Signs of Planetary Formation in the Disk of HD169142

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Introduction

HD 169142 is a Herbig Ae/Be star (2Mo), located at a distance of 145 pc. Scattered light images as well as molecular observations reveal a face-on disk extending up to 250 AU. Dent et al. (2006, MNRAS, 365,1283) detected relatively strong, angularly unresolved 7 mm emission through Very Large Array (VLA) observations. Since centimeter emission is not detected towards this object, it is expected that the observed 7 mm emission traces the dust emission from the disk, without free-free emission contamination from a possible radio jet. The lack of detectable free-free emission also suggests that this object is in a relatively advanced evolutionary stage where the accretion and outflow processes are almost halted.

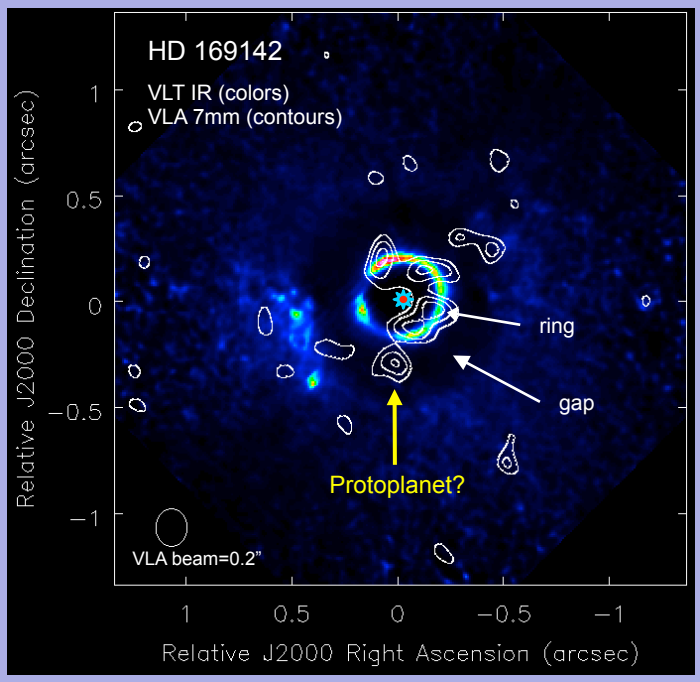
Observational Results

We present new VLA observations at 7 mm at very high angular resolution (0.2") that reveal substructure and evidence of planet formation in the disk of the Herbig Ae/Be protostar HD 169142 .

Our observations, along with near-infrared polarimetric imaging (Quanz et al. 2013; ApJ,. 766, L2), show that this disk has an inner cavity and a ring of enhanced asymmetric emission at a radius ~25 AU from the central star.

This ring, whose inner region appears devoid of emission, is surrounded by an annular gap of decreased emission in the ~30-70 AU range of radii.

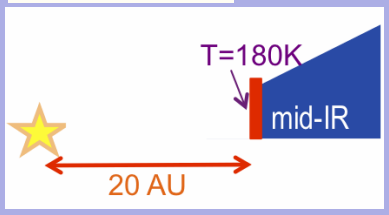
Since our 7 mm observations show a compact source in the 30-70 AU gap, we speculate that this compact source could be tracing dust emission associated with a possible protoplanet.

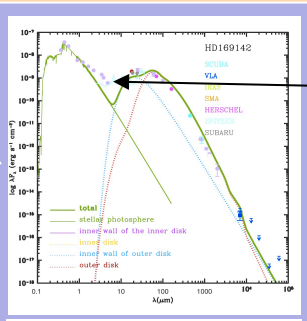


Modeling

The broad-band spectral energy distribution (SED) of the disk is modeled. From this modeling we infer the presence of a small (~1 AU) disk inside the central (R~20 AU) cavity, suggesting that the HD 169142 disk is in the pre-transitional stage.

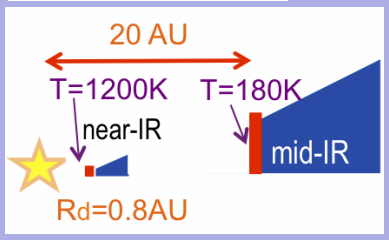
TRANSITIONAL DISK

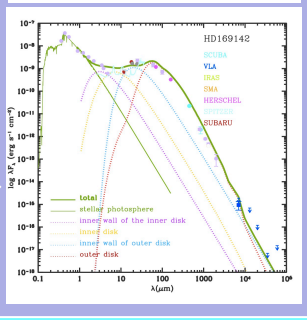




TRANSITIONAL DISK
Fails to reproduce the near-IR fluxes

PRE-TRANSITIONAL DISK





Parameters derived from the SED fitting (PRE-TRANSITIONAL DISK)

Outer disk
-i=13º (low inclination according with the images)
-M_{acc}=3.5e-9 Mo/yr (UV excess Grady et al 2007, ApJ 655, 1391)
-R_d=240 AU according to the images
-M_{disk}=0.1 Mo
-viscosity parameter=0.0008
-grain size ~1mm (disk mid-plane)

Inner disk (not well constrained)
-inclination, M_{acc}, grains and viscosity similar to those of the outer disk
-R_d=0.7 AU
-M_{disk}=0.0001 Mo

Proposed scenario for HD 169142

- The morphology of the 7 mm emission is well correlated with the VLT infrared scattered light image obtained by Quanz et al. (2013), showing a ring of radius ~25 AU and an annular gap extending from ~30-70 AU.
- The SED fitting and the VLA/VLT data indicate that the HD 169142 disk is pre-transitional, with a small inner disk, from 0.4 to 0.7 AU, and an outer disk from 20 to 250 AU. There is, therefore, a gap from 0.7-20 AU, and a second, probably less developed, gap extending from 30-70 AU.
- Inside the 30-70 AU annular gap we detect a 7 mm unresolved source, that we tentatively interpret as tracing the dust associated with a protoplanet candidate. We estimate a mass of 0.2-2 Jupiter masses for this proposed circumplanetary structure.
- We interpret these results as evidence of possible planetary formation in the disk of HD 169142. This hypothesis can be further tested with new VLA, VLT, and ALMA observations.