Constraining Dust Structure in the Protoplanetary Disks around V4046 Sgr, MWC480, and DM Tau

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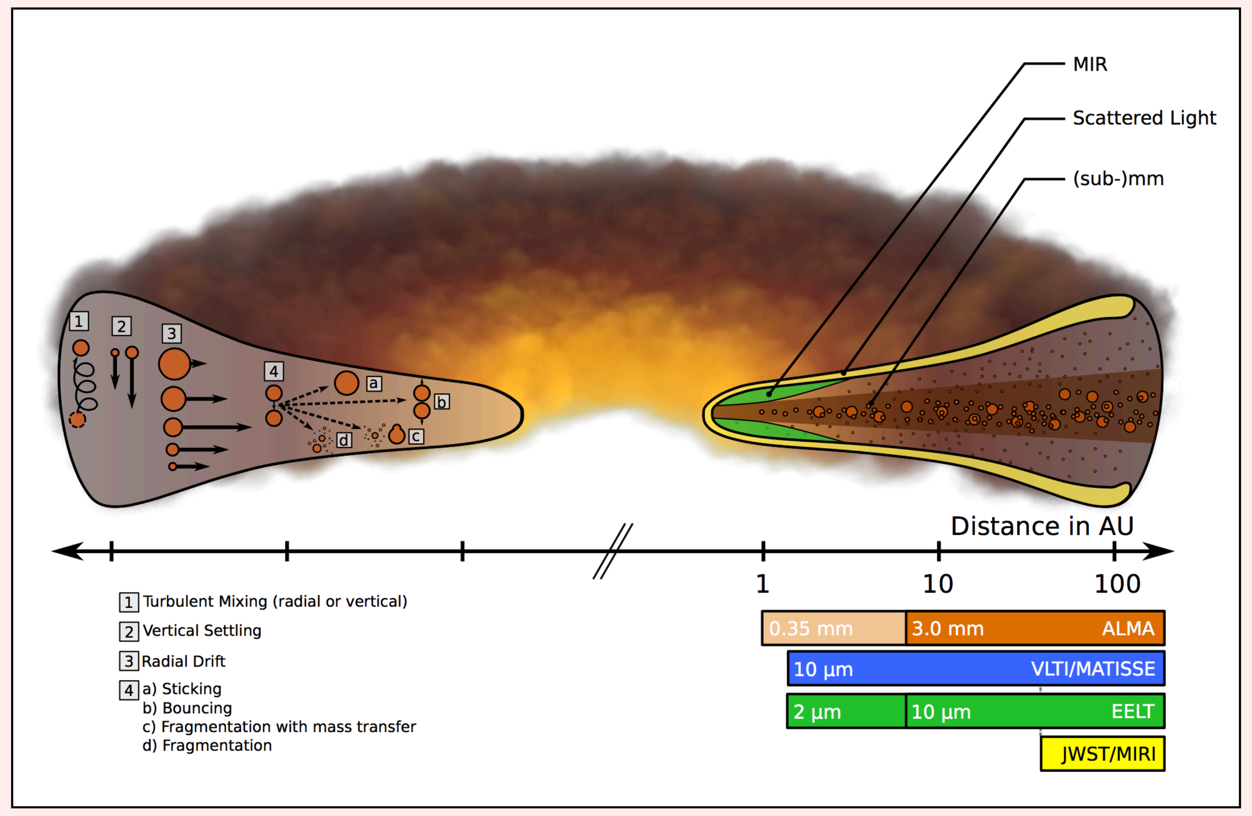


Above: A schematic diagram of a protoplanetary disk. The data used in creating the greyscale images on this poster were from ALMA, which, as shown in the orange bar marked by an asterisk at the lower right of this diagram, theoretically provides astronomers with a maximum angular resolution of 0.3 mm. (Figure from Testi et al. 2014)

Protoplanetary disks are planetary nurseries

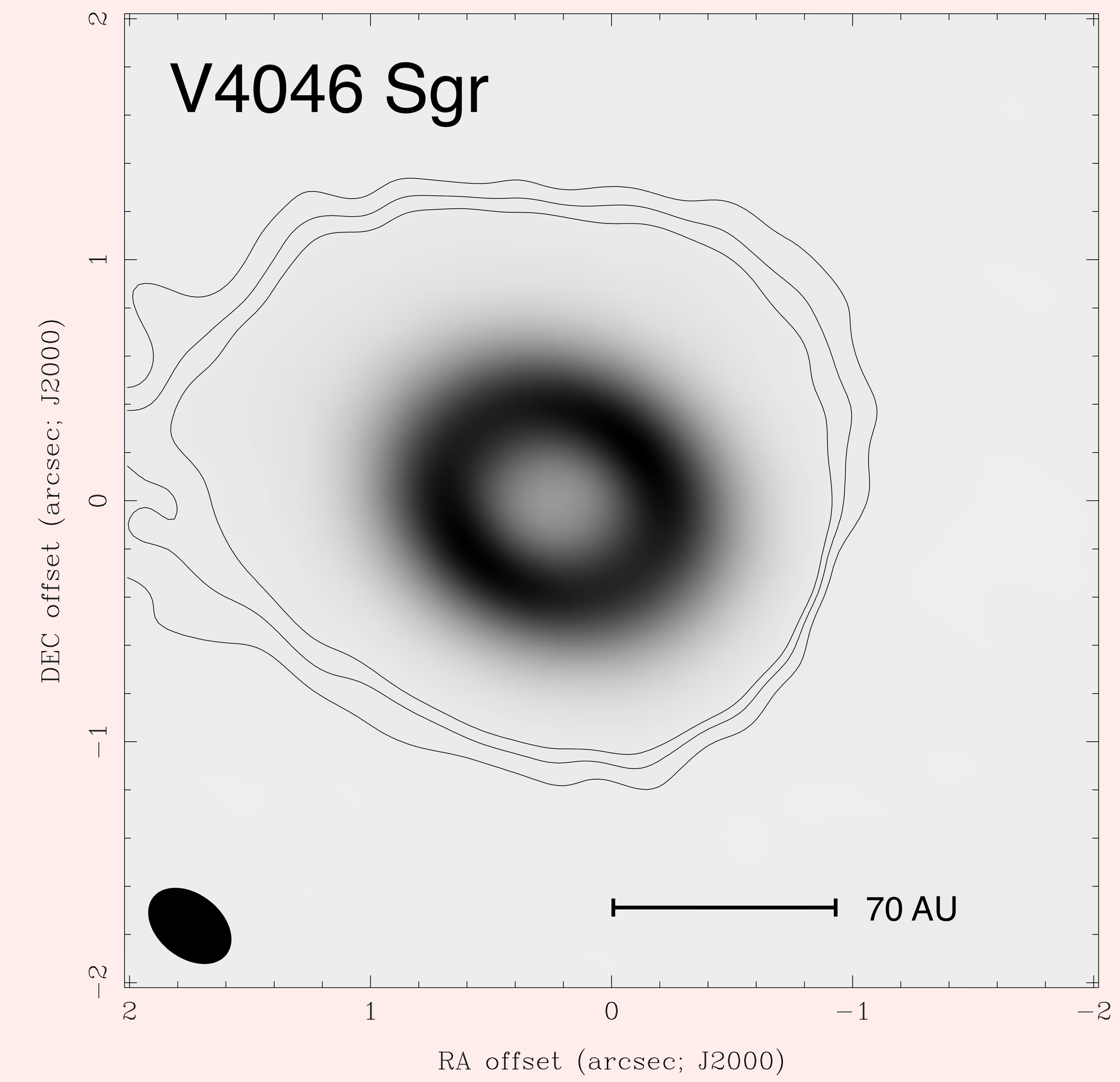
The collection of gas and dust around a young star, called a **protoplanetary disk**, is the site of planet formation. We focus on probing the dust around three stars using 1.3 mm continuum data from the Atacama Large Millimeter Array (ALMA). This allows us to study **millimeter-sized dust grains**, which are the first step in a dust grain's journey to becoming a planet-sized object.

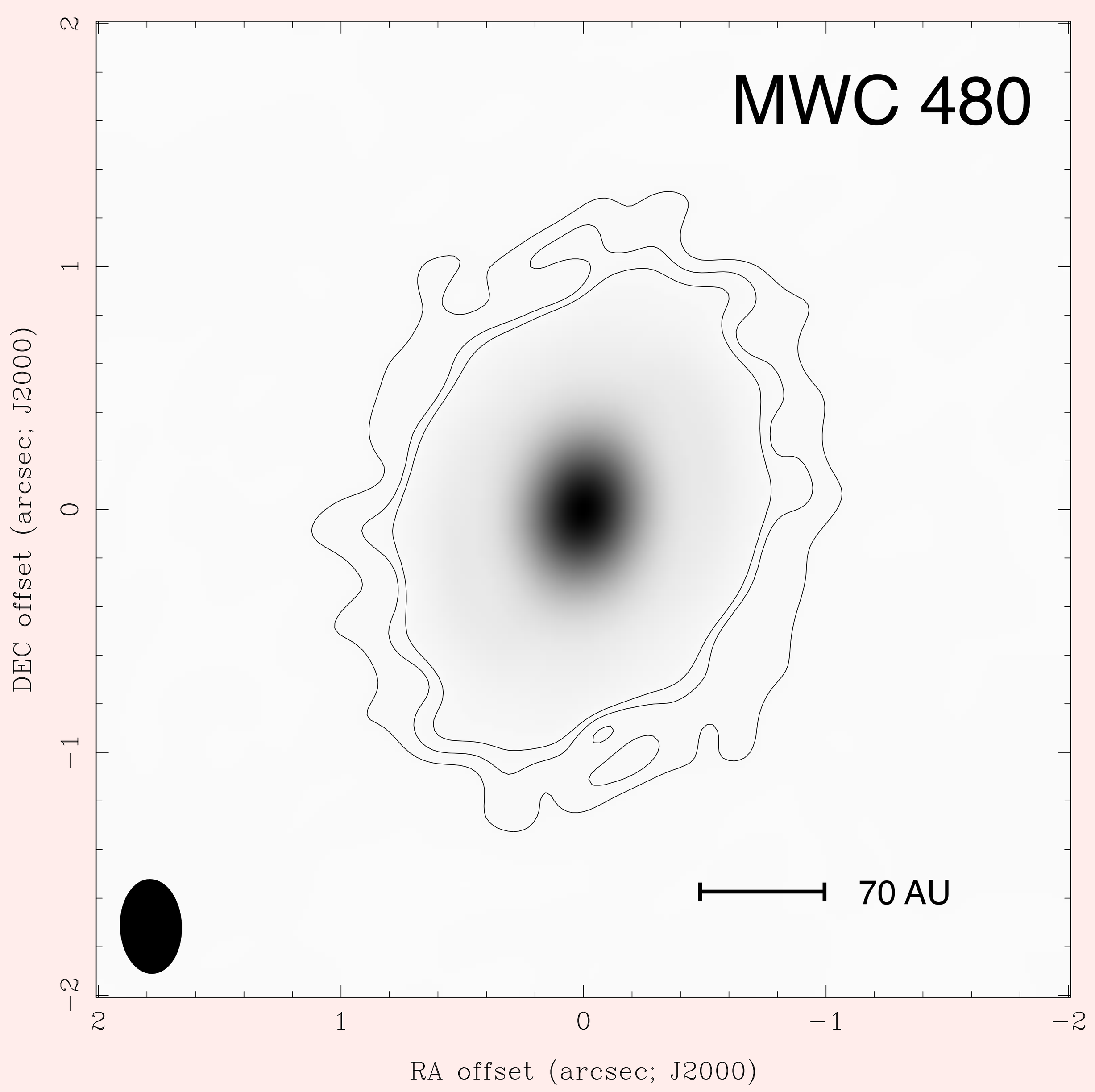
Besides imaging the disks, I am also working on modeling their structure using an **MCMC** code to derive parameters for the size and **dust-to-gas ratio** of their features and to look for faint structure.

Other than inner holes in two of the disks, I have observed no clear signs of structure down to the respective resolution limits of each observation. However, the MCMC modeling will be used to look for faint structures in the disks that cannot be resolved by eye.

V4046 Sgr

- V4046 Sgr is about 73 pc (**parsecs**, 1 pc = 206265 AU) away from the Sun
- Hosts a **circumbinary** protoplanetary disk which surrounds two stars that orbit a common center of mass
- Stellar masses: 0.9 and 0.85 solar masses (M⊙)
- Age of binary: ~ 10–20 Myr
- Binary separation: ~ 0.04 AU (**astronomical units**, 1 AU = the distance between the Earth and the Sun)
- Disk is about 102 AU in diameter
- Inner hole radius: ~ 29 AU
- Existence of inner hole means V4046 Sgr hosts a **transition disk**, where there is dust as well as potential larger bodies in the disk
- The **resolution limit** (the smallest size at which a feature can be resolved) for this observation is 18 AU



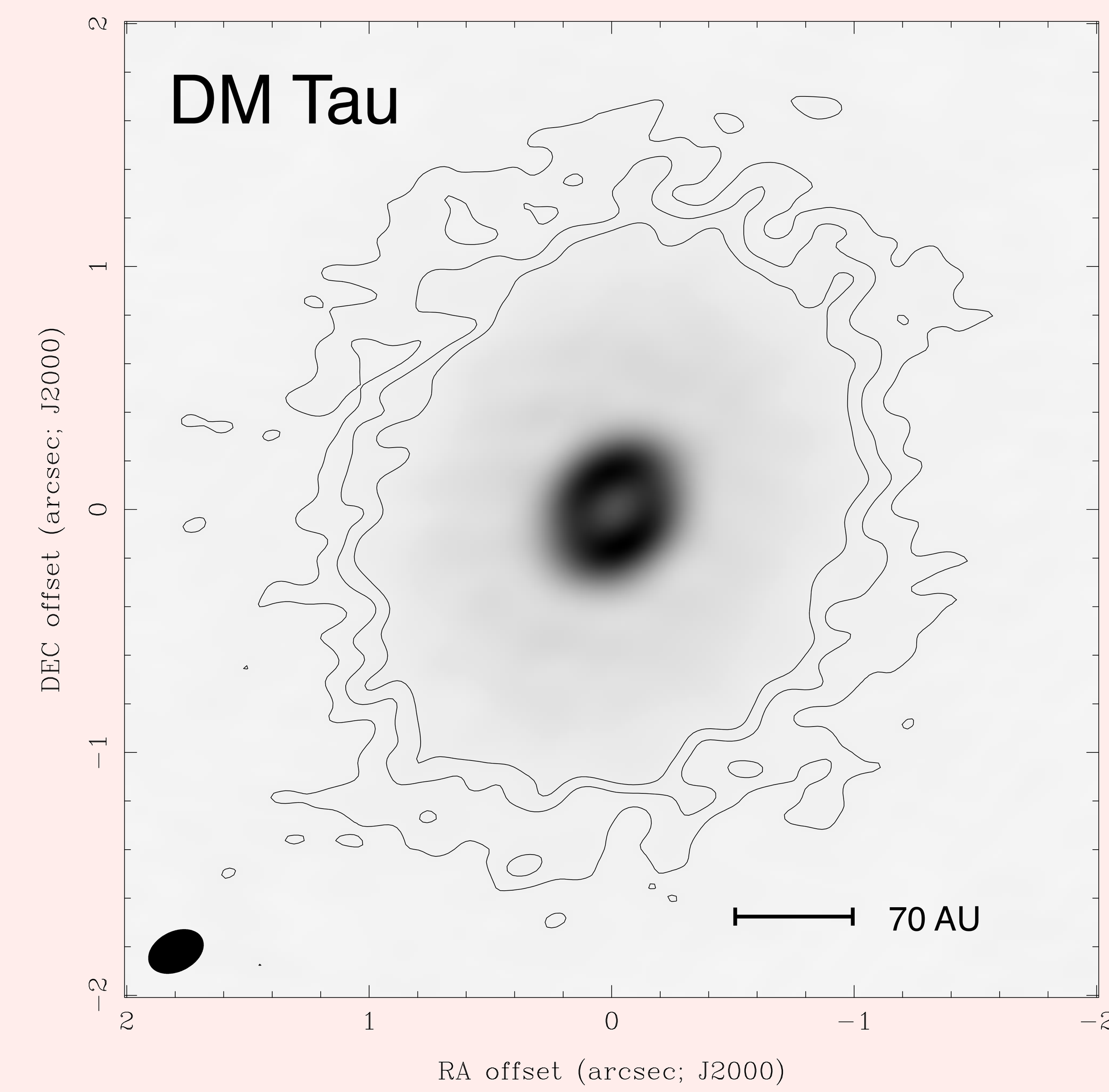


MWC 480

- MWC 480 is 131 pc away from the Sun
- Stellar mass: 2.3 M⊙
- Age of star: ~ 6 Myr
- Disk has no resolvable inner hole
- The disk has a diameter of 104 AU
- Around the central bright area of the disk, the dust density decreases with increasing radius, so there is still some emission at larger radii
- The age of this disk exceeds the current estimate for the formation timescale of kilometer-sized **planetesimals** (collections of dust that could become planets)
- Also, the mass of the disk is large enough to be able to create a planetary system with comparable mass to our Solar System
- The resolution limit for this observation is 29 AU

DM Tau

- DM Tau is 140 pc away from the Sun
- Stellar mass: 0.65 M⊙
- Age of star: ~ 5 Myr
- Disk has a complicated structure: inner hole, bright emission at intermediate radii, and faint ring at larger radii
- Although both V4046 Sgr and DM Tau have inner holes, they are quite different structurally
- Disk diameter is over 200 AU
- Inner hole radius: ~ 24 AU
- DM Tau also has a transition disk marked by its inner hole
- An inner hole in a transition disk could be cleared by a massive planet, or it could indicate dispersal of the disk
- The resolution limit for this observation is 25 AU



References: Espaillat et al. 2014, Protostars and Planets VI; Guilloteau & Dutrey 1994, A&A, 291, 2; Mannings et al. 1997, Nature 388, 555-557; Rosenfeld et al. 2013, ApJ, 775, 136; Testi et al. 2014, Protostars and Planets VI

All greyscale images have contours at 3, 5 and 7 times the noise level of the background.