A Spiral arm in the outer disk of PDS-70 ?

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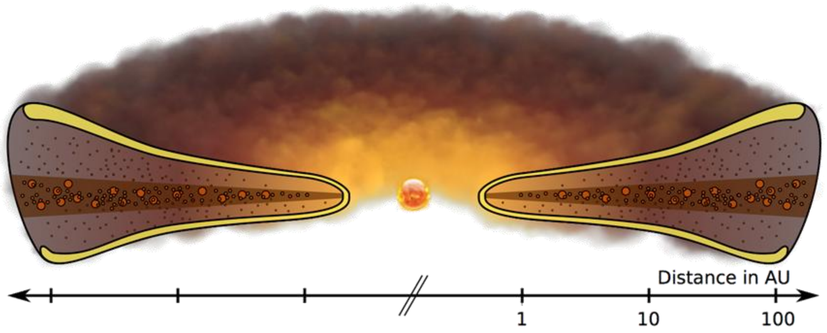
Theory : Spiral in a protoplanetary disk

Protoplanetary disk

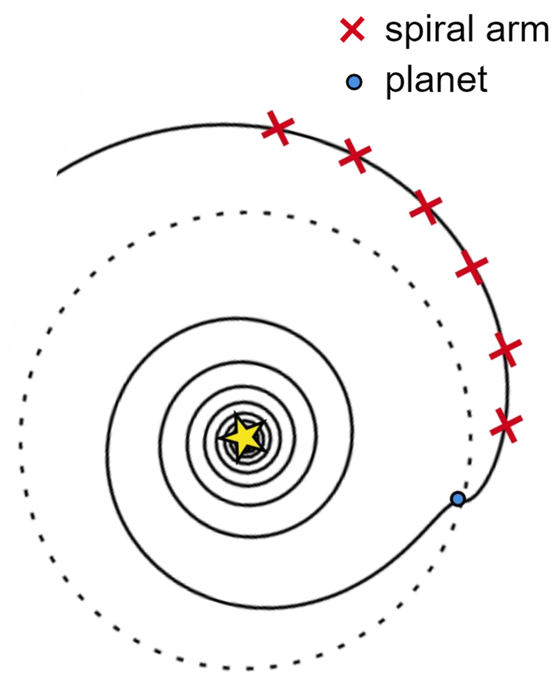
A protoplanetary disk is an accretion disk made of gas (99%) and dust (1%) found around a newly formed star (~few Myrs old). It is the expected birth place of planets.



Disk schematic from http://www.til-birnstiel.de

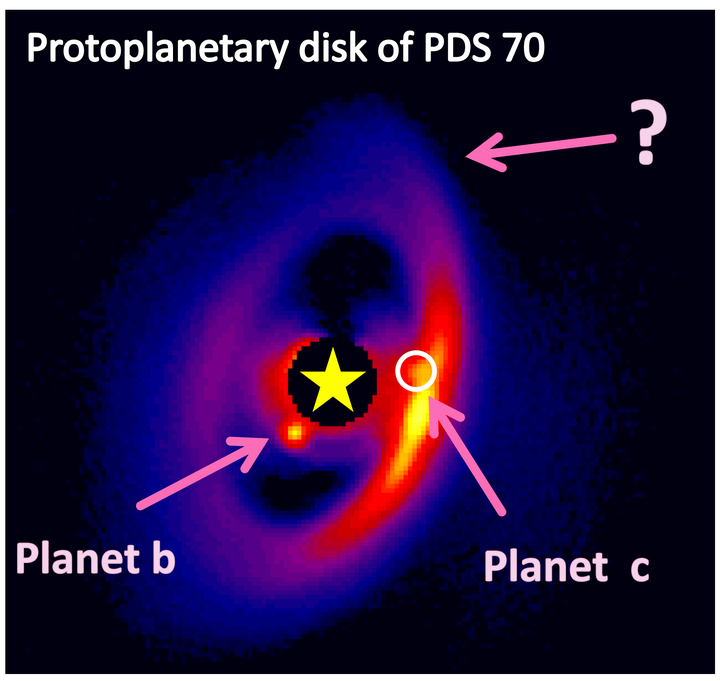
Spiral arms dynamics : density waves driven by a planet

Spiral-shaped density waves are thought to be launched at Lindblad resonances resulting from the interactions between an embedded planet and the protoplanetary disk. The spiral arm is expected to follow the motion of the planet inducing it.



Spiral in a 1-planet system (Ogilvie, Lubow 2002)

Application : Star PDS-70



Question : Is this a spiral arm ?

A spiral arm caused by dynamical interactions between planet PDS 70 c and the protoplanetary disk. The planet completes a revolution in 191 years. Hence, in 6 years it is expected to rotate by 11° Note that the disk is seen with a 49 deg inclination - it is circular !

Hypothesis : rigid-object motion following planet c

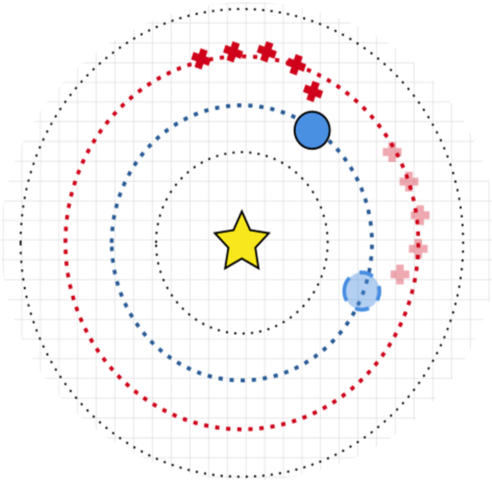


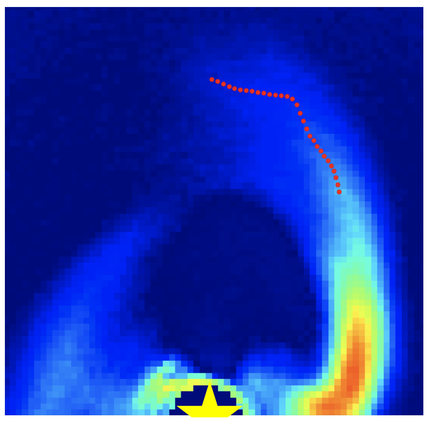
Illustration is not scaled on PDS 70

Method : Follow the spiral arm trace over 6 years of observations

Based on observations of star PDS 70 from 2015 to 2021

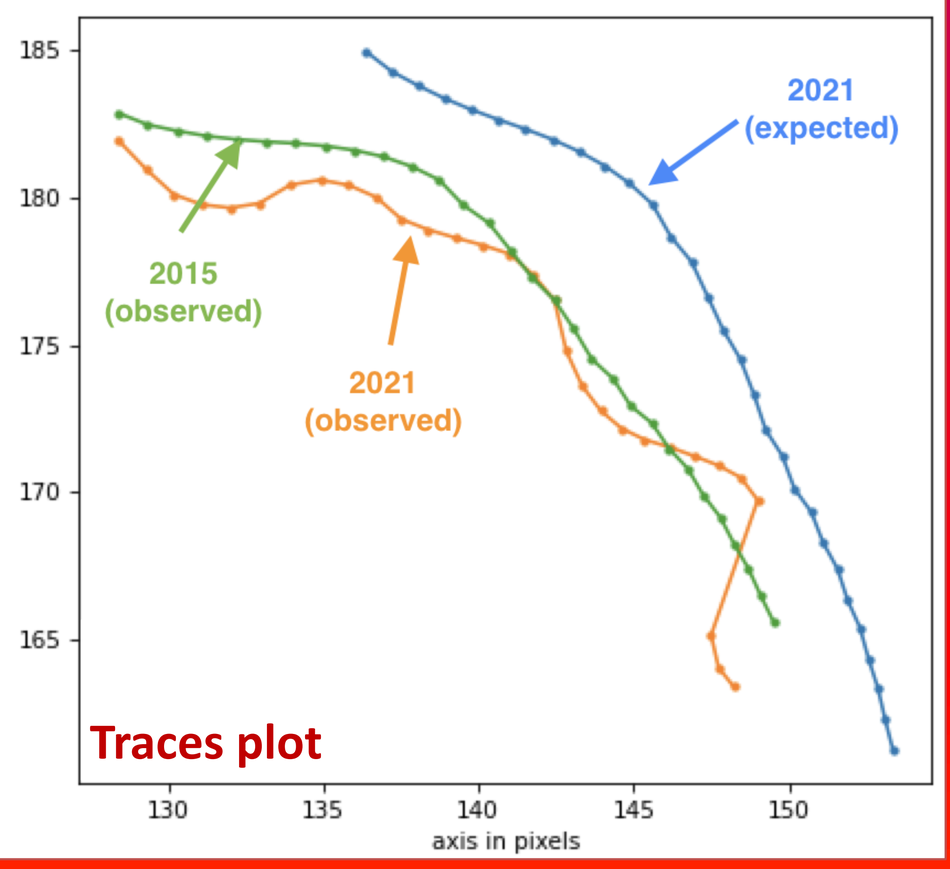
Observation vs expectation

Measurement : Traces were computed from **radial local maxima** along the spiral.



Result : expectation ≠ observation

A significant shift was expected. Instead observations showed perfectly aligned spiral traces from 2015 to 2021.
Theoretical traces for 2015 were computed by performing reverse rotation of observations from 2021



Traces plot

Conclusion(s) – In 6 years, we don't see any motion !

It is not a spiral arm

It is a double ring disk, and the extended signal is the visible part of the outer ring. Observations at other wavelengths may support this hypothesis. However, it does not fully explain the asymmetric shape.

OR

It is a spiral arm but

the rigid-body motion hypothesis is inappropriate and/or other forces are constraining the spiral and its motion.