

# Something's Fishy in Fomalhaut

Allegheny Observatory Public Lecture Series

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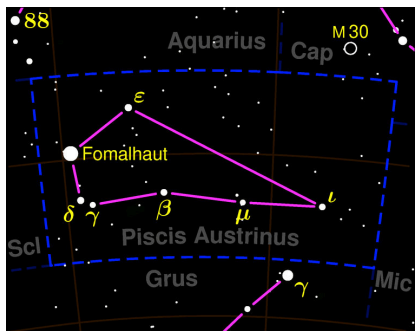


# Outline

- 1 Discovery of Planet Fomalhaut b
  - Fomalhaut the star
  - How to Find a Planet
  - The First Photograph of a Planet Around Another Star
- 2 Controversy and Doubt
  - How Did Fomalhaut b Form?
  - Why is it so Bright?
  - Why is it Invisible?
- 3 The “Zombie Planet”
  - So What's in the Pictures?

# Fomalhaut

## The Southern Fish

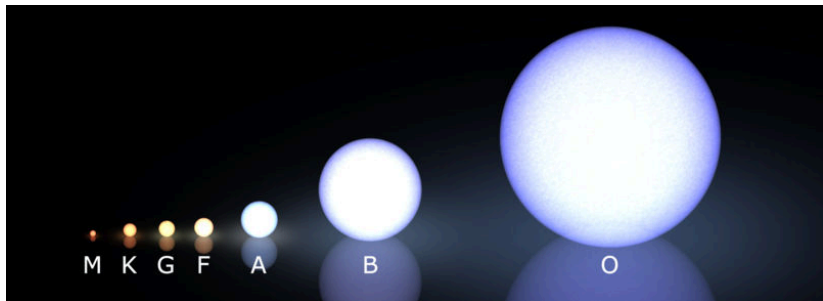


## The Fish's Mouth



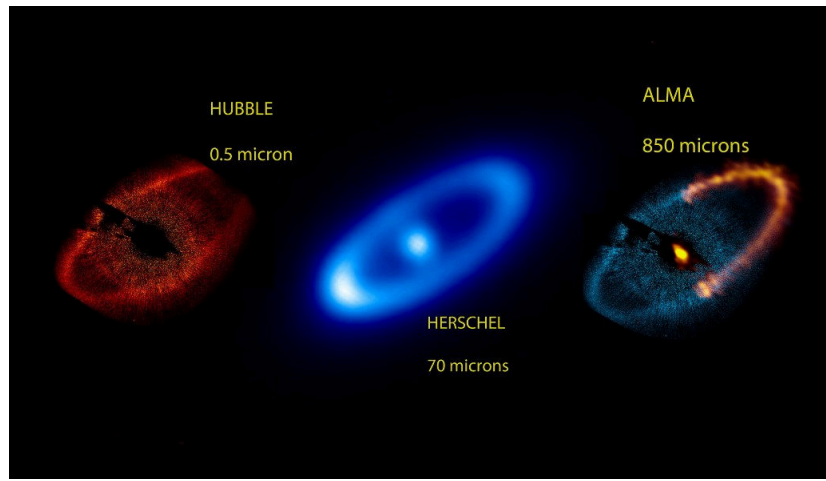
# Fomalhaut

- 17<sup>th</sup> brightest star in the sky
- 25 light-years away
- Type A star



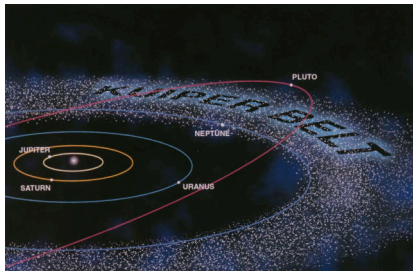
# What Makes Fomalhaut Interesting?

## Images of the Fomalhaut Debris Disk

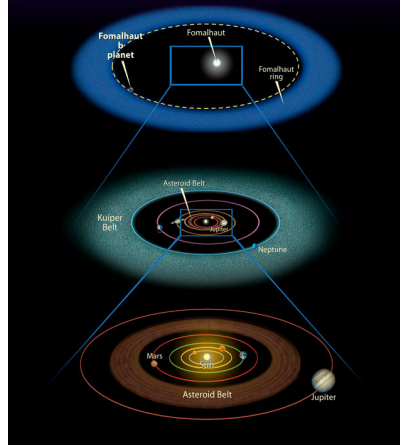


# Debris Disks and Planets

## The Sun's Debris Disk



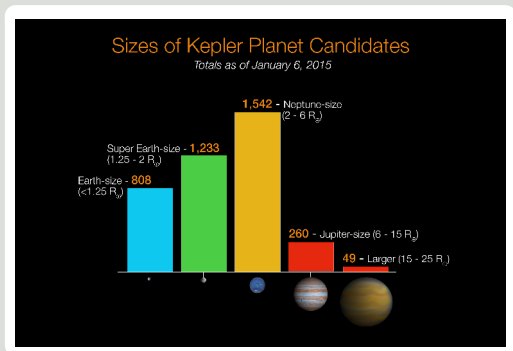
## Comparison of Fomalhaut System and Solar System



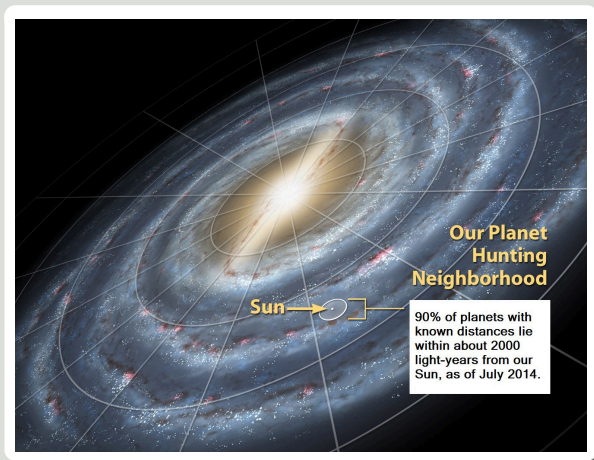
# How to Find a Planet

## From Easiest to Hardest

- Transits (video)
- Doppler Shift (demo)
- Direct Imaging



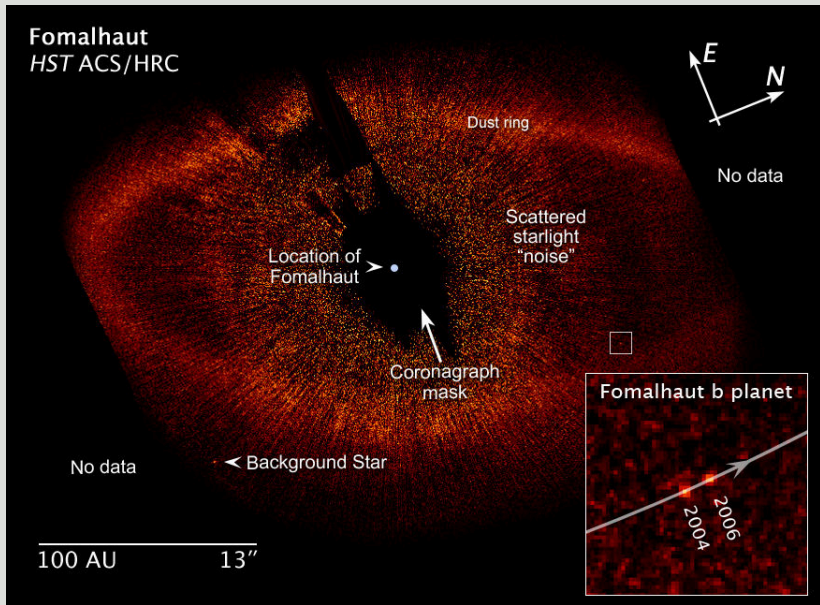
# Space Searched So Far



- See Exoplanet Encyclopedia (<http://exoplanet.eu>) for the current list.



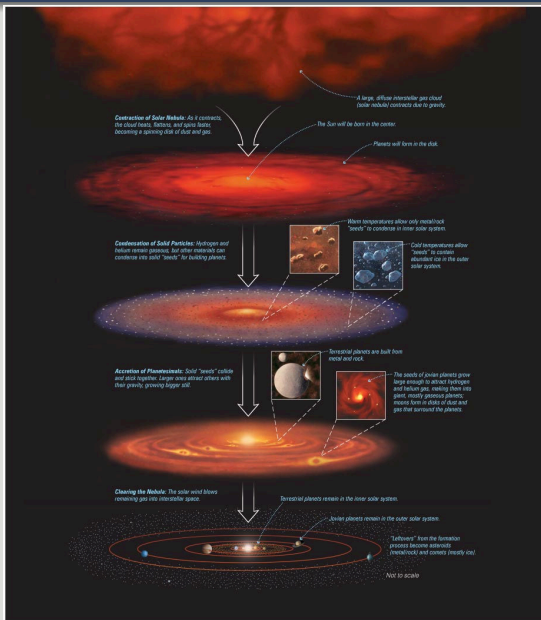
# First Directly Imaged Exoplanet



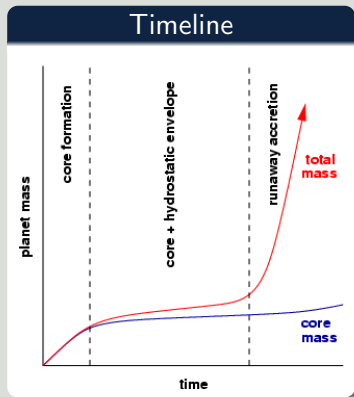
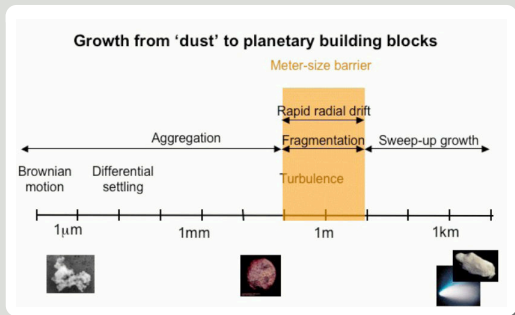
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# Planet Formation in the Solar System

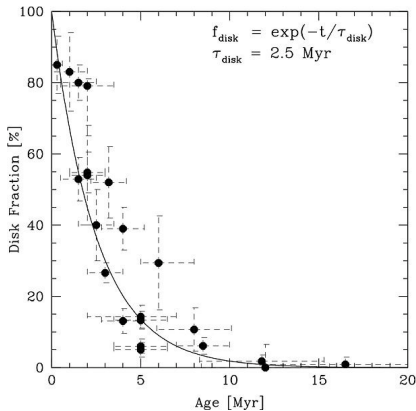


# Core Accretion

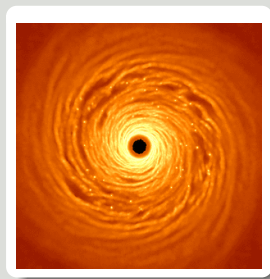
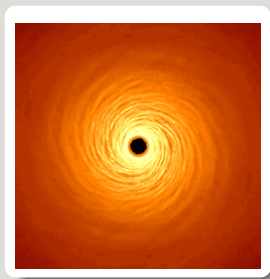
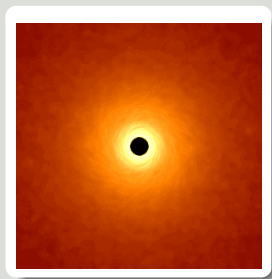


# Problem: Protoplanetary Disk Lifetimes

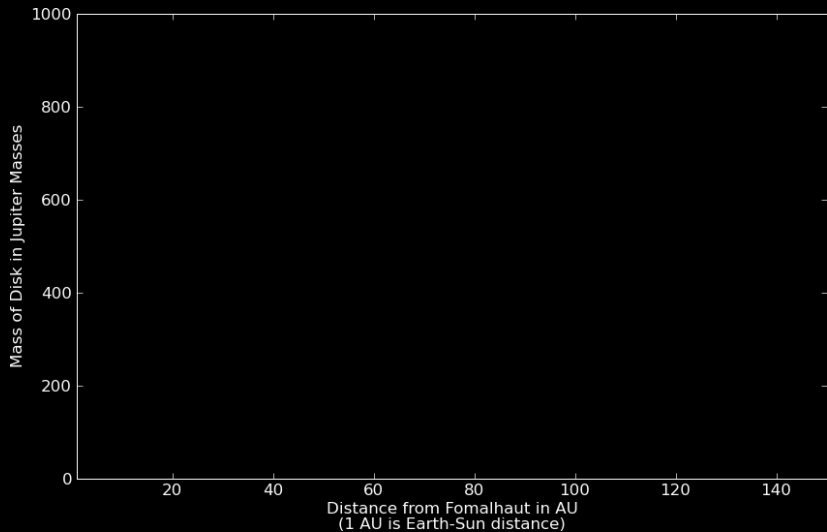
- It takes about 10 Myrs to form Jupiter
- This time **INCREASES** with distance from the star



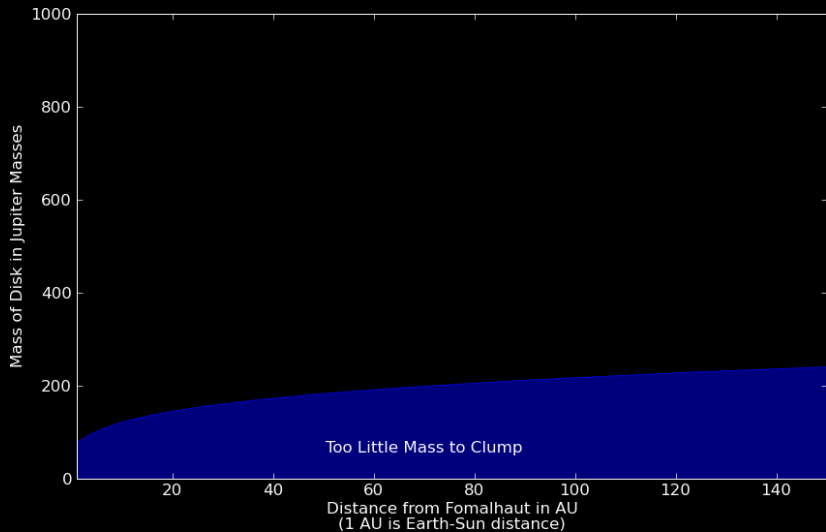
# Solution 1: Gravitational Instability



# Disk Fragmentation

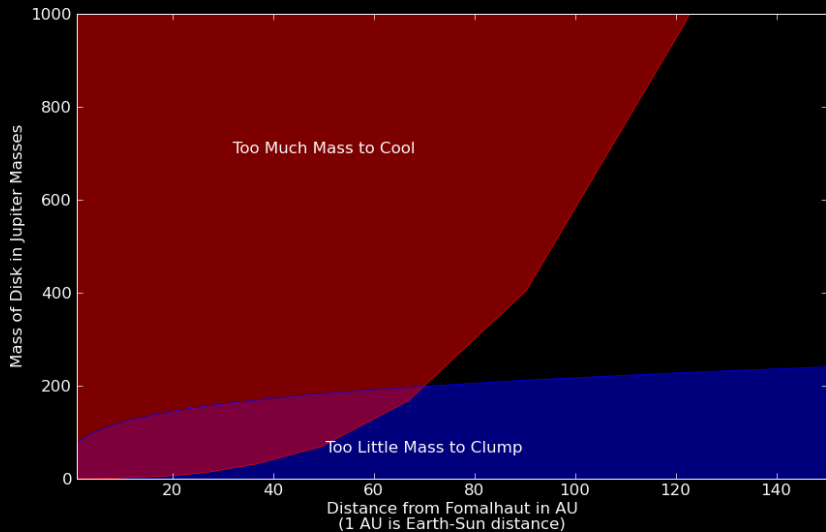


# Disk Fragmentation

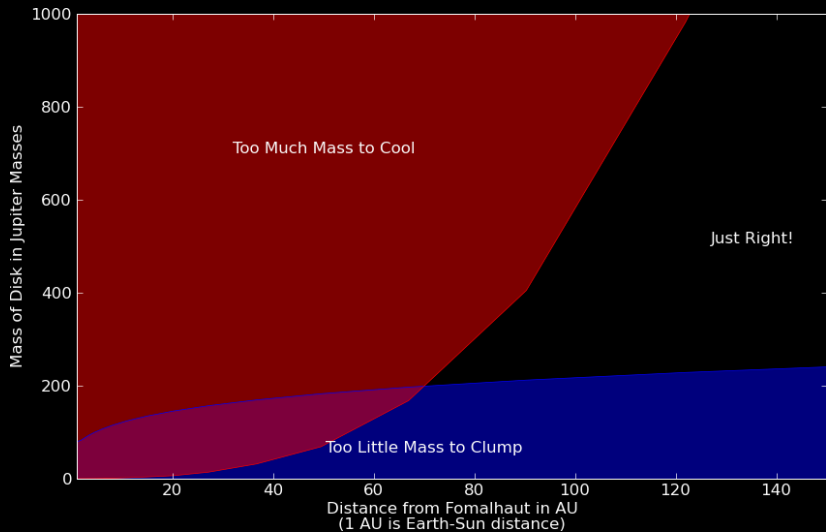




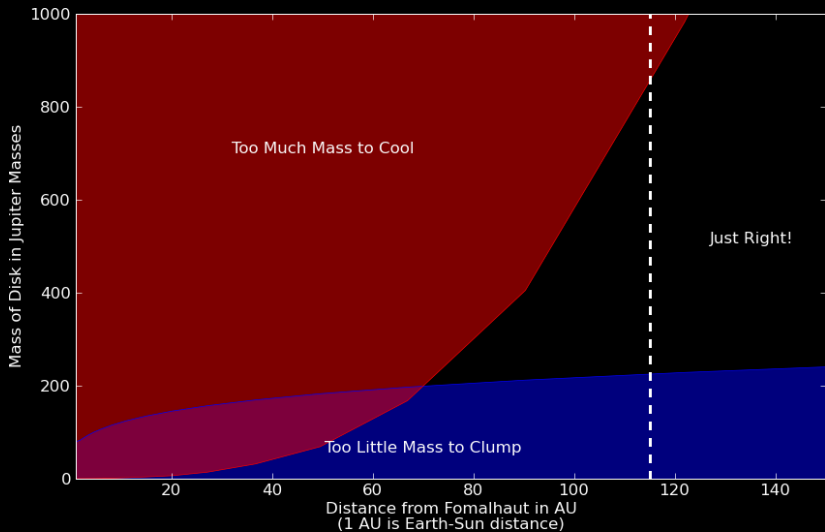
# Disk Fragmentation



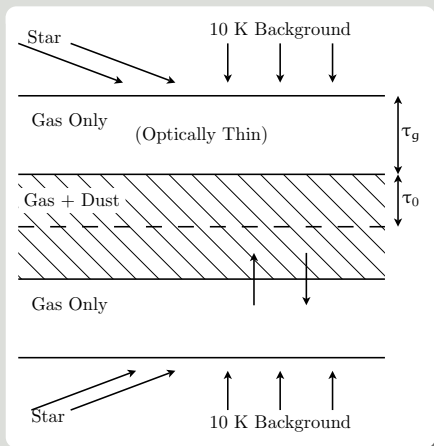
# Disk Fragmentation



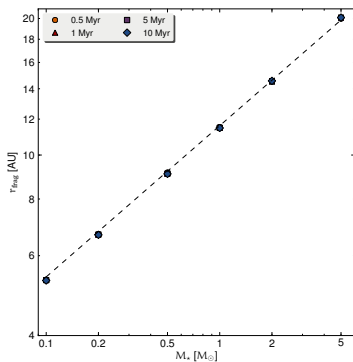
# Disk Fragmentation



# Taking it Further: Dust Settling

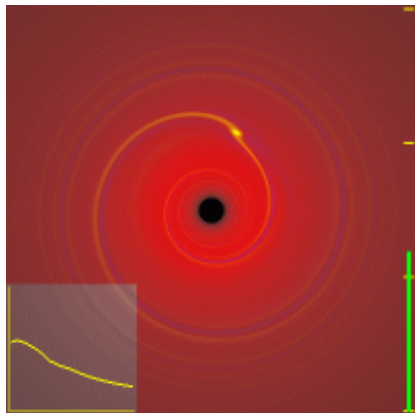


## How Close to the Star?

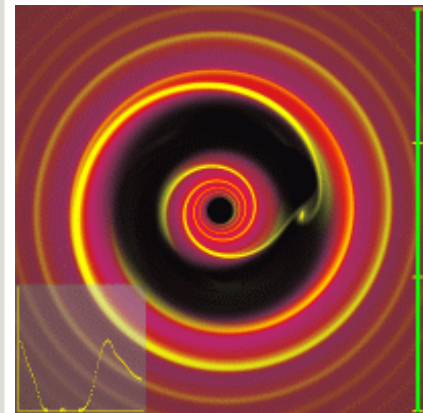


# Solution 2: Planet Migration

Type 1 (< 10 Earth-Masses)

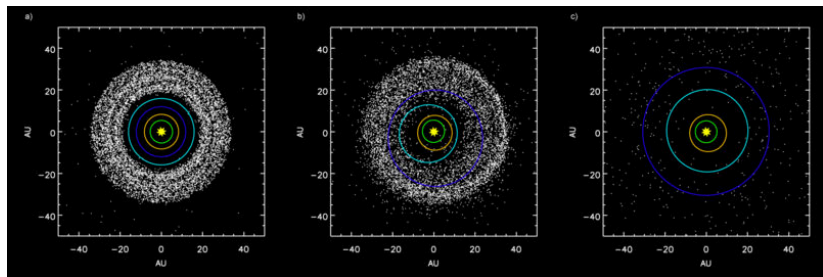


Type 2 (> 10 Earth-Masses)



# Solution 3: Planet-Planet Scattering

Nice Model: Maybe Uranus and Neptune switched places



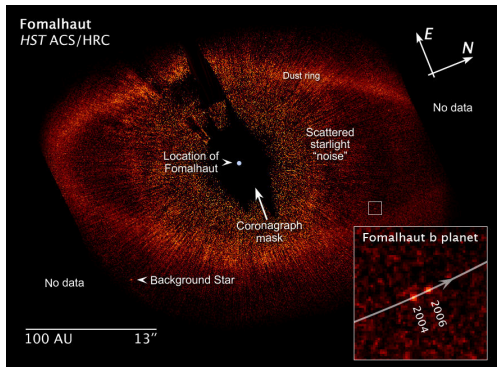
Explains:

- Kuiper belt orbital resonances with Neptune
- Lack of small objects in outer Solar System
- Late heavy bombardment
- (video)

# Problem: Why is Fomalhaut b so Bright?

The Hubble image shows visible light

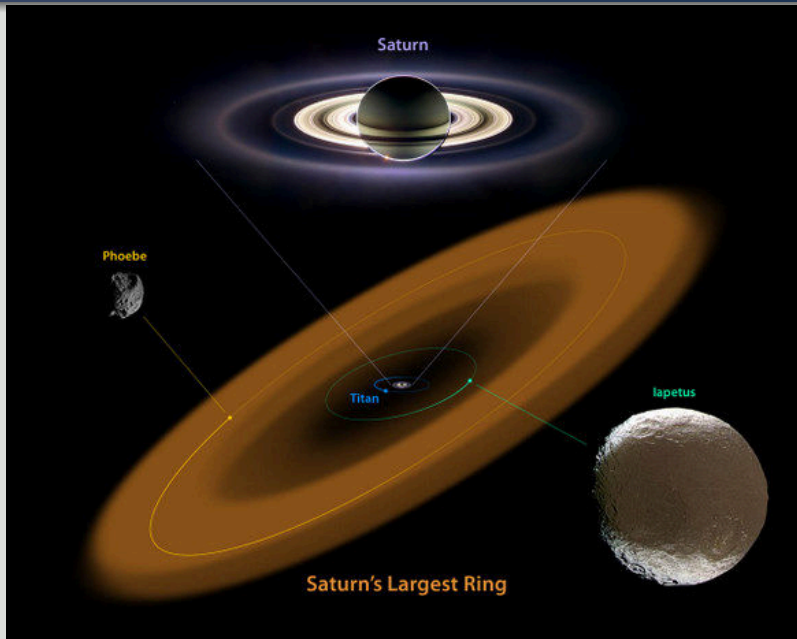
- Must be reflected from the star
- Fomalhaut b must be big (radius)



The debris disk is intact

- If Fomalhaut b was too big, it would disrupt the debris disk
- Fomalhaut b must be small (mass)

# Solution: Rings





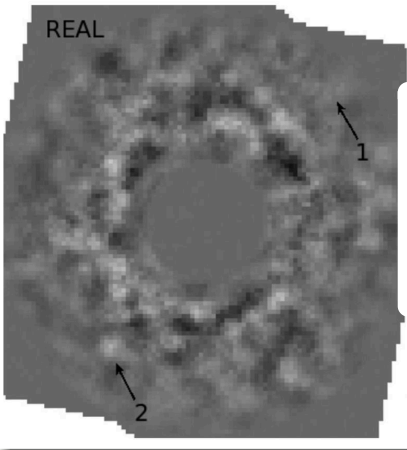
# Problem: Fomalhaut b Should be Bright in IR Light



# BIG Problem: Fomalhaut b is Missing in IR Light

It Should be at Arrow 1

REAL



## ASTRONOMY

### Celebrated Exoplanet Vanishes In a Cloud of Dust—Or Maybe Not

Every week, astronomers add new extrasolar planets to a roster that now numbers more than 700. But on rare occasions, a finding comes along that threatens to knock one of those discoveries off the list. Last week, Fomalhaut b, an exoplanet that once enjoyed celebrity status, faced an identity crisis after astronomers failed to spot it in a new round

of observations. So Janson applied for time on NASA's space-based Spitzer telescope—a powerful infrared imager—to look at Fomalhaut. Despite his hunch that the planet didn't exist, "I would have been happy to find something," Janson says. "Weird things happen in nature, and if we would have found something, that would have been fantastic

NEWS&ANALYSIS

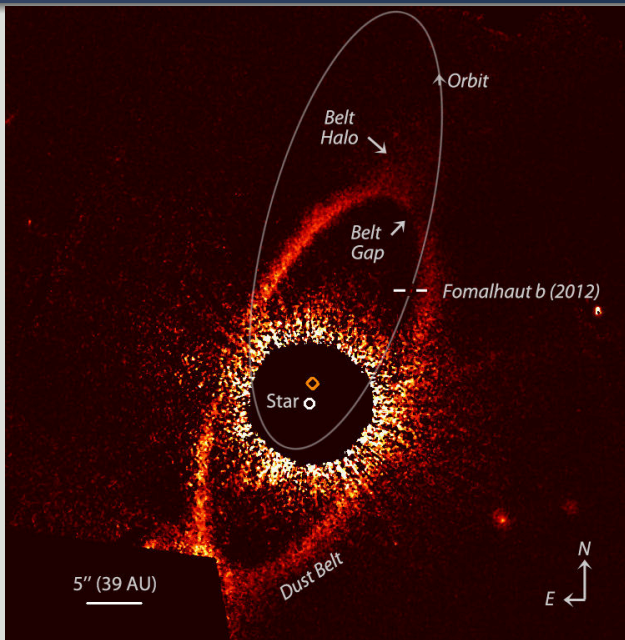
were several times as sensitive as the infrared observations Kalas's group had made—should have detected something. To be visible in optical light, Janson argued, the planet's ring would have to be several times wider than the planet itself and would have to be tilted to reflect the star's light into earthly telescopes—an improbable combination. "Toward the end, I said I wouldn't call this a planet myself," Janson says. After returning from the conference, he and his colleagues completed their analysis and wrote a paper that has just been accepted by *The Astrophysical Journal*.

Janson does not dispute that Kalas's group saw something. "There is certainly something

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# New Observations



# What is it?

## Three Related Possibilities

- A planet with a huge ring?
- A planet surrounded by a cloud of debris?
- The remnants of a catastrophic collision?

## Fomalhaut c?

- There must be at least one more planet to explain the debris disk
- We never found the planet that we went looking for in the first place!

# Questions?

