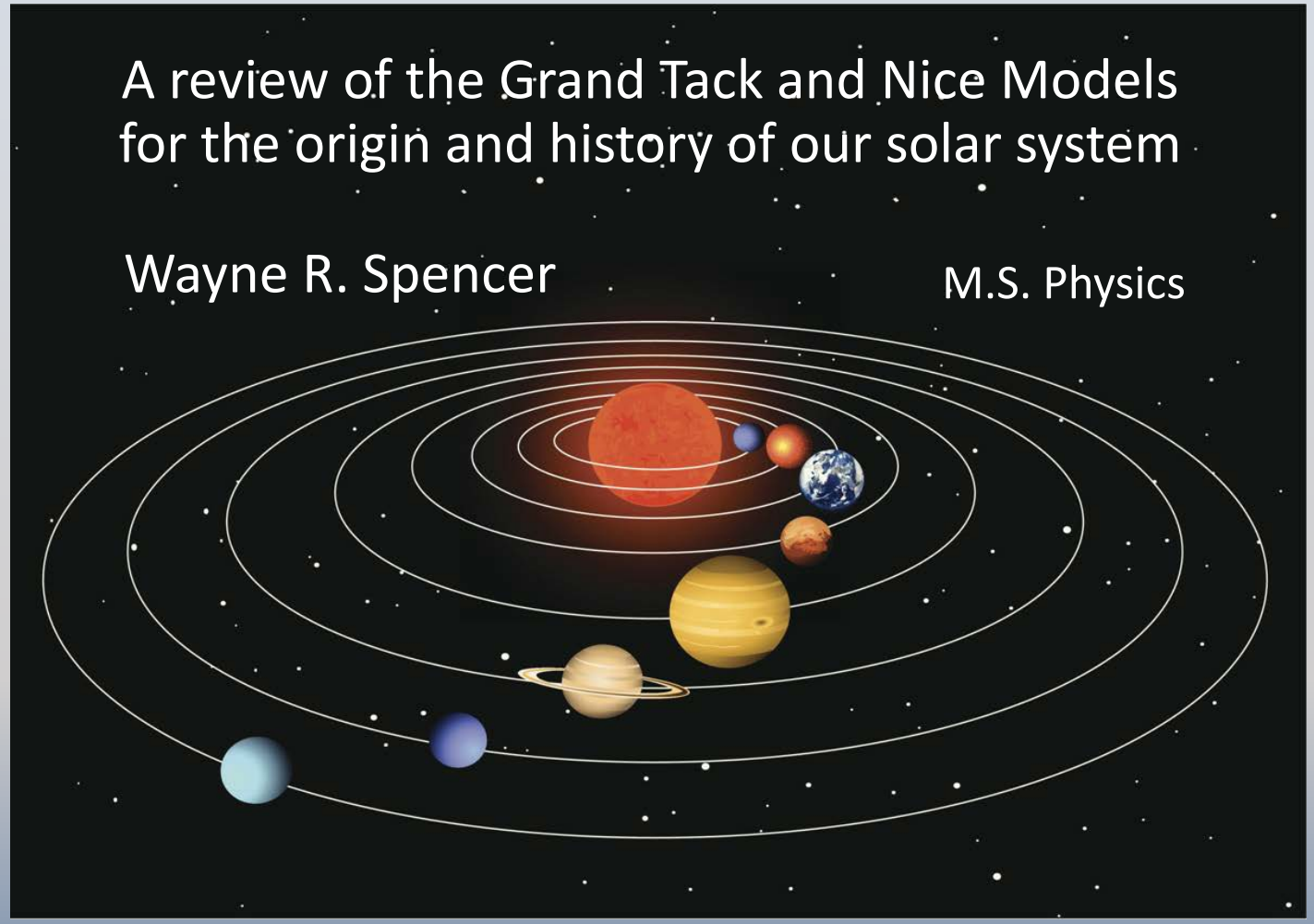
The Proposed Origin of Our Solar System with Planet Migration



Proceedings of the Eighth International Conference on Creationism, 2018

Planetary Science from 1994 to 2018

- **In 1994 at the ICC I did a critique of the Nebular Hypothesis for the origin of the solar system. Paper was called "The Origin and History of the Solar System."**

- **Beginning in 2001 I wrote a number of papers regarding extrasolar planets. First one was "The Existence and Origin of Extrasolar Planets" in the Journal of Creation.**
- **"Retrograde Exoplanets Challenge Theories" on AIG website, 2011**
- **"The Challenges of Extrasolar Planets", CRS Quarterly, 2017**

http://creationanswers.net/resources/planetarysciencepubs.htm

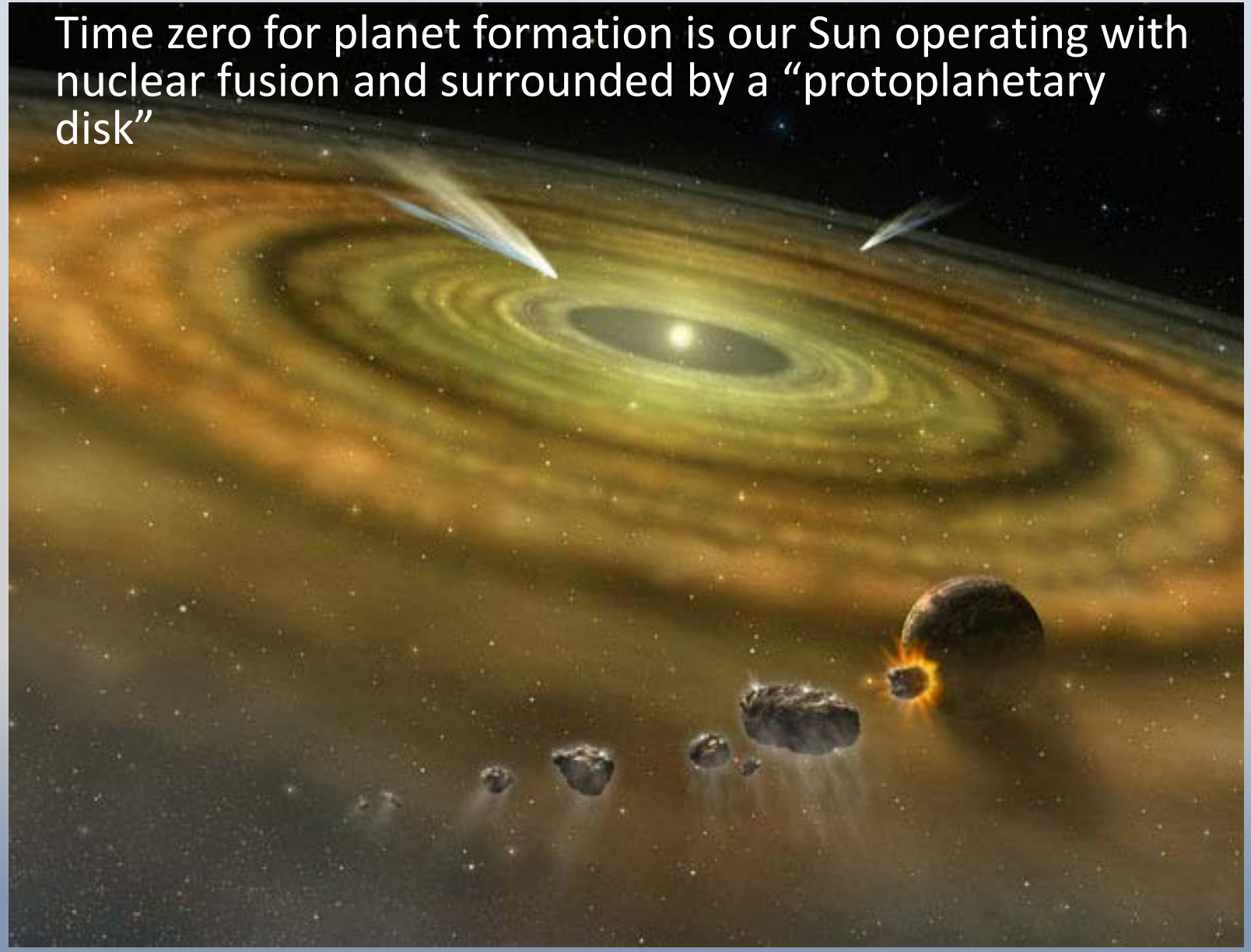
Planetary Science from 1994 to 2018

- **Planetary scientists are working to put our solar system and extrasolar planetary systems under the same theoretical framework.**
- **There are a number of valid detection methods for extrasolar planets and there is a growing variety of confirmed exoplanets. (3,798 confirmed cases as of July 2, 2018)**
- **Planet orbit migration is now well accepted theory. However, migration cannot be directly observed.**
- **The *Grand Tack* and *Nice* Models apply planet orbit migration in our own solar system. This is a significant change in planetary science regarding our solar system.**
- **These models are being well received in the scientific community.**

My View of Planetary Science

- **In 1994 I emphasized intelligent design at creation with catastrophic events possible at the time of Noah's Flood to explain our solar system**
- **For extrasolar planets I accept most of the observational evidence for exoplanets.**
- **However, I believe they were supernaturally created.**
- **I put forward evidence for impacts from space on Earth during Noah's Flood and wrote about the possible effects of this (1998 ICC).**
- **In 2014 Danny Faulkner put forward the Day Four Cratering Hypothesis, which has impacts on the fourth day of Creation Week and other impacts during Noah's Flood. I have now adopted this view (see "Evaluating the Day Four Cratering Hypothesis" Answers Research Journal 7, Sept. 10, 2014)**
- **I now rely more on processes during Creation Week and less on later catastrophic events in the solar system**

Theoretical Methods in Planetary Science



What are the Grand Tack and Nice ('niece') Models?

The Grand Tack

- **The Grand Tack concerns Jupiter, Saturn and the inner planets**
- **Proposed in 2012**
- **From formation of Jupiter to 600,000 years later**
- **Jupiter starts at 3.5 A.U. (not 5.2), Saturn starts at 4.5 A.U. (not 9.58)**
- **Jupiter migrates inward with Saturn following**
- **Jupiter and Saturn in 2:3 resonance. Inward migration of Jupiter stops at 1.5 A.U.**
- **Jupiter and Saturn migrate outward in resonance**

The Nice Model

- **The Nice Model concerns the outer planets and their outward migration**
- **Proposed in 2005**
- **Begins where the Grand Tack ends and proceeds for 100 to 700 million years**
- **Initial orbits – Jupiter 5.45 A.U., Saturn 8.18, Neptune 11.5 (not 30.2), Uranus 14.2 (not 19.3)**
- **Saturn, Uranus, & Neptune migrate outward together (mutual resonances)**
- **Outer solar system begins with a massive belt of planetesimals**
- **Neptune scatters the outer planetesimals**

Theoretical Methods in Planetary Science

- **Solids can be thought of as in three size categories (rough numbers):**
  1. **Dust (centimeter size and below)**
  2. **Planetesimals (1 Km to 20 Km diameter)**
  3. **Planetary embryos (1,000 to 7,000 Km diameter, Mars' sized)**
- **Planetesimals and planet embryos are *assumed* at the start of the simulations**
- **Gas giant planets are believed to form first, while gas is prevalent. (Mass of gas assumed ~ 100 X Mass of dust initially)**
- **There could have been planets that did not survive to the present**

Accretion of Solid Bodies

"In the simplest terms accretion of terrestrial planets is envisaged as taking place in four stages:

(1) Settling of circumstellar dust to the mid-plane of the disk.
(2) Growth of planetesimals up to ~1 km in size.
(3) Runaway growth of planetary embryos up to ~10^3 km in size.
(4) Oligarchic growth of larger objects through late-stage collisions.

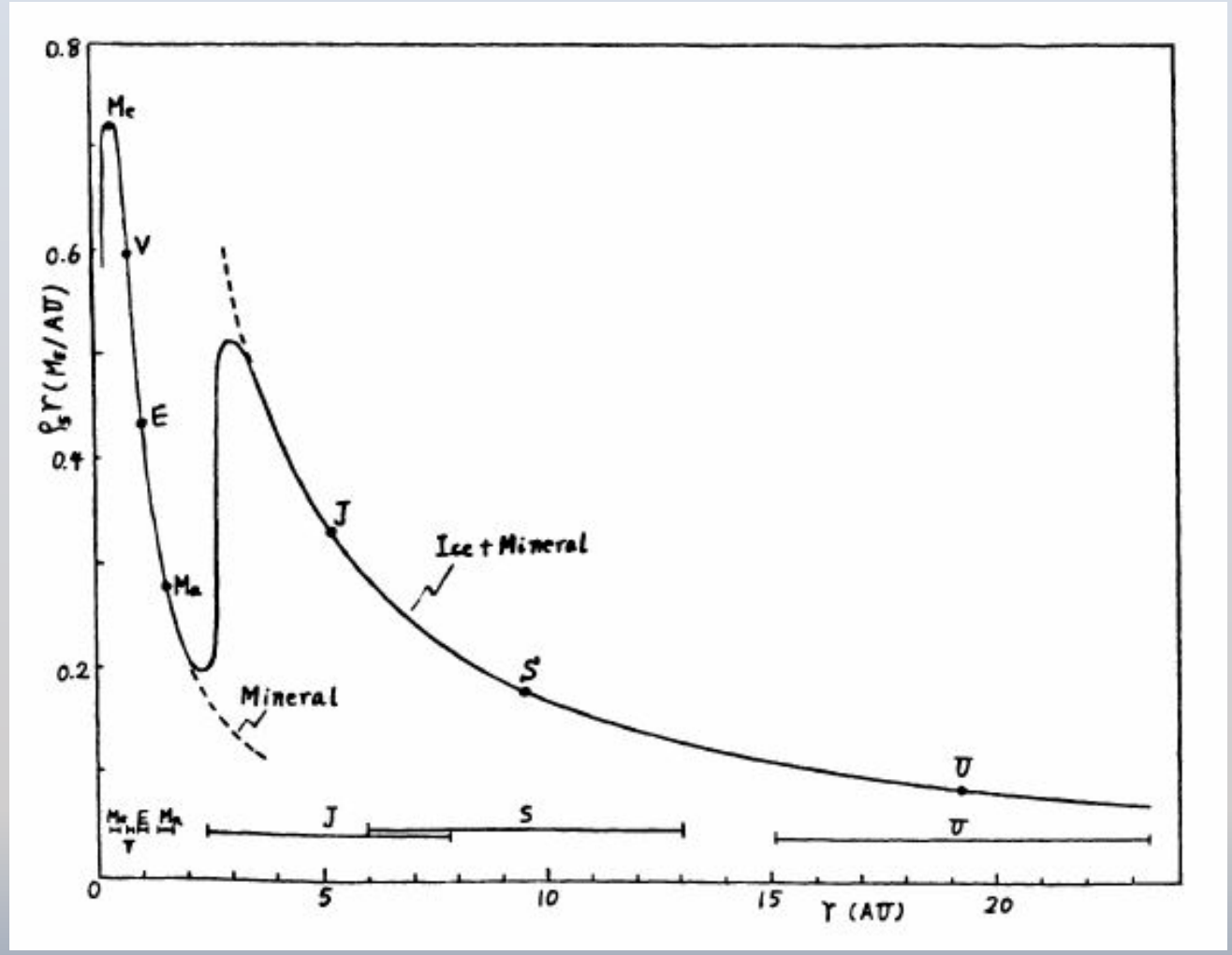
Stage 1 takes place over time scales of thousands of years and provides a relatively dense plane of material from which the planets can grow. The second stage is the most poorly understood at present but is necessary in order to build objects that are of sufficient mass for gravity to play a major role. Planetesimals would need to be about a kilometer in size in order for the gravitationally driven stage 3 to start.

We do not know how stage 2 happens, although clearly it must. Scientists have succeeded in making fluffy aggregates from dust, but these are all less than a cm in size."

Zahnle, K., N. Arndt, C. Cockell, A. Halliday, E. Nisbet, F. Selsis, and N.H. Sleep 2007, Emergence of a Habitable Planet. *Space Science Reviews* 129:35-78

Starting Assumptions – The Minimum Mass Solar Nebula (MMSN)

- **Total Mass of Gas = 0.02 – 0.04 (Mass of Sun)**
- **The MMSN assumed NO PLANET MIGRATION**
- **Start with the planet masses and spread that out over a certain distance surrounding the orbit**
- **Assume solar proportions of the elements**
- **Vertical scale is disk surface density x distance**

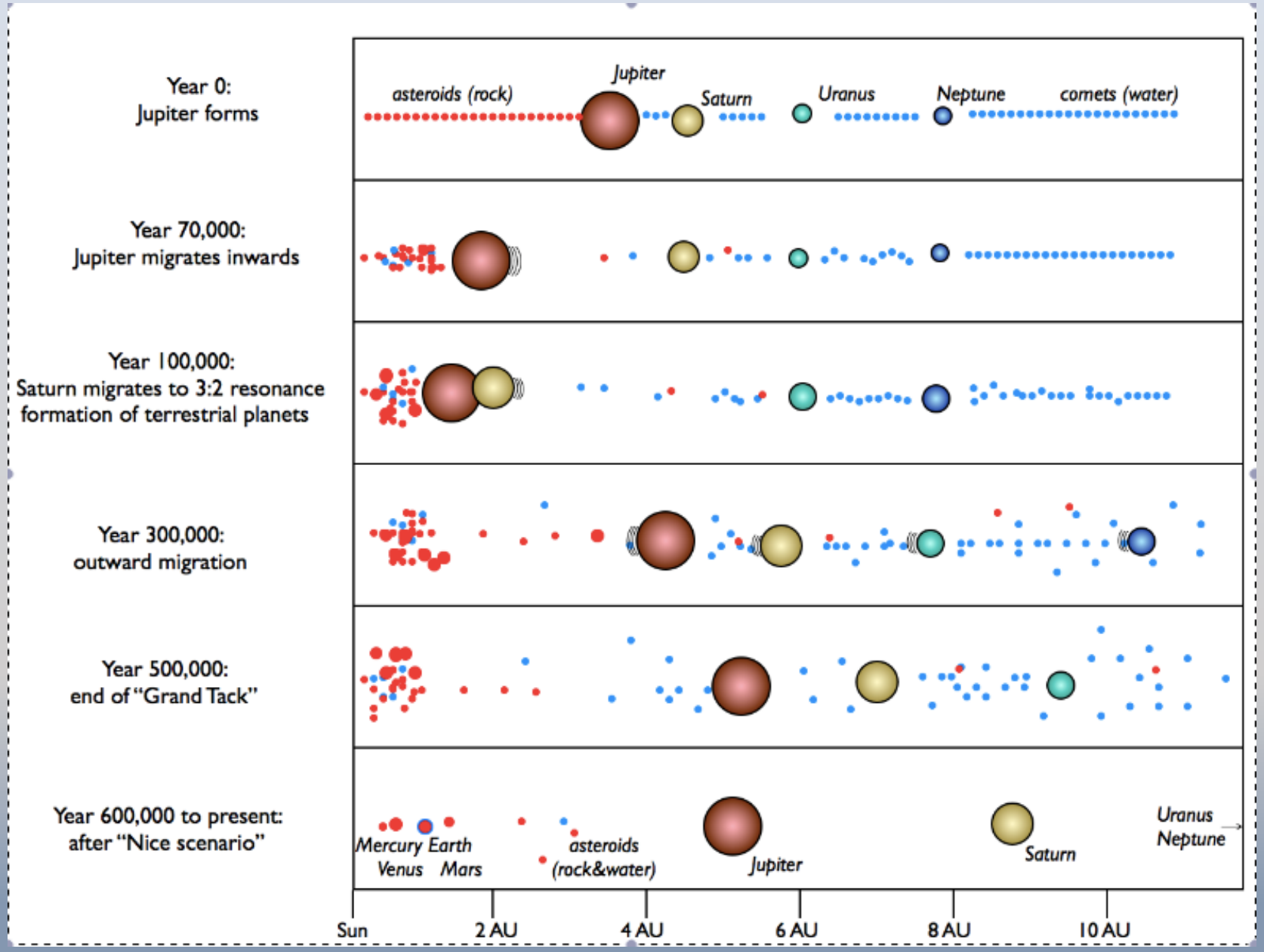


Hayashi, Chushiro 1981. *Formation of the Planets* in *Fundamental Problems in the Theory of Stellar Evolution. Proceedings of IAU Symposium No. 93*, Kyoto, Japan July 22-25, 1980, Dordrecht:D. Reidel (pp. 113-128).

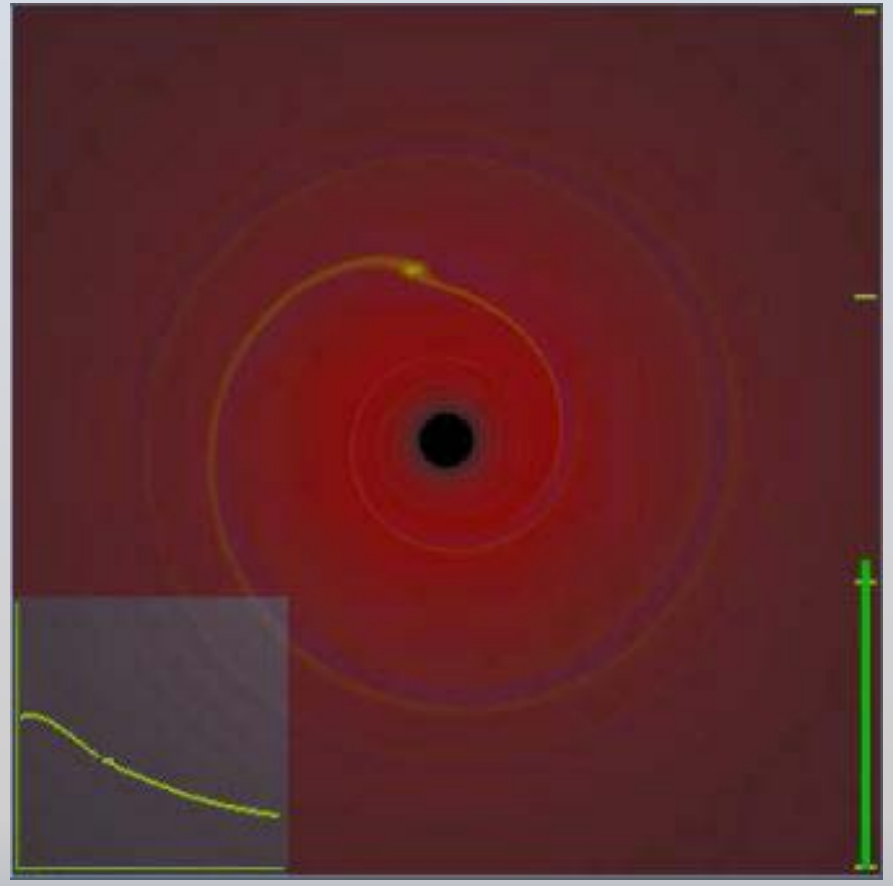
Planet Orbit Migration

- **Now a well-accepted theoretical process from the research on extrasolar planets.** ***However, planet migration is not directly observed, even in "Direct Imaging."***
- **Planet orbit migration can be either inward or outward**
- **Planet orbit migration has multiple possible mechanisms**
    1. **Caused by the disk of gas and dust (Types I, II, and III)**
    2. **Caused by solid planetesimals near the planet (lots of them)**
    3. **Caused by planet-planet orbit resonances**
- **All the above mechanisms have been applied in the new Grand Tack and Nice models**

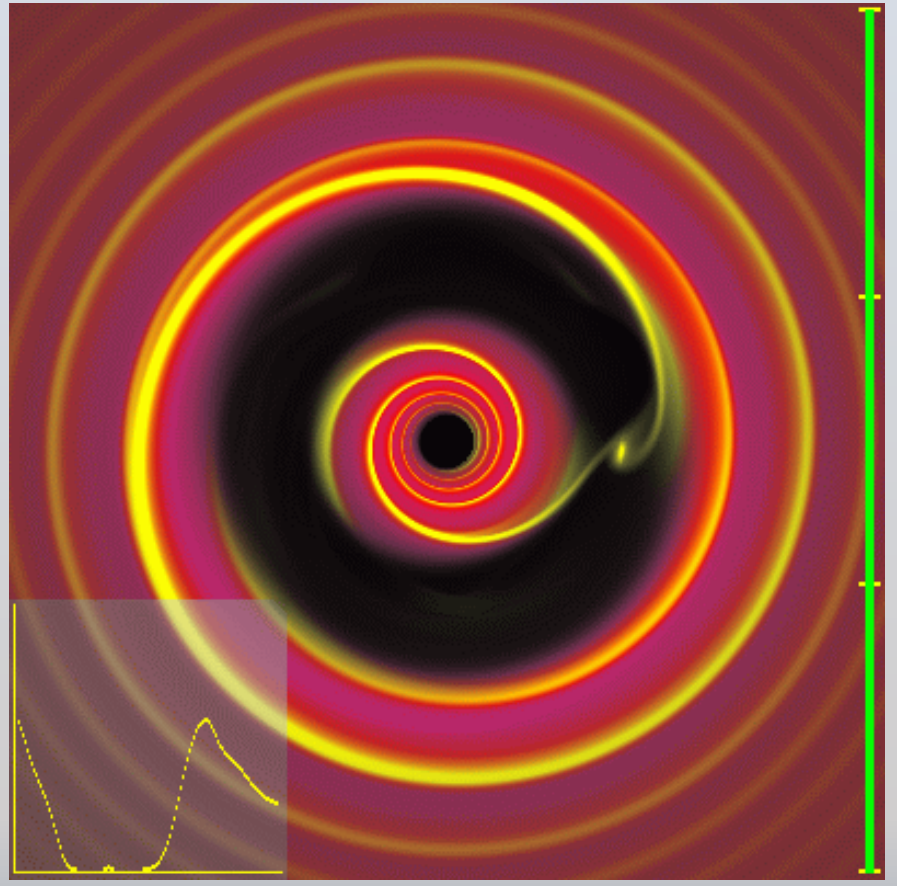
The Grand Tack Model



Gas-Caused Migration Types I, II, and III (Grand Tack)

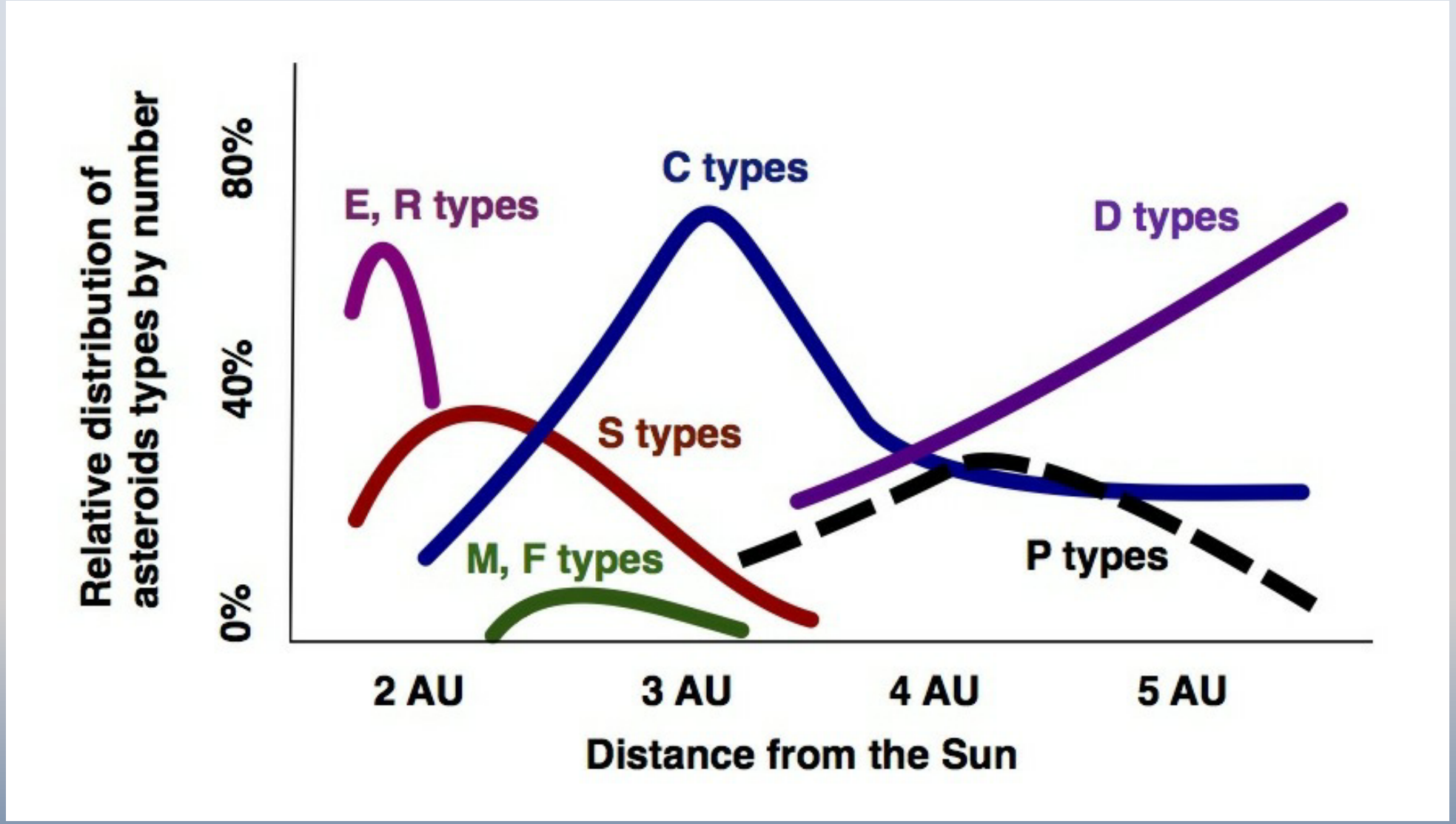


Type I Migration. The planet's mass is small and it does not modify the disk. Faster orbit change.



Type II Migration. The planet's mass is large enough to modify the disk and form a gap. Slower orbit change.

Asteroid Compositions and the Grand Tack



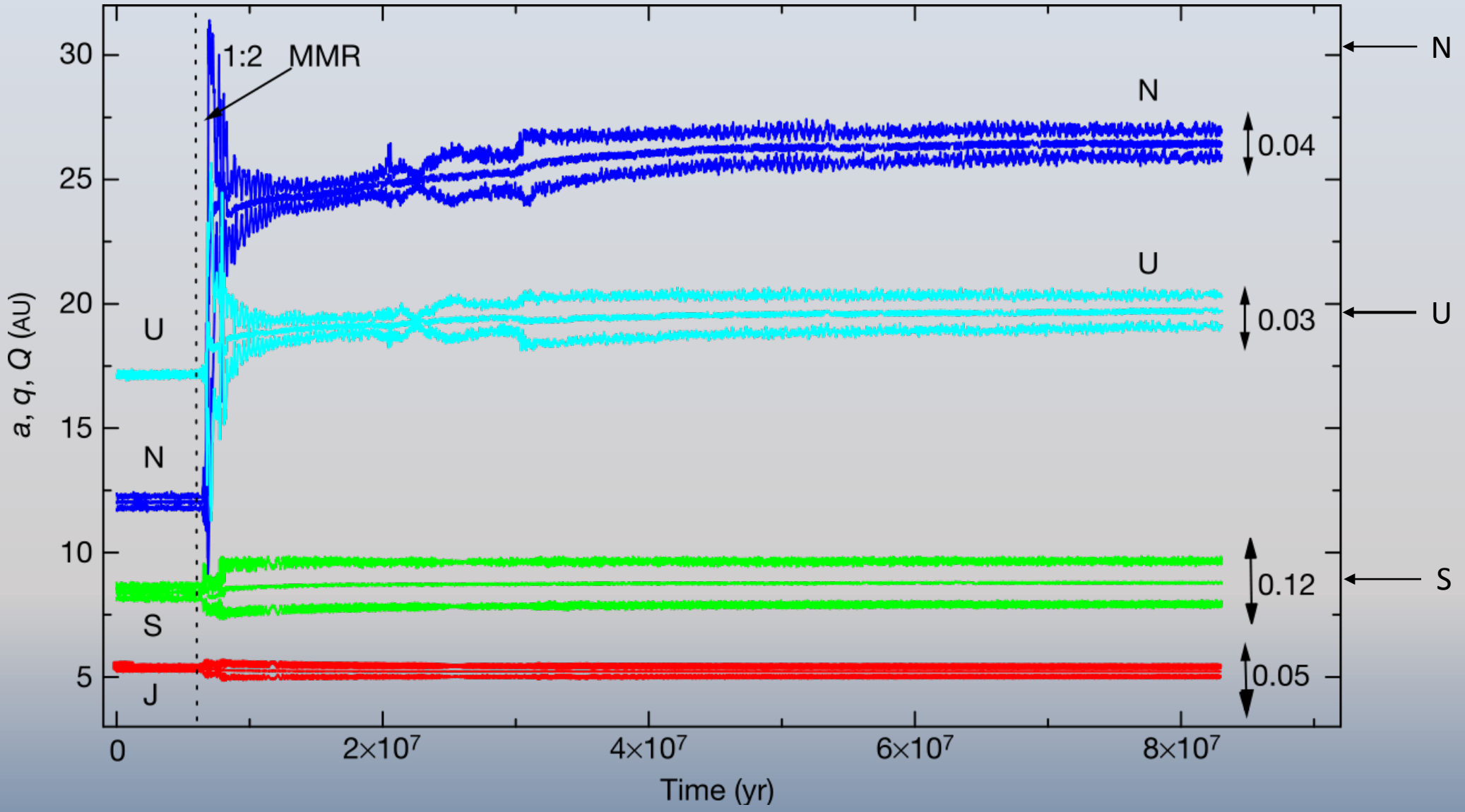
‘Successes’ of the Grand Tack

- **Jupiter pulls asteroid-like objects inward, that will contain volatile compounds, including water.**
- **Since Jupiter sweeps up material between 2 and 3 A.U., this explains why Mars’ mass is small (11% of Earth).**
- **If Jupiter stops at 1.5 A.U. this leaves sufficient space near the Sun for the rocky planets to form.**
- **For Saturn to stop Jupiter’s inward migration, the mass ratio of Jupiter/Saturn is critical (must be between 2 and 4). Also the two gaps must overlap.**
- **When Jupiter & Saturn migrate back outward this mixes small bodies and rebuilds the asteroid belt in a somewhat ‘zoned’ manner.**

The Nice ('niece') Model

- **The outer planets begin closer to each other and closer to the Sun than their present orbital positions (except Jupiter)**
- **Gas has dissipated in the solar disk before the Nice migration starts**
- **At the beginning of the Nice model, there is a massive disk of planetesimals in the outer solar system. It exists from about 15 to 35 A.U. distance and totals about 35 Earth masses.**
- **Saturn, Neptune, and Uranus all migrate outward**
- **When Neptune moves into the planetesimal disk, it causes an "instability", which scatters planetesimals.**

The Nice Model Scenario



Migration Mechanisms of the Nice Model

Caused by Planetesimals

- **A planetesimal near the planet is scattered by it. This can change the planet's angular momentum slightly.**
- **If there are enough planetesimals, the planet's orbit could be slowly altered.**

Caused by Orbit Resonances

- **In orbit resonances between two planets, the orbital periods are small integer multiples, causing them to frequently pull on each other.**
- **Migration models start the planets closer together and put them in more eccentric orbits to make migration more likely.**

From 1992 to the Nice Model

1992 From Stuart Ross Taylor (see Spencer 1994 ICC)

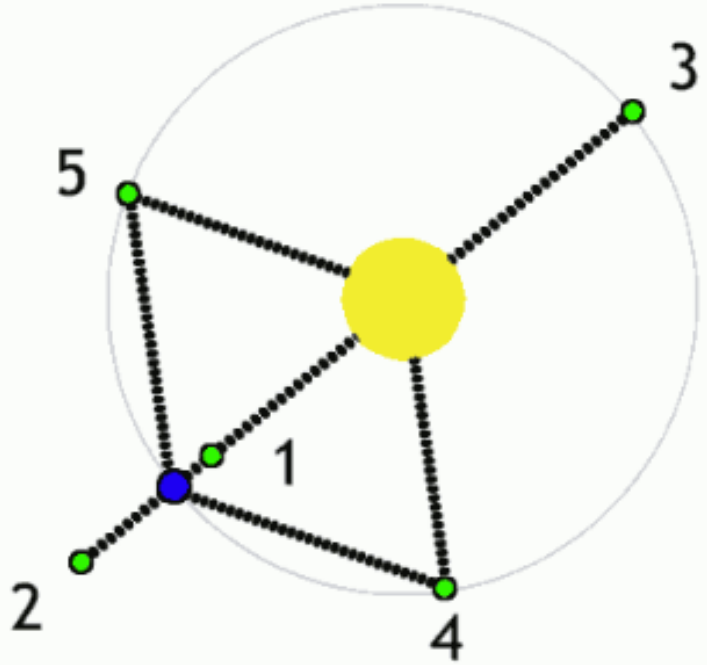
> **"Other estimates for the times taken to form a 10-Earth-mass core are 700,000 years for Jupiter, 3.8 m.y. for Saturn, 8.4 m.y. for Uranus, and 23 m.y. for Neptune"**

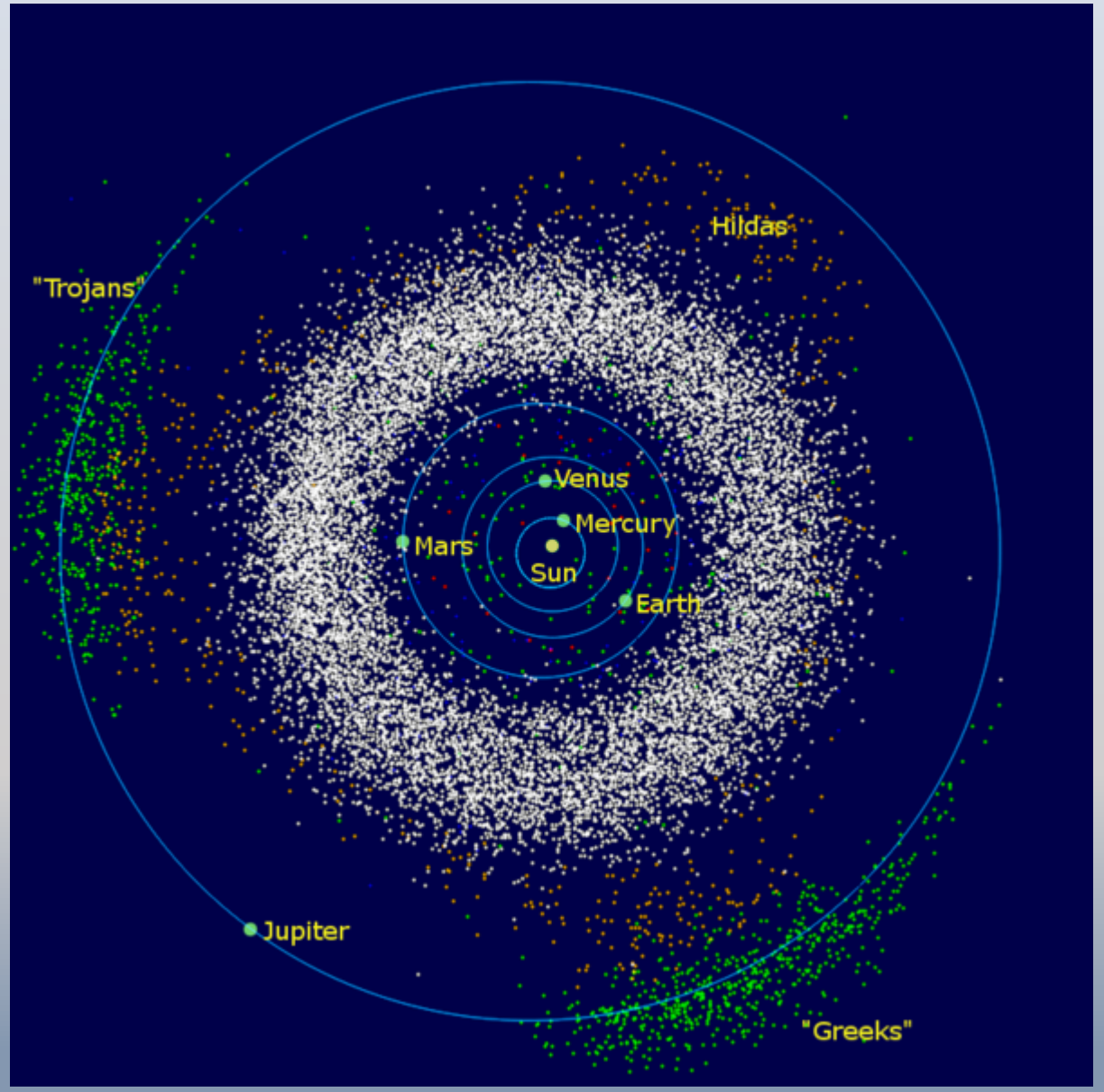
Answered in the Nice Model?

- **Nice Model starts Saturn, Uranus, & Neptune closer to the Sun, where the disk is more dense**
- **Then they migrate out to their current orbits**

The Trojan Asteroids for Jupiter

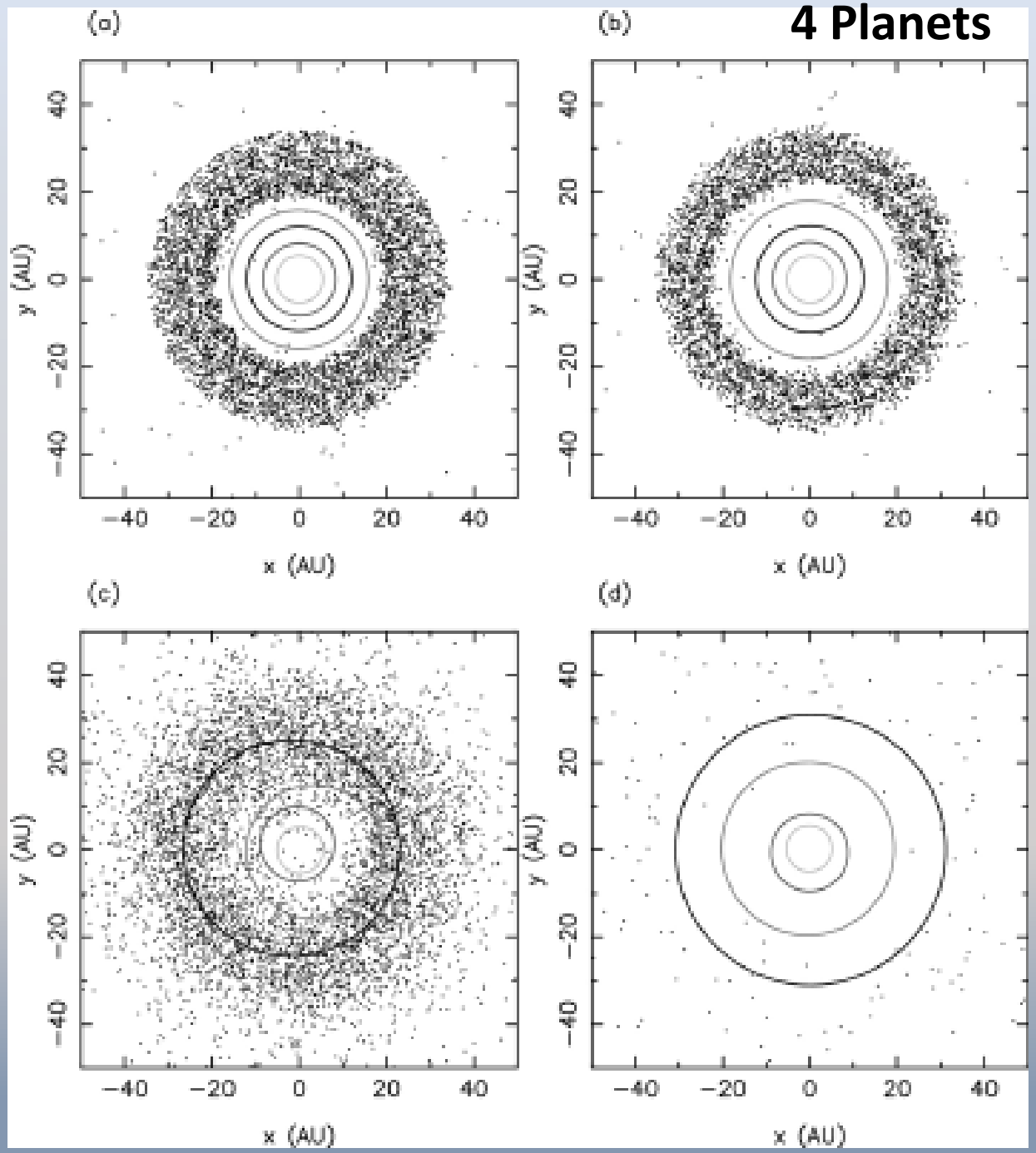
The Lagrange Points





The Disk Instability of the Nice Model

- **When Neptune reaches the outer disk, planetesimals are scattered!**
- **Many variations on the Nice model have been tried by researchers.**



Our Solar System and the Bible

- **The new solar system theories do not allow for intelligent design**
- **The Bible implies a young age for the entire universe**
- **Exodus 20:11 has everything created in six days**
- **Genesis 2:1 emphasizes the completeness of everything at the end of the creation week, so there was no long period in which Earth was uninhabitable.**
- **Though not described in Scripture, it is reasonable to infer that solar system objects were created on the fourth day**
- **Thus, Scripture implies the origin of the solar system was rapid and supernatural**

Three Important Questions

What are the assumptions made by the models?

Would the necessary conditions plausibly exist in a real system?

How do the models compare to observations of real disks?

Limitations of the Computer Simulations

- **The Grand Tack & Nice models assume a sequence of events that cannot be verified by observations**
- **They do not *predict* characteristics of our solar system, rather they *adapt to* the characteristics of our solar system. Many conditions are input into the simulations.**
- **Planetesimals and Planet Embryos are assumed to exist at the beginning of the simulations, though how they formed is unexplained.**
- **All collisions with a planetary embryo are assumed to result in a merging of the two objects onto the embryo. (Unlike the Moon's formation by impact)**
- **Current simulations cannot handle the migration of planets in a gaseous disk and handle the accretion of gas onto the planet at the same time.**

Migration and Accretion cannot be modeled together

“Hydrodynamical simulations of planet migration do not have the requisite resolution to realistically include gas accretion, yet these two are intimately coupled in the Grand Tack model. This is a key uncertainty for the Grand Tack; it is unclear whether long-term outward migration of Jupiter and Saturn is possible given the stringent mass ratio requirement”

Raymond, Sean N., and Alessandro Morbidelli (2014) The Grand Tack model: a critical review. Proceedings of the International Astronomical Union 9 (July) no. S310:197.

Special Timing Required

- **The rapid formation of Jupiter before migration begins (est. 1 to 5 million years)**
- **The gas in the disk must last long enough for Jupiter and Saturn to migrate through it *twice*!**
- **What if Saturn formed too early or too late, or its mass were different? The relationship between Jupiter and Saturn is the key to both models working.**
- **Initial positions and disk density are varied to adjust timing**
- **Planet orbit eccentricities are also changed at the start to adjust timing**
- **When did the planetesimal disk instability occur? (100 MY or 700 MY)**

The Protoplanetary Disk and the MMSN

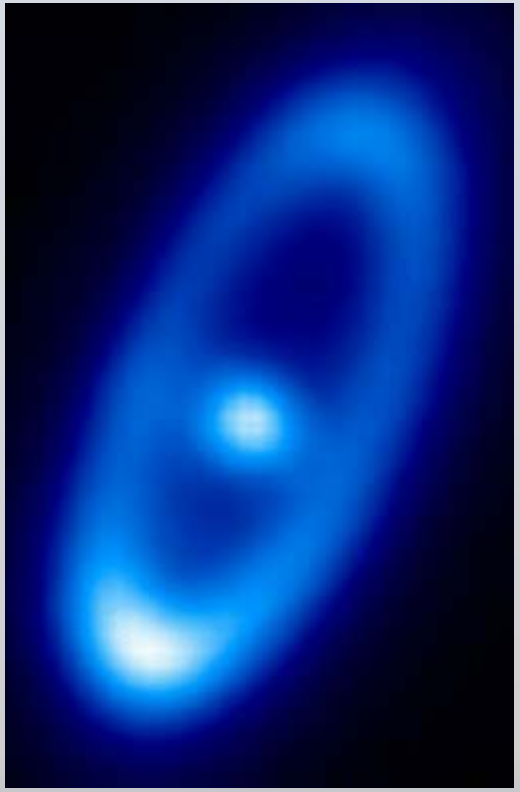
- **The MMSN disk model assumed no planet migration, from 1981**
- **It requires a much more dense disk to support migration over wide distances as in the Grand Tack and Nice models**
- **Desch (2007) attempted make a new disk model based on the initial positions of the planets in the Nice model**

The Desch Disk:
5.45 A.U. Surface density 10 X MMSN (Jupiter)
22 A.U. Surface density 4 X MMSN (Uranus, late Nice)
Leads to a big problem – all planets spiral into the Sun!

"I would claim that a new Solar Nebula consistent with the Nice model is still to be built"

Crida, A. 2010. Solar System Formation. In Volume 21 of Reviews in Modern Astronomy, Editor Siegfried Roser. (p.222).

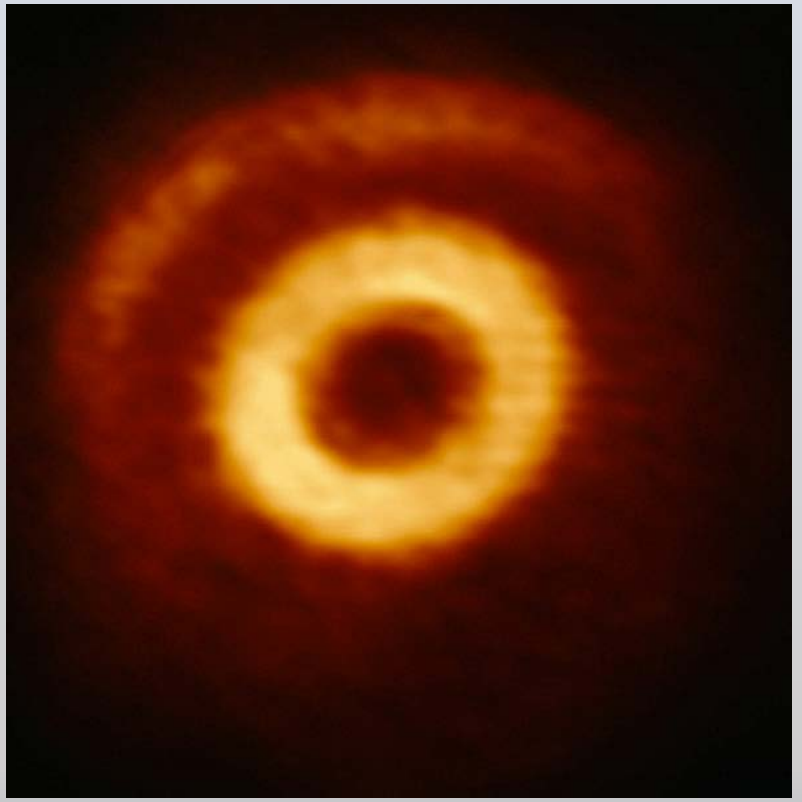
What about real disks?



Fomalhaut
Bright star 25 LY away

ESA Herschel Mission
April 2012 IR Image

Dust disk 133 A.U. in radius



V1247 Orionis

1000 LY away

ALMA IR image from November 2017

Outer disk about 85 A.U. in radius

Three Important Questions

What are the assumptions made by the models?

That orbit migration is real

Would the necessary conditions plausibly exist in a real system?

Probably not. Disks are not well understood. Models of disks give conflicting results

How do the models compare to observations of real disks?

Real disks are larger and less dense. Also we can 'see' dust but not larger solids.

What kind of conclusions should we draw?

- **The new Grand Tack and Nice model simulations do not constitute evidence that they actually happened.**
- **On the other hand, they explore cause and effect (what if …)**
- **When investigators put all the planets in the same simulation, Jupiter's orbit precesses and this causes resonances with the inner planets**
- **Thus, Jupiter affects all the other planets – it's like a dynamic anchor for the whole system**
- **The real solar system has the planets spread out enough in near circular orbits to make the whole system very stable**

Potential problems with the new migration models

- **Why didn’t Jupiter migrate in earlier? This would ruin everything!**
- **Certain moons such as the regular moons of Saturn**
- **Also the moons of Uranus and Pluto (both inclined)**
- **Planet rings, especially Saturn**

How did the planets get into their orbits? - Isaac Newton

"I do not know any power in nature which could cause this transverse motion without the divine arm. . . . So then gravity may put the planets into motion but without the divine power it could never put them into such a Circulating motion as they have about the Sun, & therefore for this as well as other reasons I am compelled to ascribe the frame of this Systeme to an intelligent agent."

And from a second letter . . .
"I would now add that the Hypothesis of matters [created matter] being at first eavenly spread through the heavens is, in my opinion, inconsistent with the Hypothesis of innate gravity without a supernatural power to reconcile them, & therefore it infers a Deity."

From two letters from Isaac Newton to Richard Bentley, dated 17 January 1692. Richard Bentley was the Master of Trinity College, Cambridge at the time. Bentley had asked Newton questions about gravity, apparently in preparation for a sermon.

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