In the beginning God created the heavens and the earth

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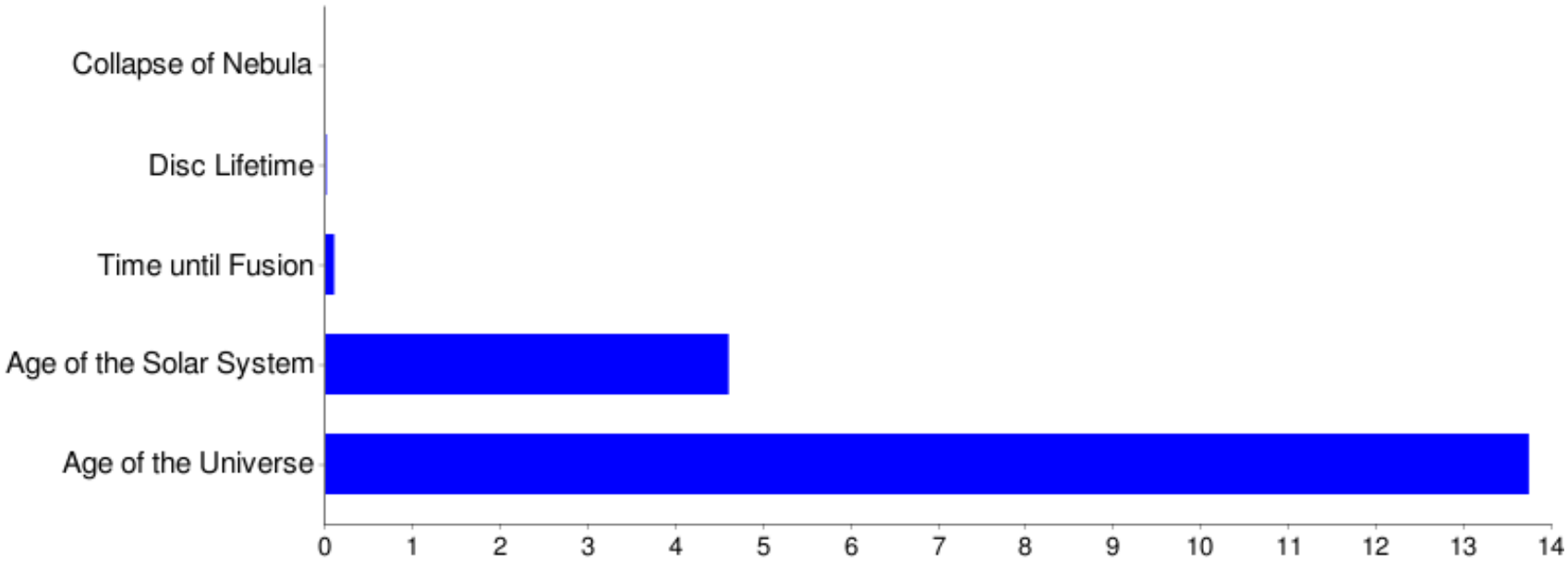
In the beginning God created the heavens and the earth.

The earth was without form and void, and darkness was over the face of the deep. And the Spirit of God was hovering over the face of the waters.

And God said, Let there be light, and there was light. And God saw that the light was good. And God separated the light from the darkness. God called the light Day, and the darkness he called Night. And there was evening and there was morning, the first day.

ESV, Genesis 1

Timescales


Collapse of Nebula
Disc Lifetime
Time until Fusion
Age of the Solar System
Age of the Universe
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14

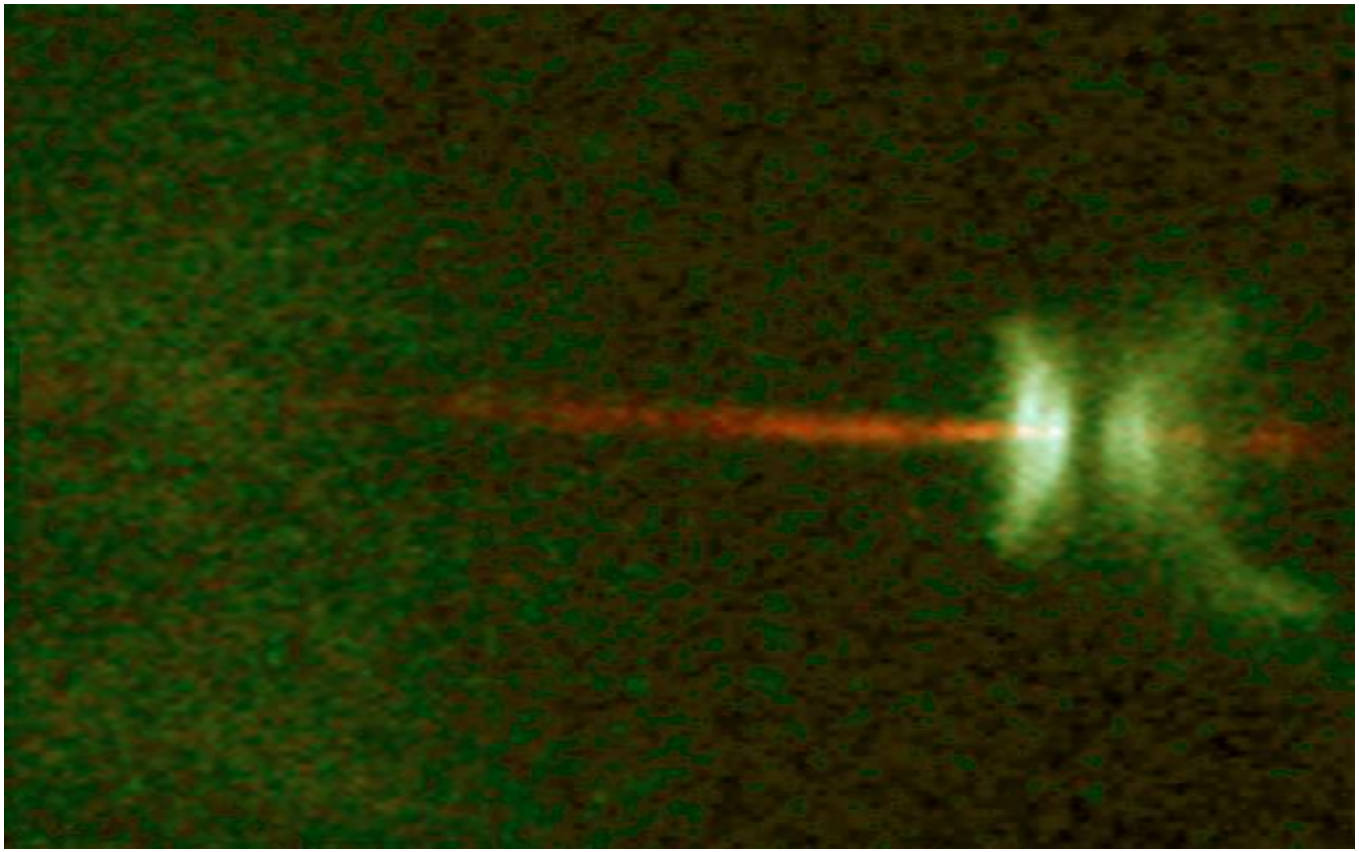
Orion

Credit: Hanno Rein

Protoplanetary Discs in Orion

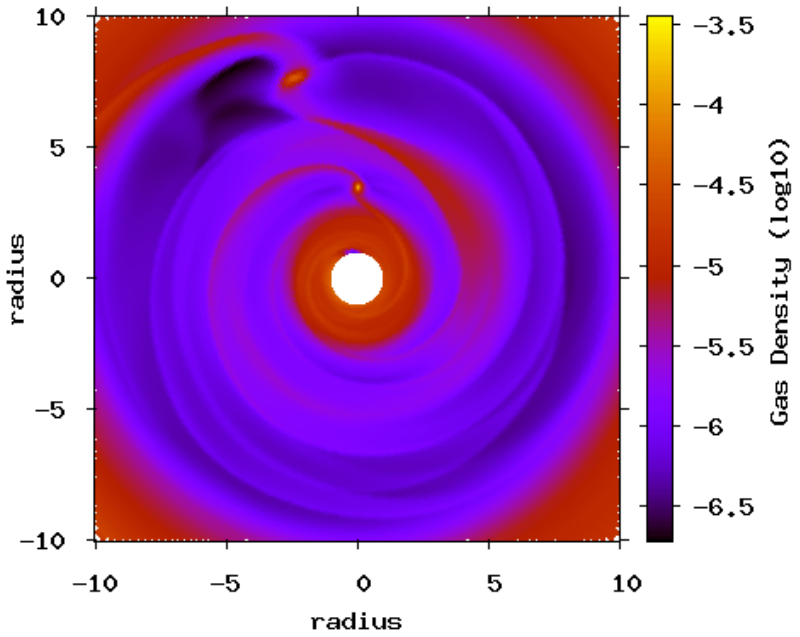
Credit: C.R. O'Dell, NASA

Protoplanetary Disc



Credit: C. Burrows, WFPC2, NASA

Planet Formation inside Disc

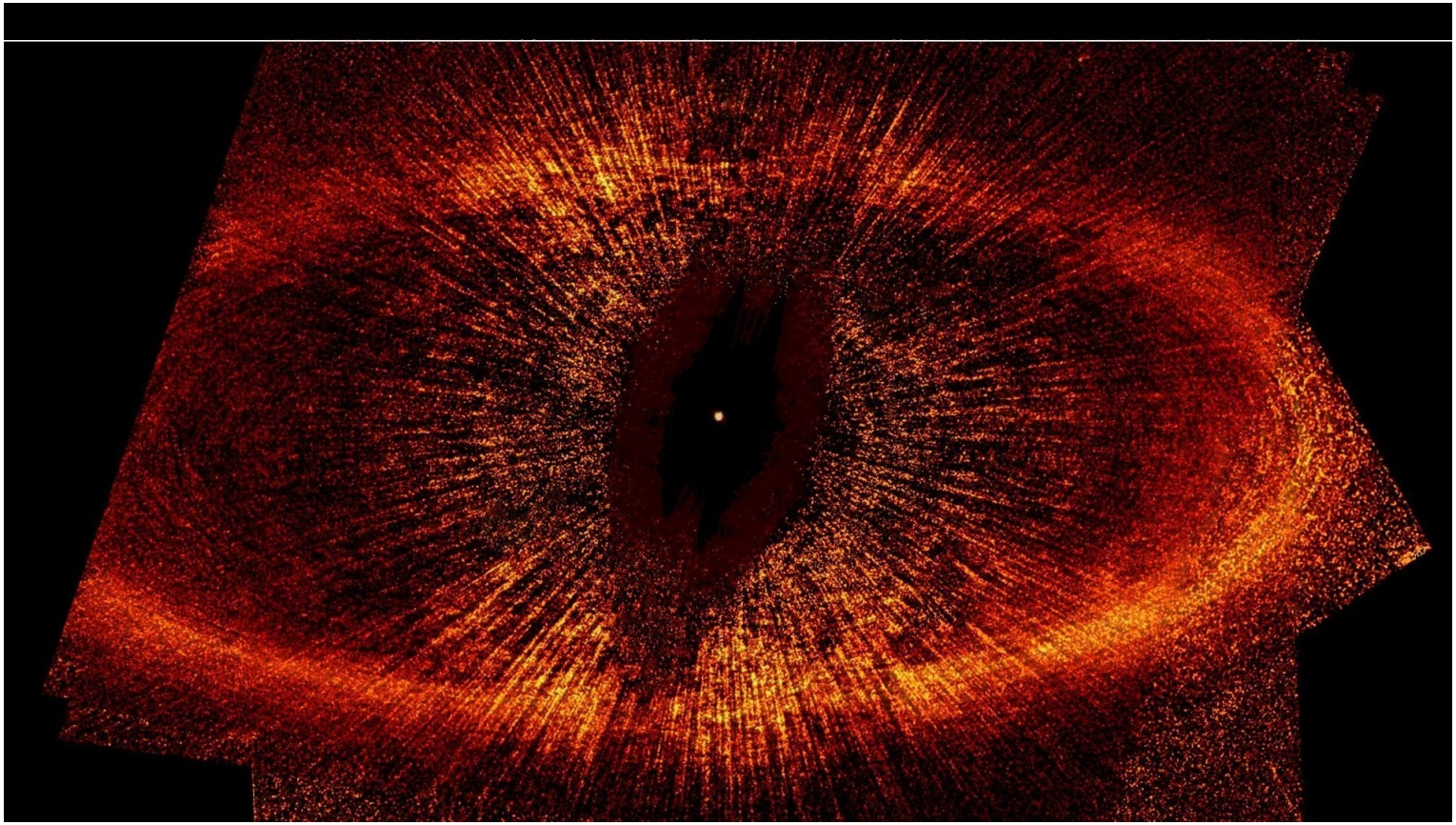


Credit: Hanno Rein

Different models of the early phase:

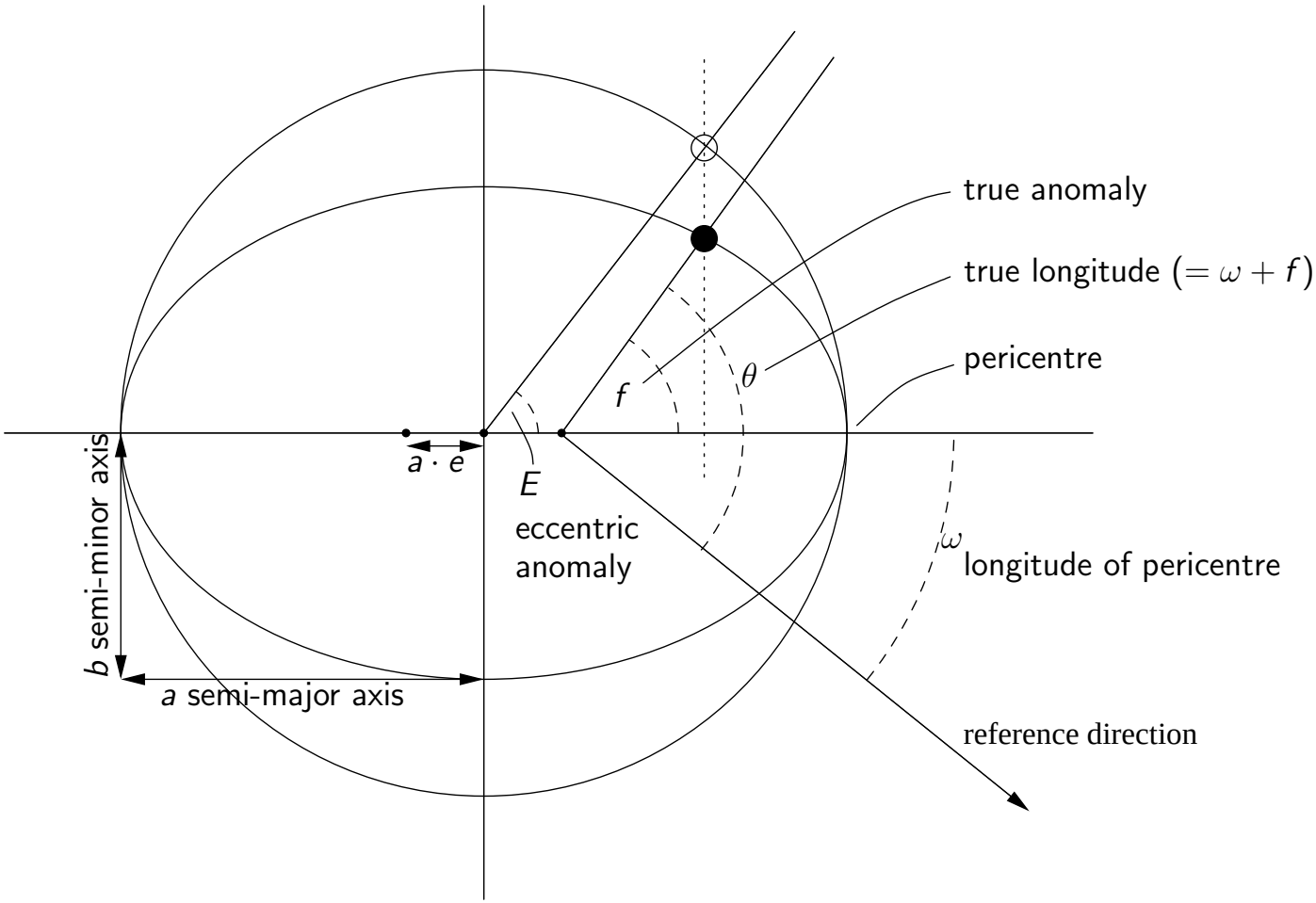
- Gravitational Fragmentation
- Core Accretion

Debris Disc



Credit: NASA, ESA, P. Kalas, J. Graham, M. Clampin

Ellipse


true anomaly
true longitude ($= \omega + f$)
pericentre
f
θ
$a \cdot e$
E
eccentric
anomaly
ω
longitude of pericentre
b semi-minor axis
a semi-major axis
reference direction

Mean Motion Resonance

Keppler's third law

$$\frac{p}{q} = \frac{T_1}{T_2} = \left(\frac{a_1}{a_2}\right)^{1.5}$$

p, q are small integers

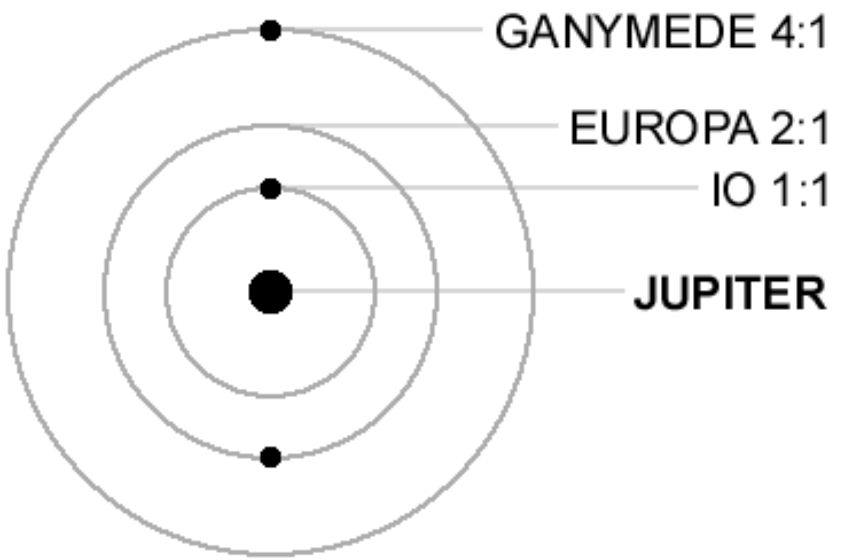
Resonant angles

$$\Delta\bar{\omega} = \bar{\omega}_1 - \bar{\omega}_2$$

$$\psi_1 = p\lambda_2 - q\lambda_1 - (p-q)\bar{\omega}_1$$

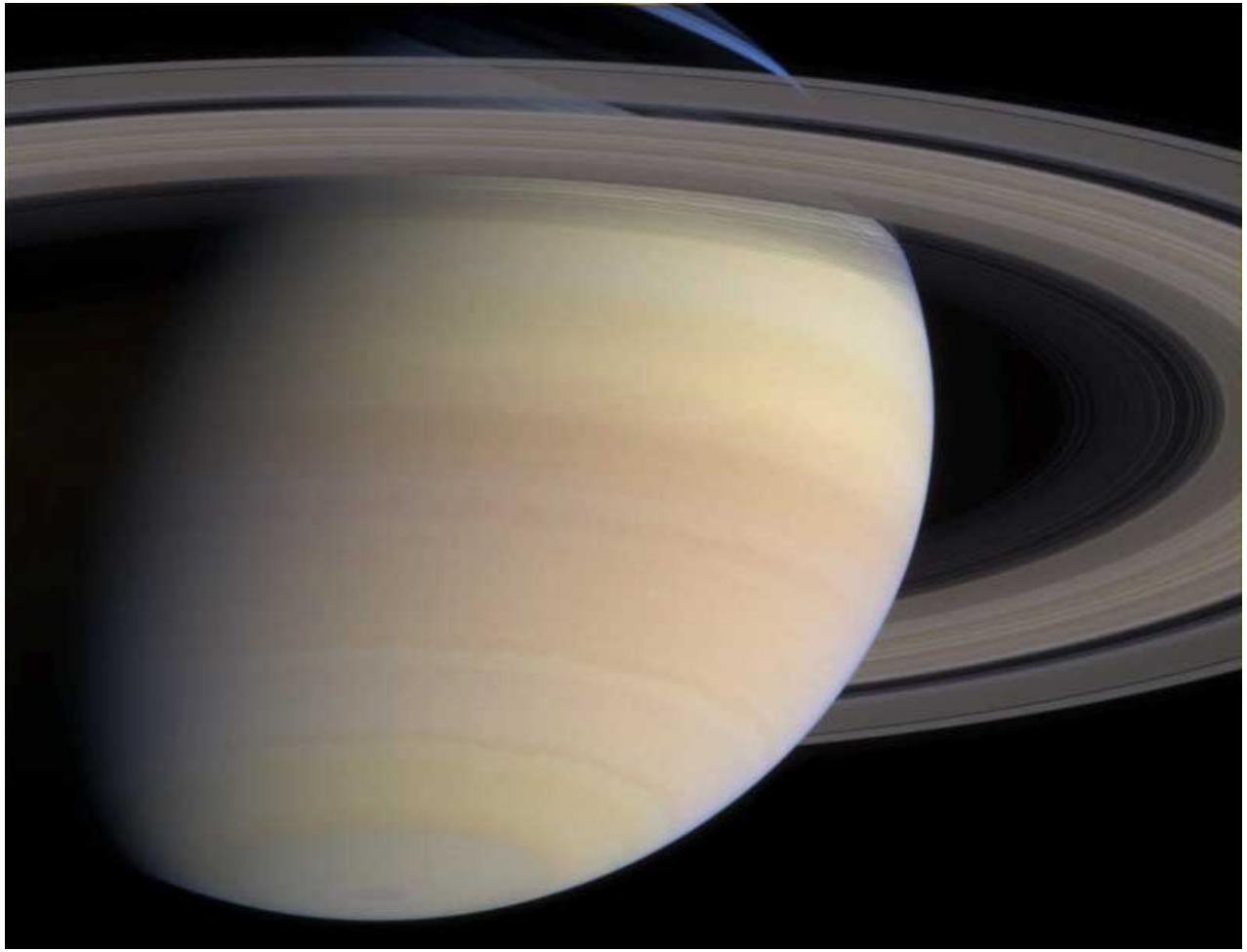
$\bar{\omega}_i$ longitude of periastron
λ_i mean longitude

Jupiter Satellites

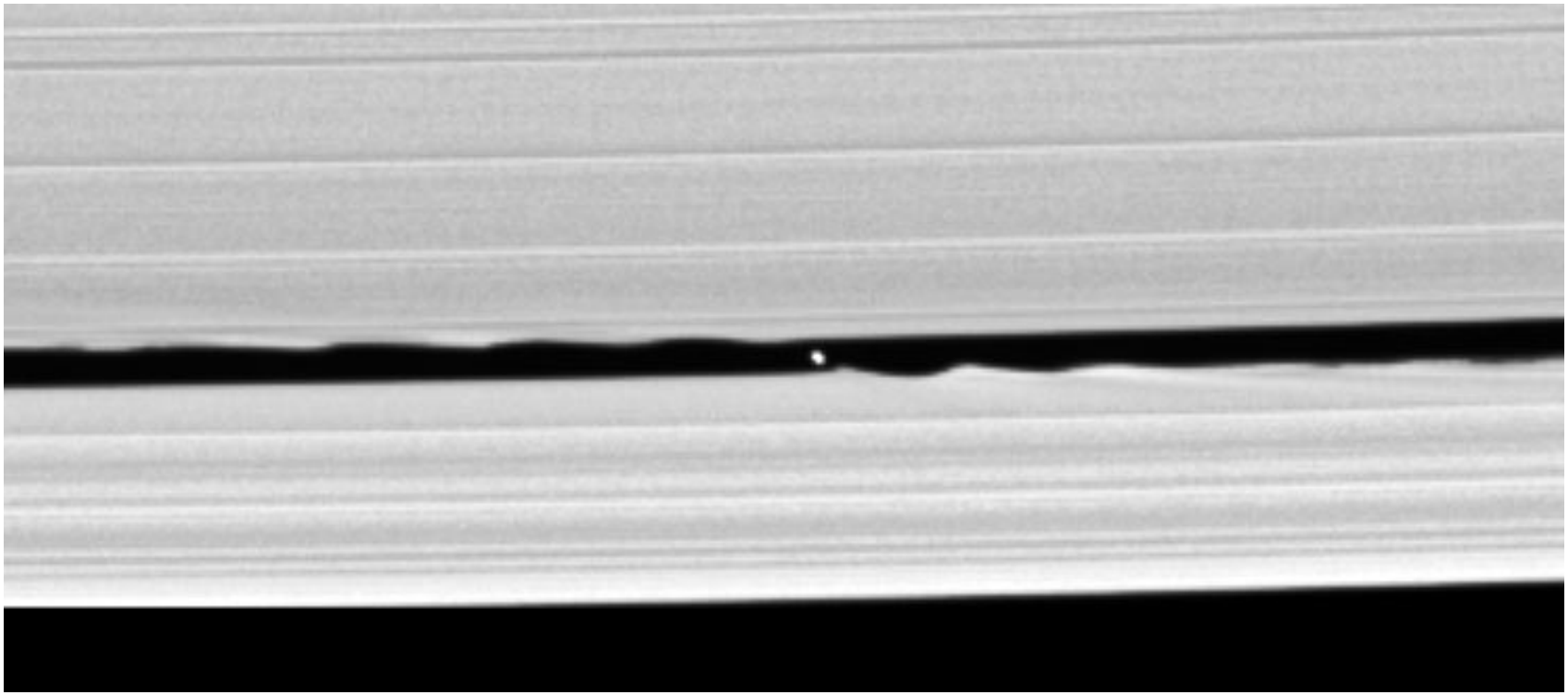


Credit: NASA, JPL, DLR

Saturn Rings

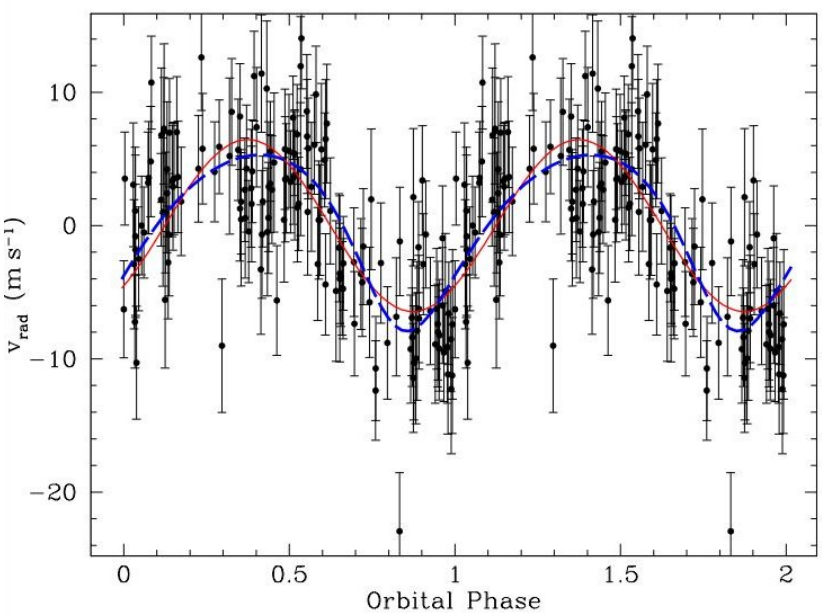


Saturn Rings and Daphnis



Credit: NASA, JPL, Space Science Institute

GJ876 - Observations

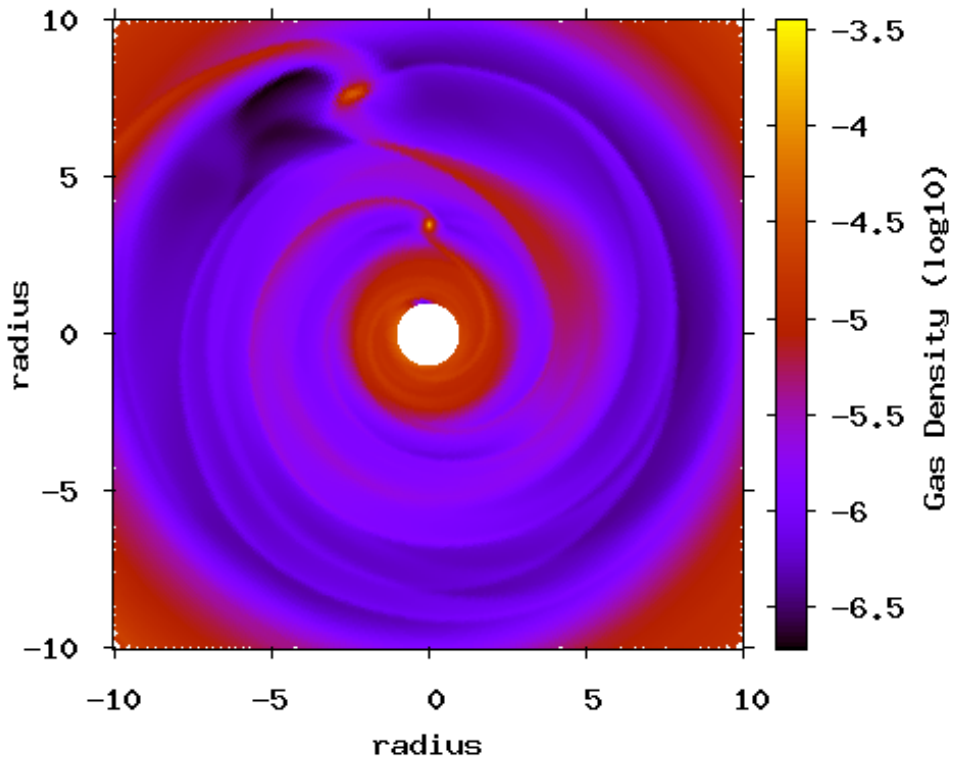


Credit: Rivera et al. 2005

Best fit (Butler et al., 2006)

$M \sin i$	a (AU)	e
1.93	0.208	0.0249
0.619	0.1303	0.2243
0.0185	0.0208	-

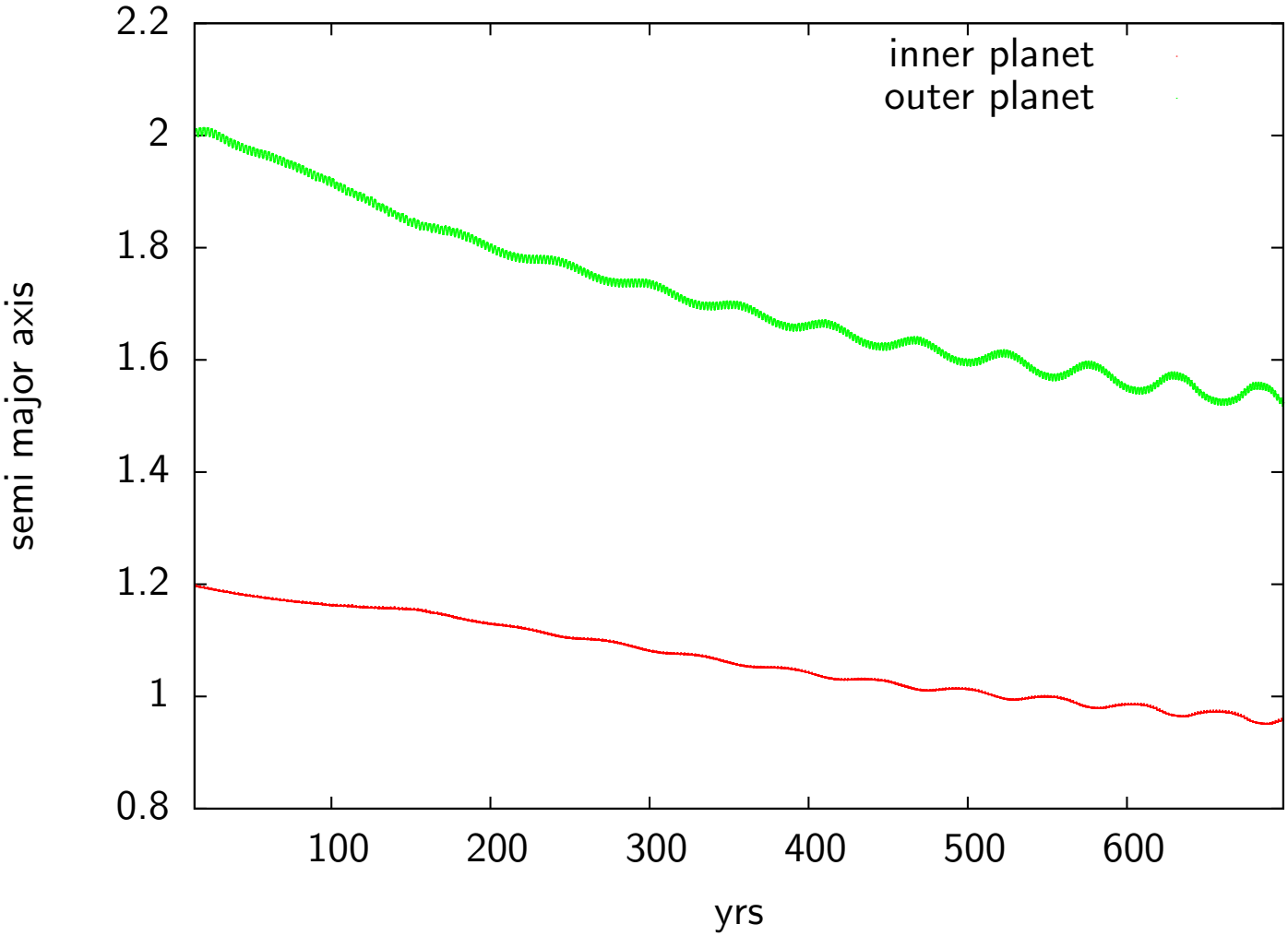
Resonance Capture

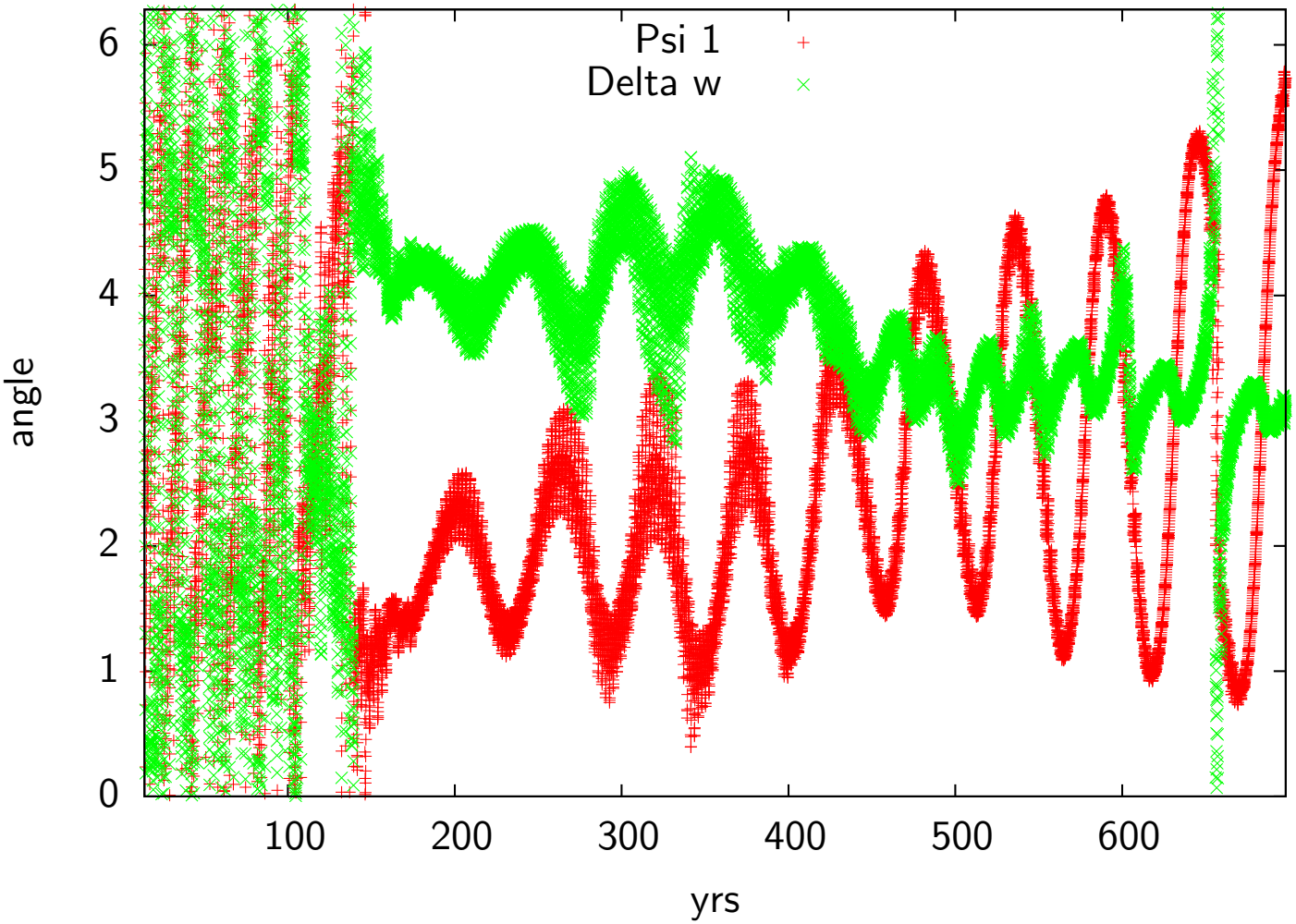


Credit: Hanno Rein

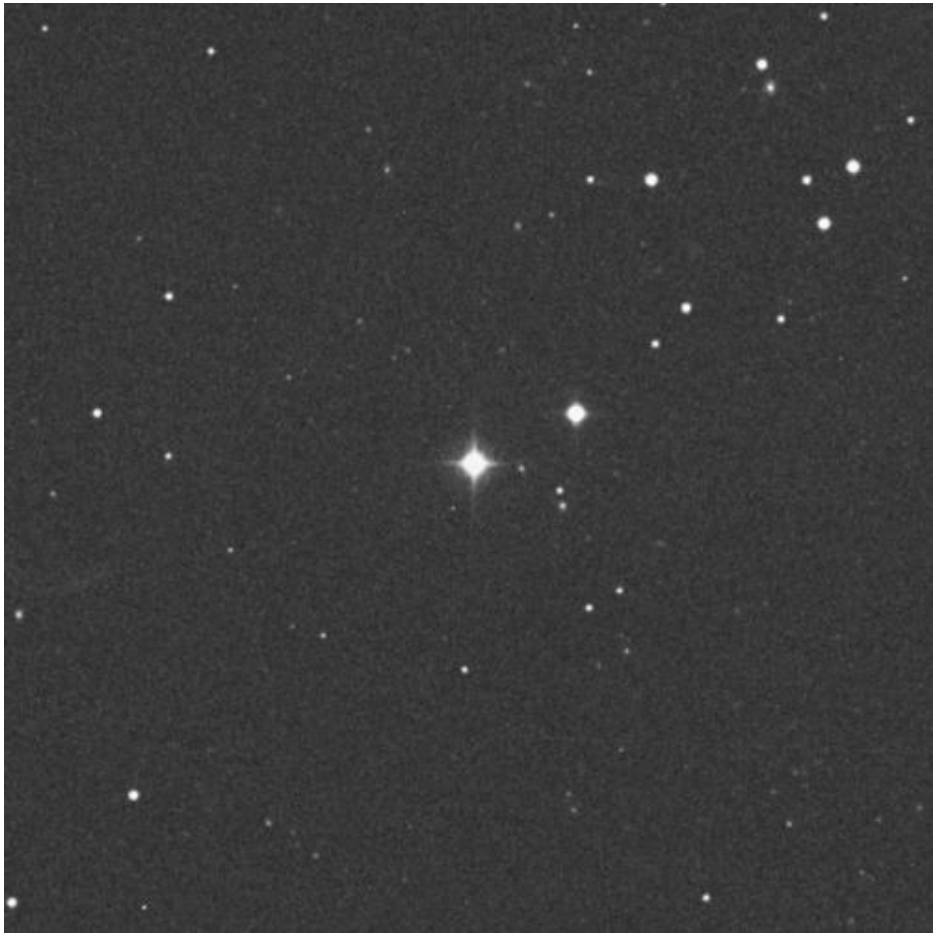
Differential Migration

$$\frac{1}{\tau_1} = \frac{\dot{a}_1}{a_1} \neq \frac{\dot{a}_2}{a_2} = \frac{2}{\tau_2}$$


inner planet
outer planet
semi major axis
yrs
2.2
2
1.8
1.6
1.4
1.2
1
0.8
100
200
300
400
500
600


Psi 1
Delta w
angle
yrs
0
1
2
3
4
5
6
100
200
300
400
500
600

HD 108874

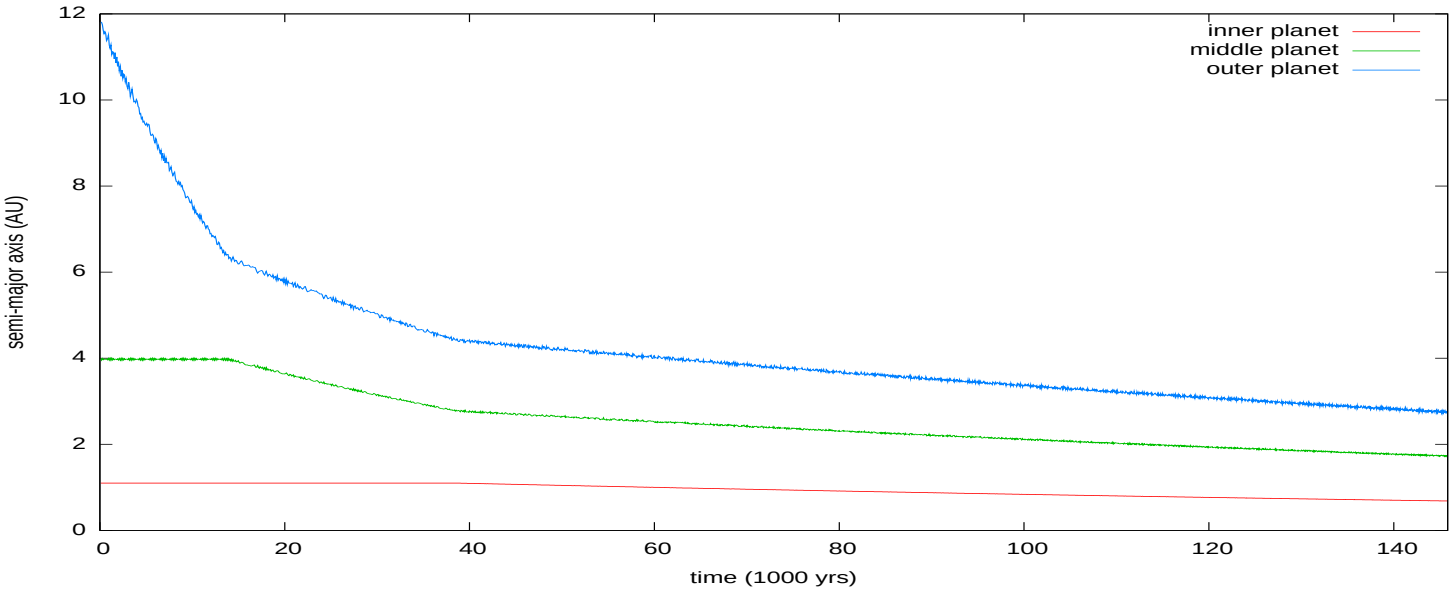


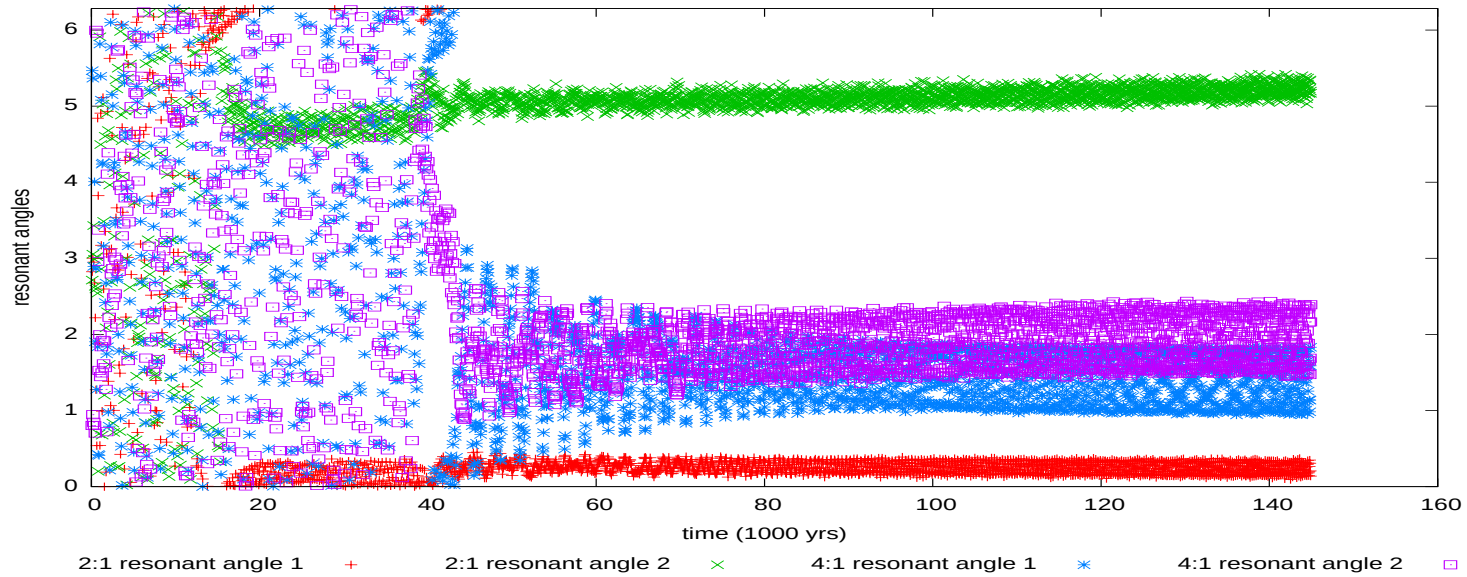
Credit: POSSI

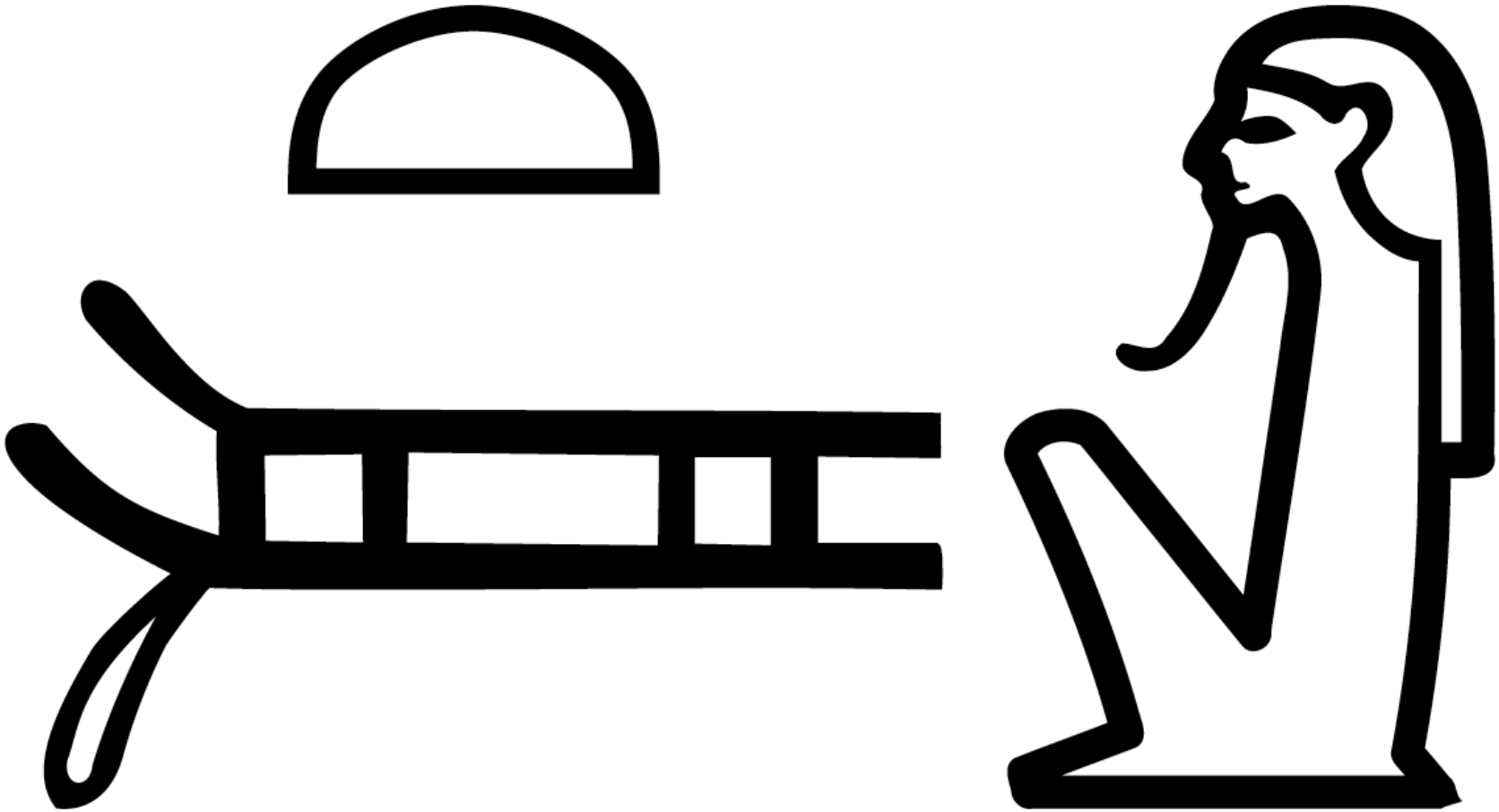
Observed Orbital Parameters

	$M \sin i$ (M_J)	a (AU)	e
HD108874b	1.37(12)	1.055(61)	0.068(24)
HD108874c	1.02(10)	2.68(17)	0.253(42)

$$\left(\frac{2.68}{1.055}\right)^{1.5} \approx 4.04$$


inner planet
middle planet
outer planet
semi-major axis (AU)
time (1000 yrs)
0
2
4
6
8
10
12
0
20
40
60
80
100
120
140


resonant angles
time (1000 yrs)
0
1
2
3
4
5
6
0
20
40
60
80
100
120
140
160
2:1 resonant angle 1
2:1 resonant angle 2
4:1 resonant angle 1
4:1 resonant angle 2



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