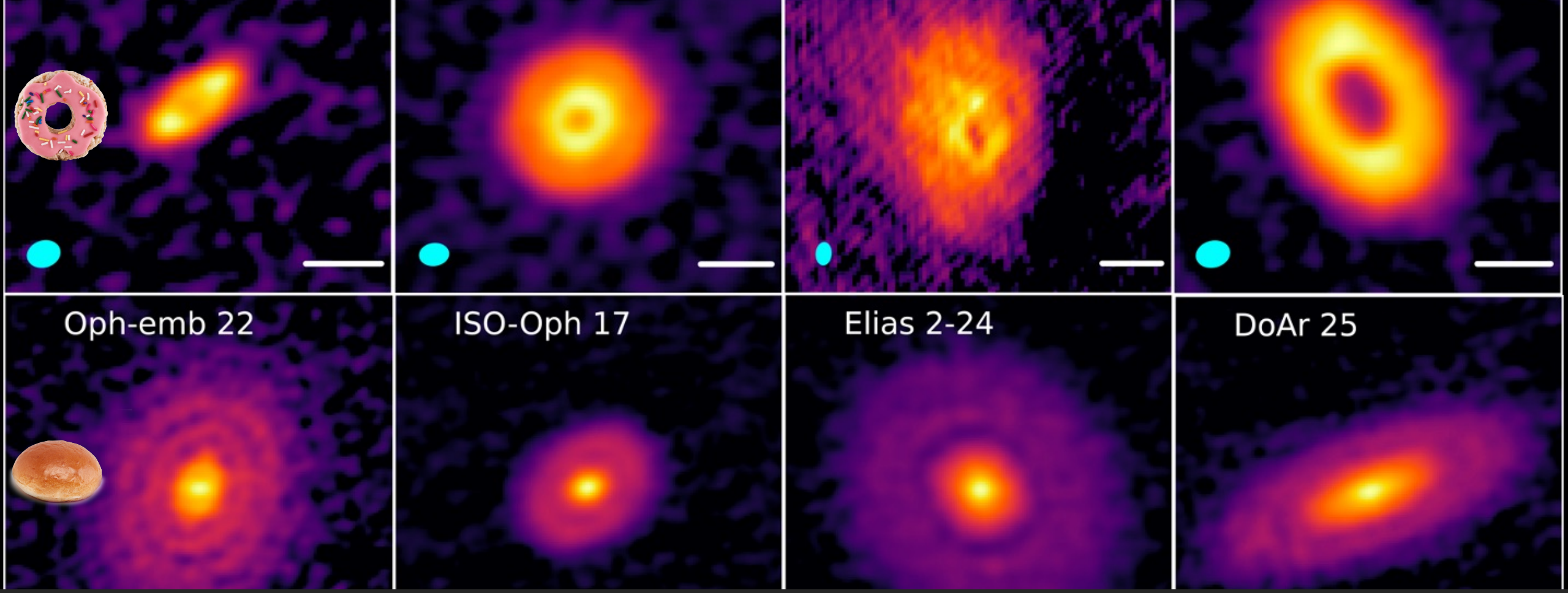


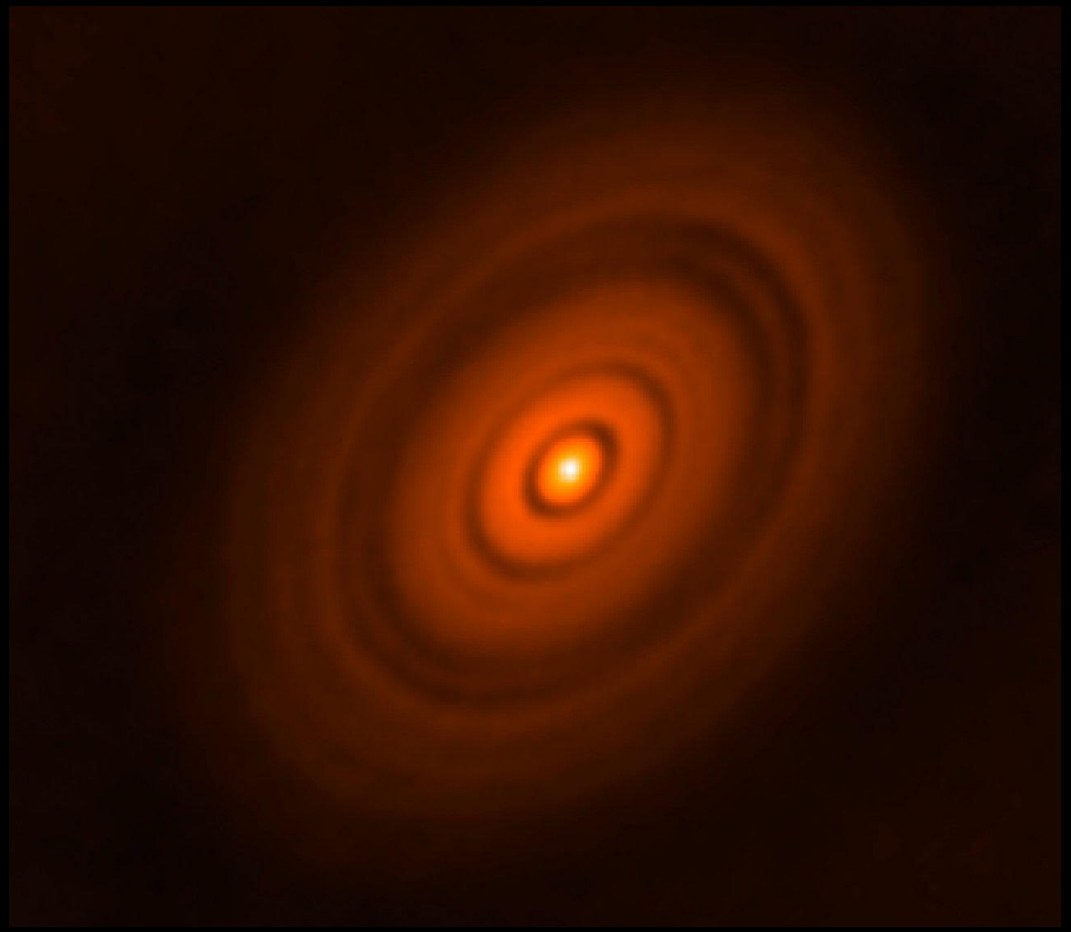
Early Evolution of Planetary Disk Structures Seen for the First Time

Cheng-Han Hsieh, Yale University

CAMPOS team: Héctor G. Arce (Yale), Jaime Pineda (MPE), María José (MPE), Dominique Segura-Cox (UT Austin), Diego Mardones (U. Chile), Aiswarya Arun (U. Chile), Michael Dunham (U. Fredonia)

Contact: cheng-han.hsieh@yale.edu

Previous studies predominantly target Large, Luminous disks or more Evolved disks with ages greater than 2 Myrs (Class II).

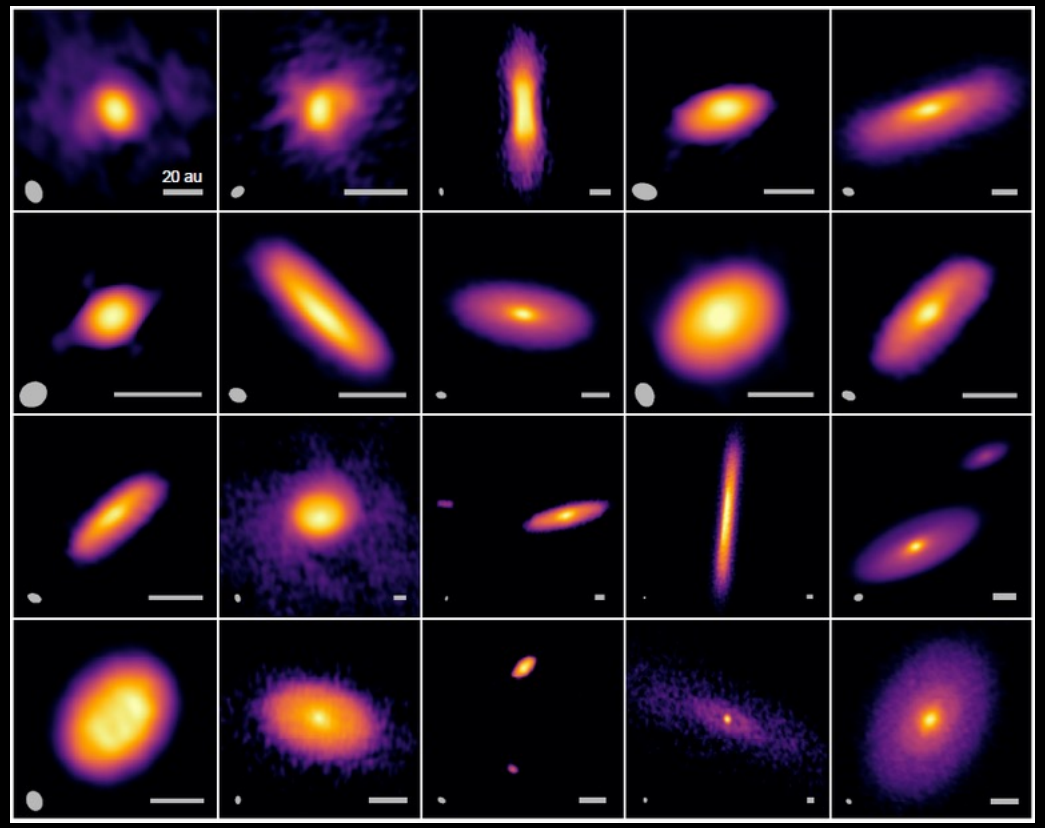


Stephens et al. 2023

Evolved disks surveys:

- ODISEA Survey (Cieza et al. 2021)
- DSHARP Survey (Andrews et al. 2018)

Substructures in younger disks are hard to find:

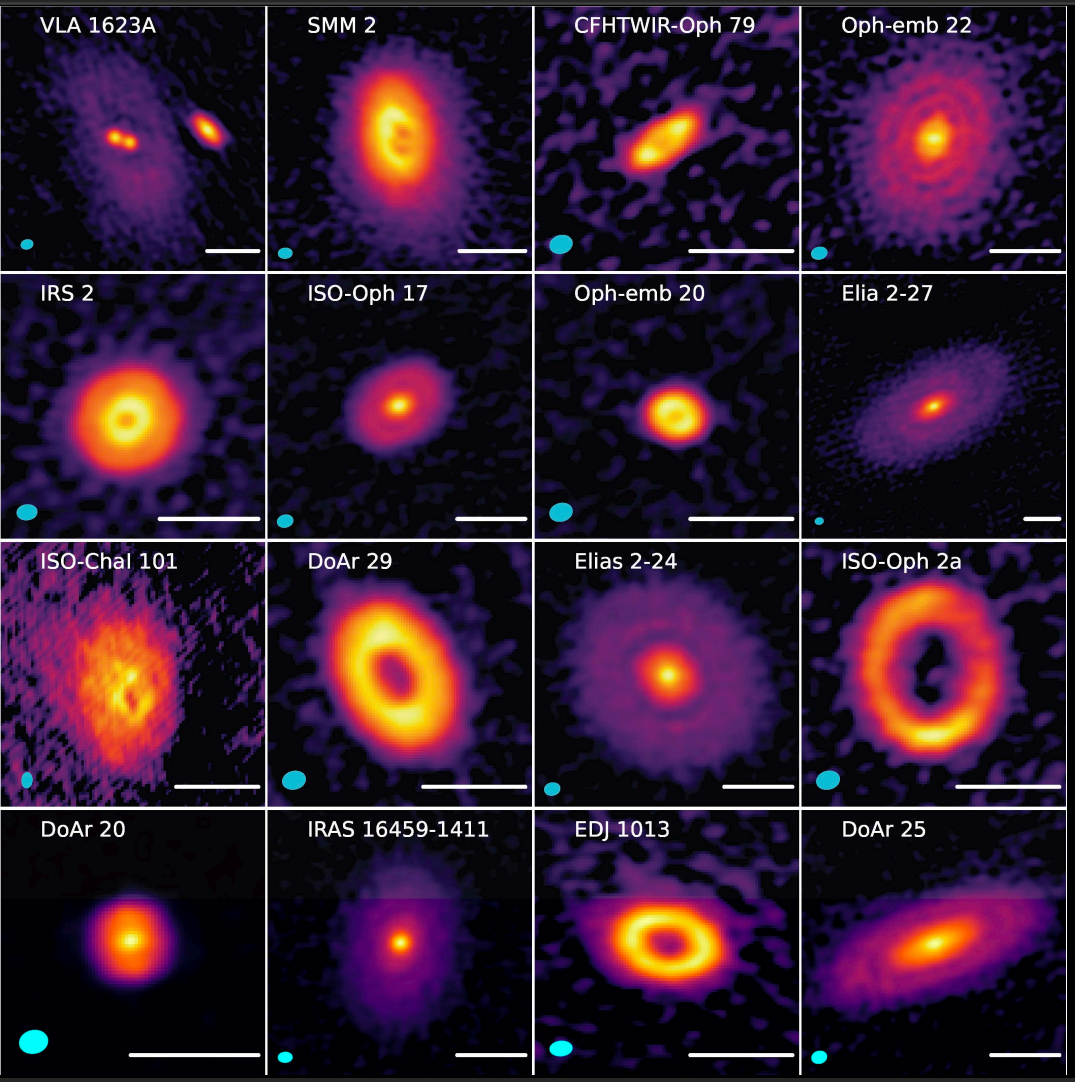


eDisk Survey (Ohashi et al. 2023)

How early does disk substructures form and, as a corollary, how early planet formation begins?

The CAMPOS Survey

Substructures detected:



We use ALMA to survey nearly all the embedded protostars in:
Chamaeleon I & II, Ophiuchus, Ophiuchus North, Aquila, Cor Australis, and Serpens.

Atacama Large Millimeter Array (ALMA)

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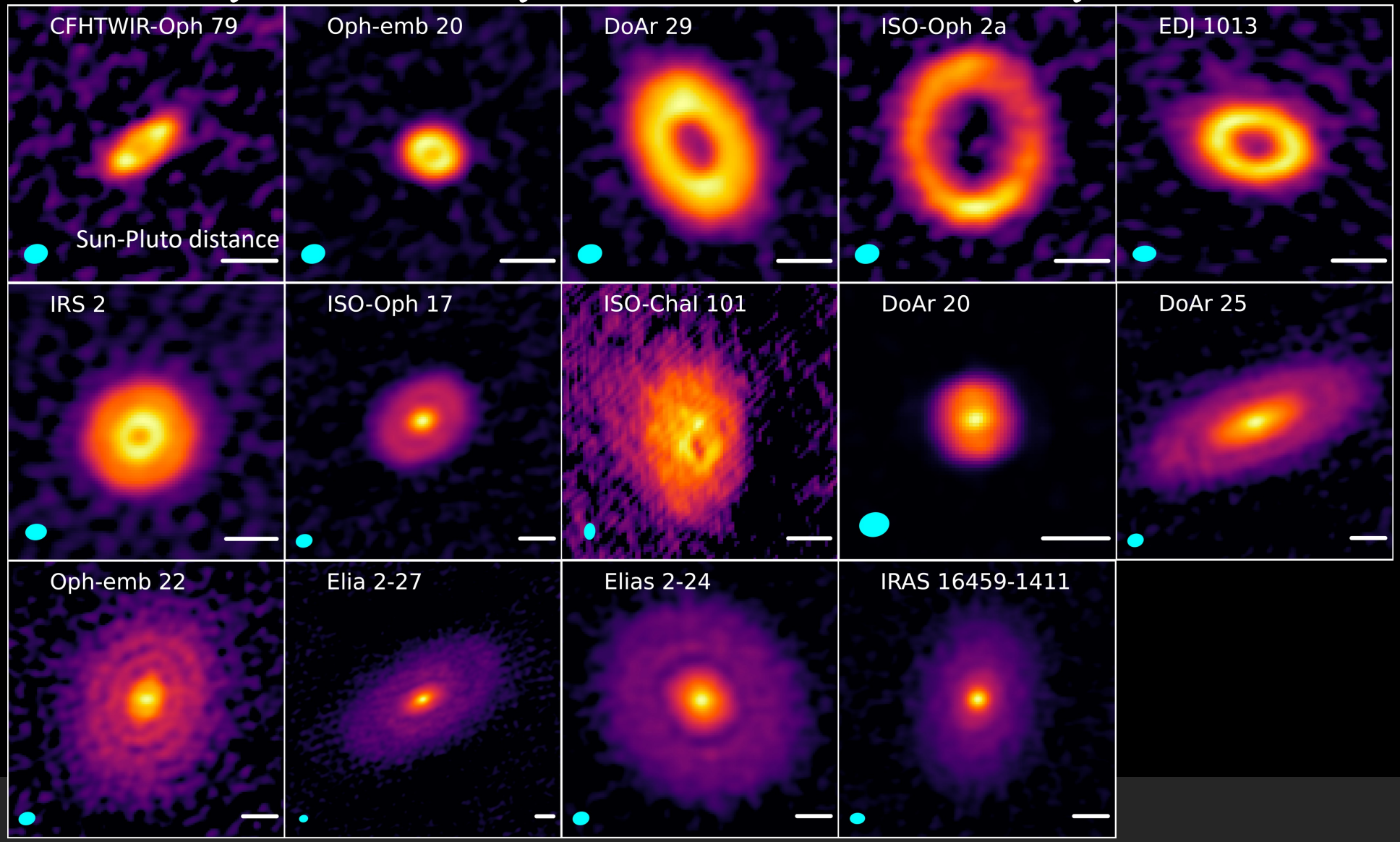
Younger Giant Planet Formation begins? Older Time

Class I 0.2 – 0.5 Myr

Flat 0.5 – 1.0 Myr

Class II 1.0 – 2.0 Myr



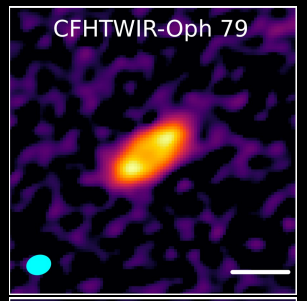
Disk with multiple rings morphology are generally larger!

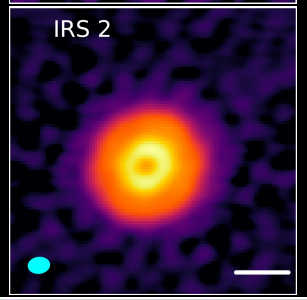
Time

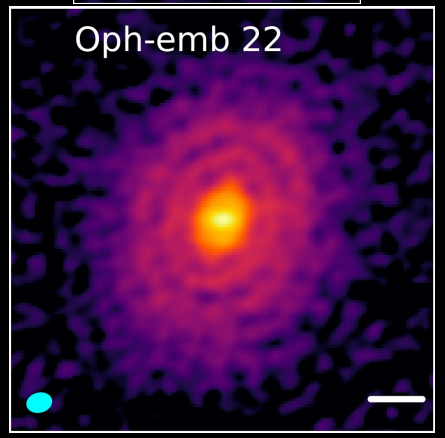
Class I
0.2 – 0.5 Myr

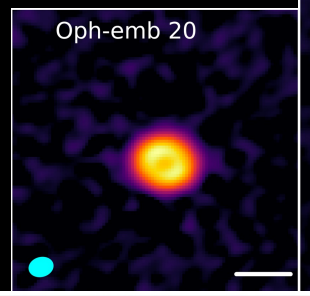
Flat 0.5 – 1.0 Myr

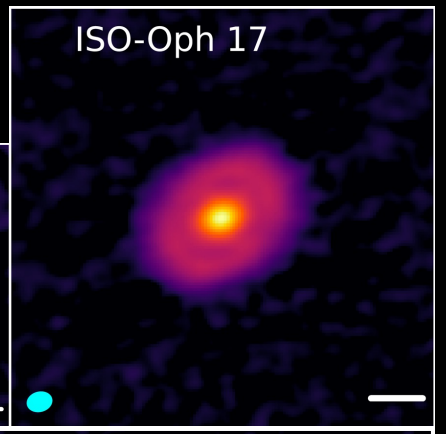
Class II 1.0 – 2.0 Myr

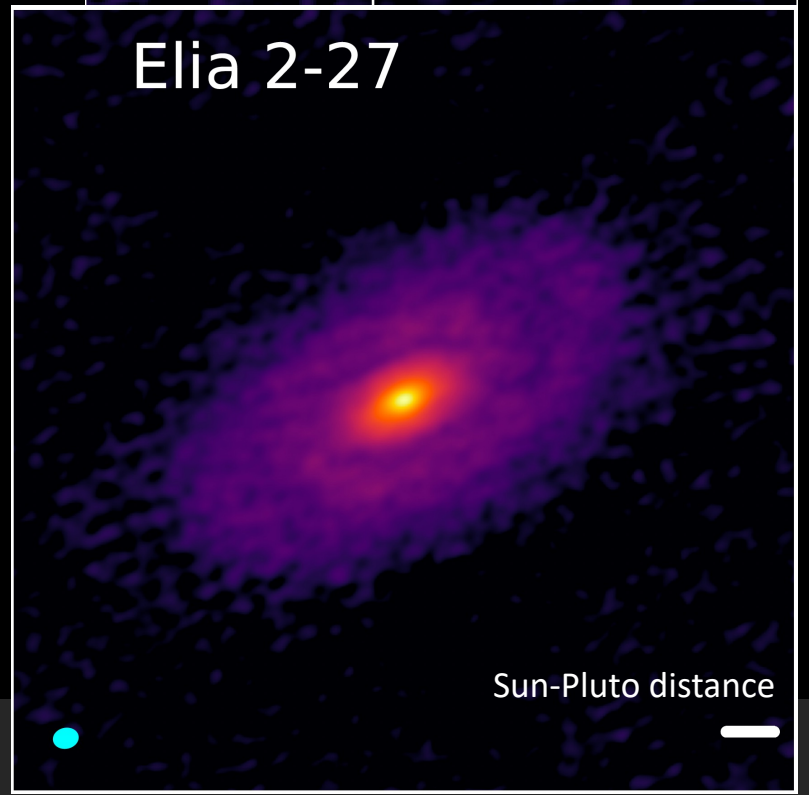


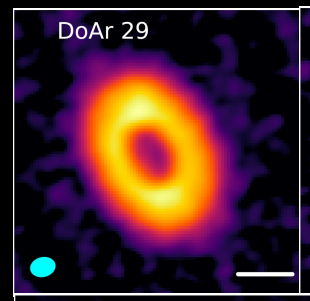


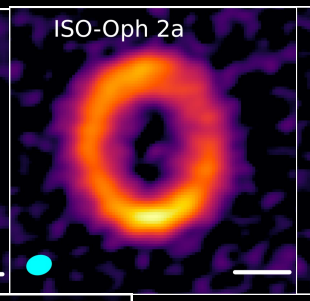


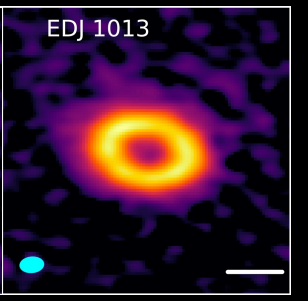


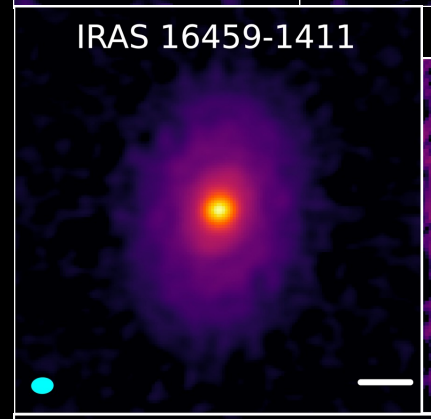


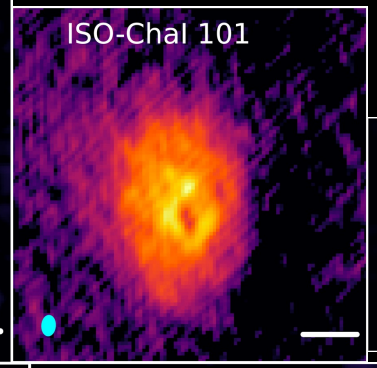


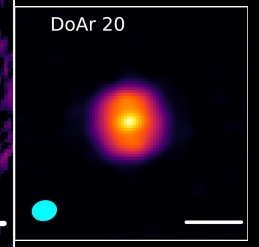


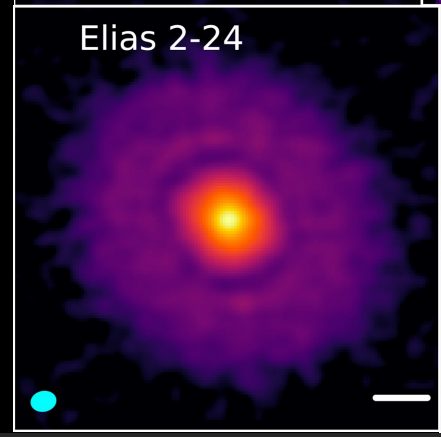


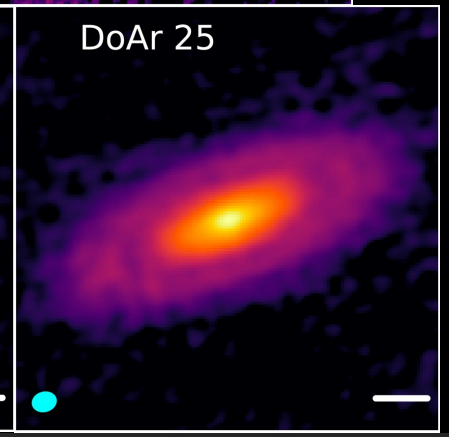












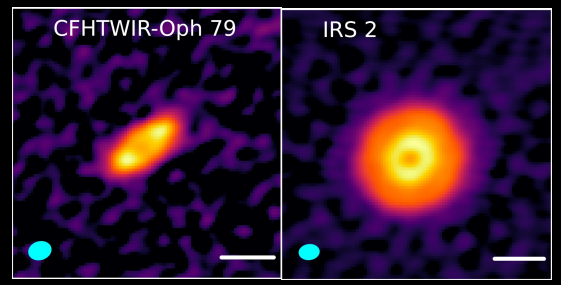
Contact: cheng-han.hsieh@yale.edu

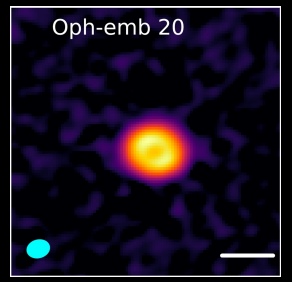
Class I
0.2 – 0.5 Myr

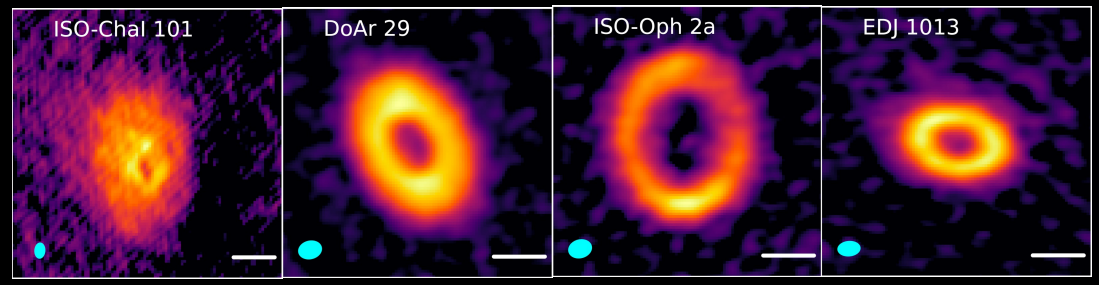
Flat
0.5 – 1.0 Myr

Class II
1.0 – 2.0 Myr

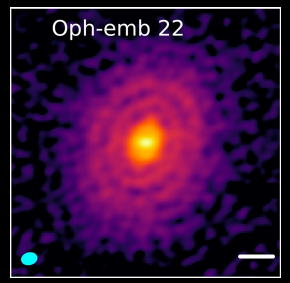
Time

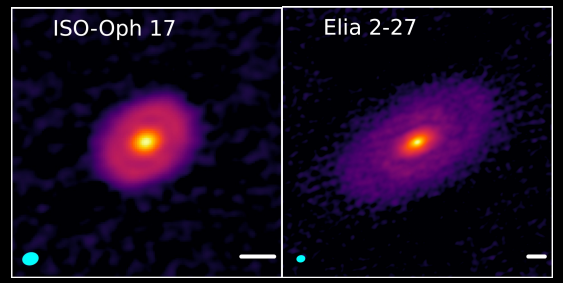


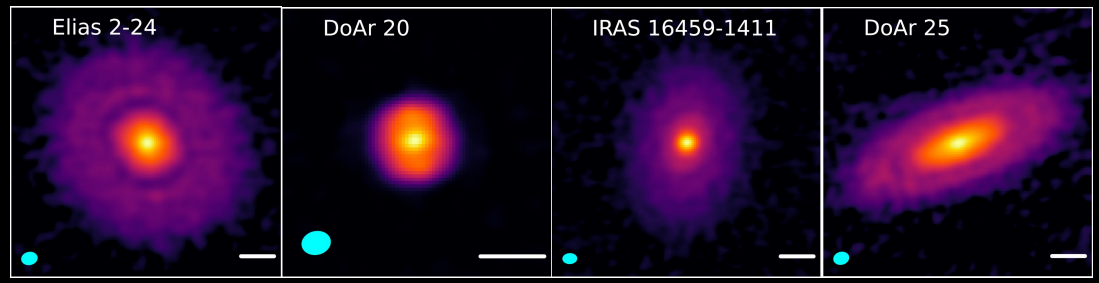




2 populations of Disk Substructures?







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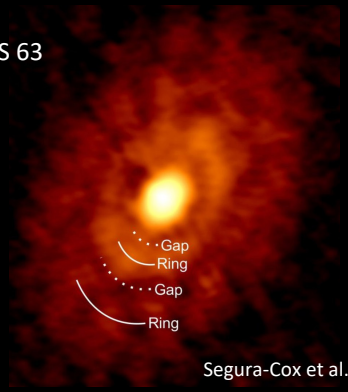
Class I
0.2 – 0.5 Myr

Flat
0.5 – 1.0 Myr

Class II
1.0 – 2.0 Myr

Time

IRS 63

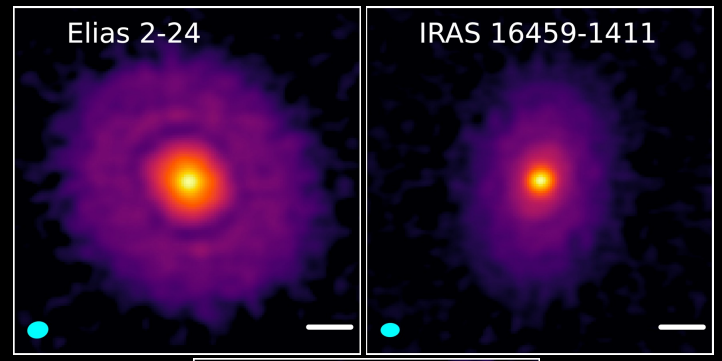


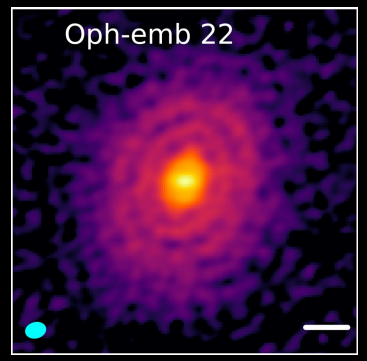
Segura-Cox et al. 2020

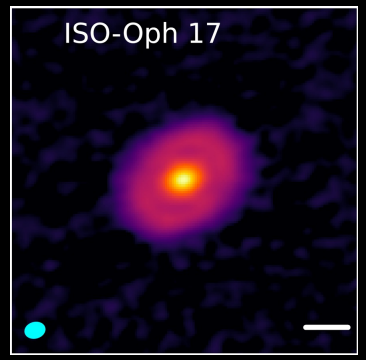
HL Tau

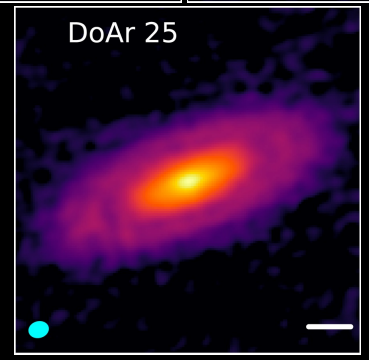
ALMA Partnership et al. 2015

Multiple ring systems tend to be centrally filled!









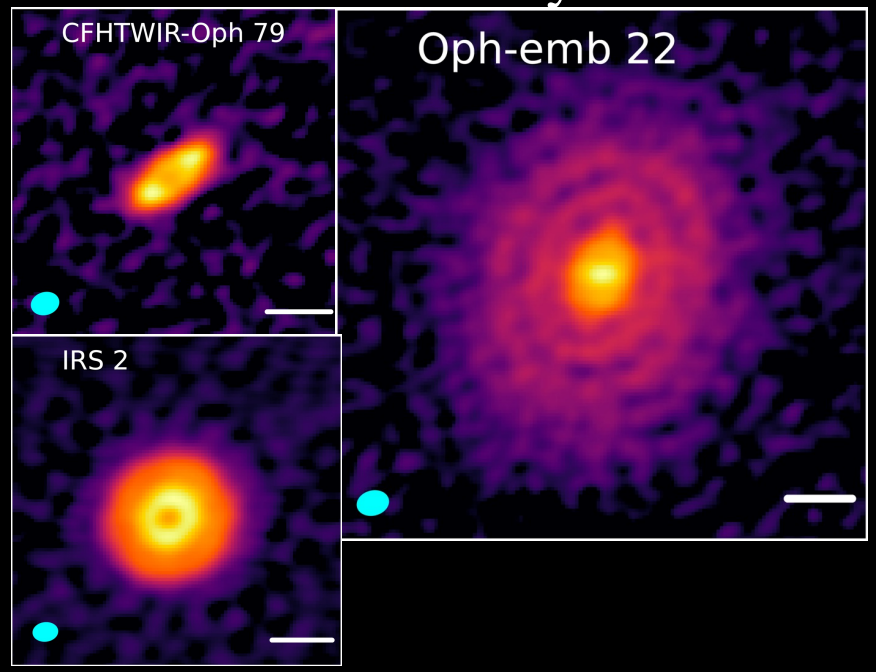
Contact: cheng-han.hsieh@yale.edu

Take home message

Personal Website:
https://chenghanhsieh.com

I. Disk substructures only start to appear for sources with age $\sim 0.3\ Myr$.

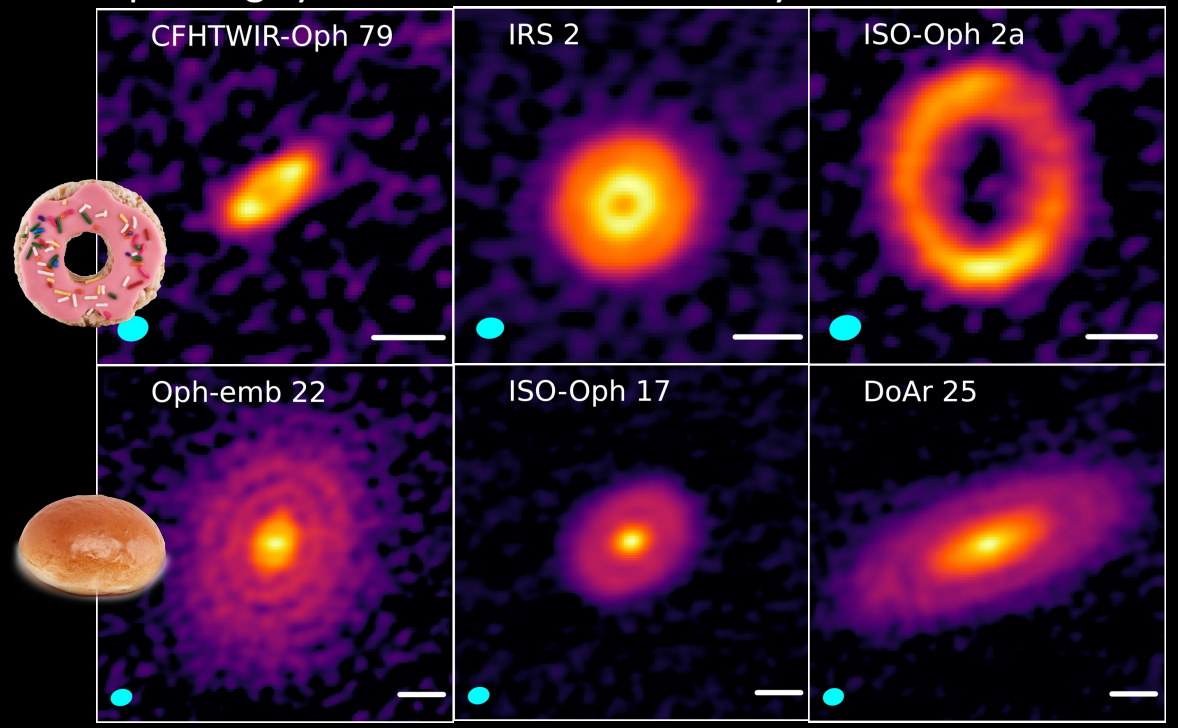
Class I
0.2 – 0.5 Myr



Is this when giant planet formation begins?

II. 2 populations of Disk Substructures?

Multiple ring systems tend to be centrally filled! **Hsieh** et al. in prep.



Will these disks make different planetary system architectures?

Will one population evolve into our Solar System than the other?