Finding young planets by their imprints on circumstellar disks

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CARMA

Combined Array for Research in Millimeter-Wave Astronomy

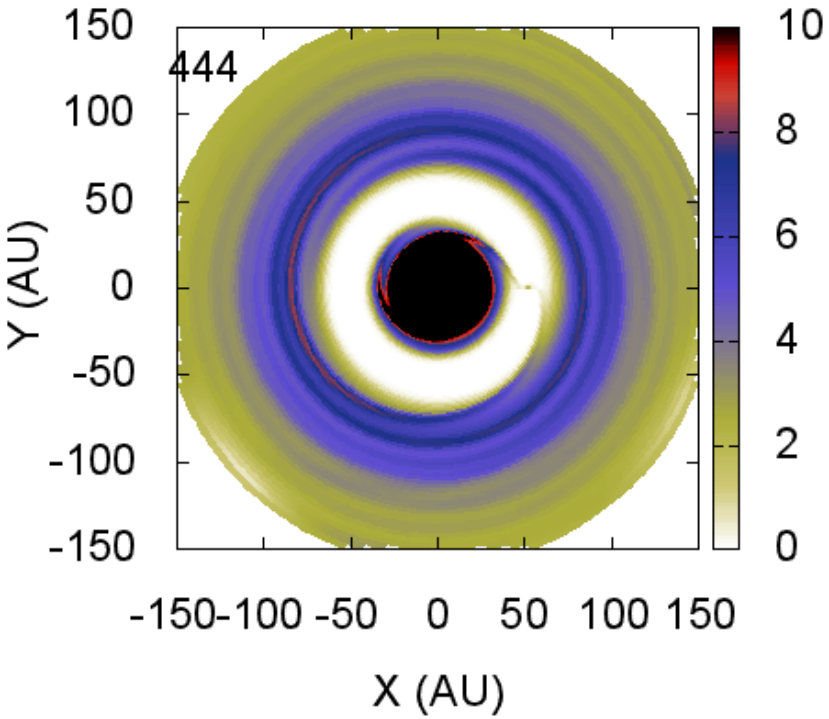
Talk Outline

- Brief introduction on the disk-planet interaction
- Probing the presence of planets through mm-wave observations
- Constraining the physical properties of young planetary systems
- New frontiers: - ALMA and VLA observations of transitional disks

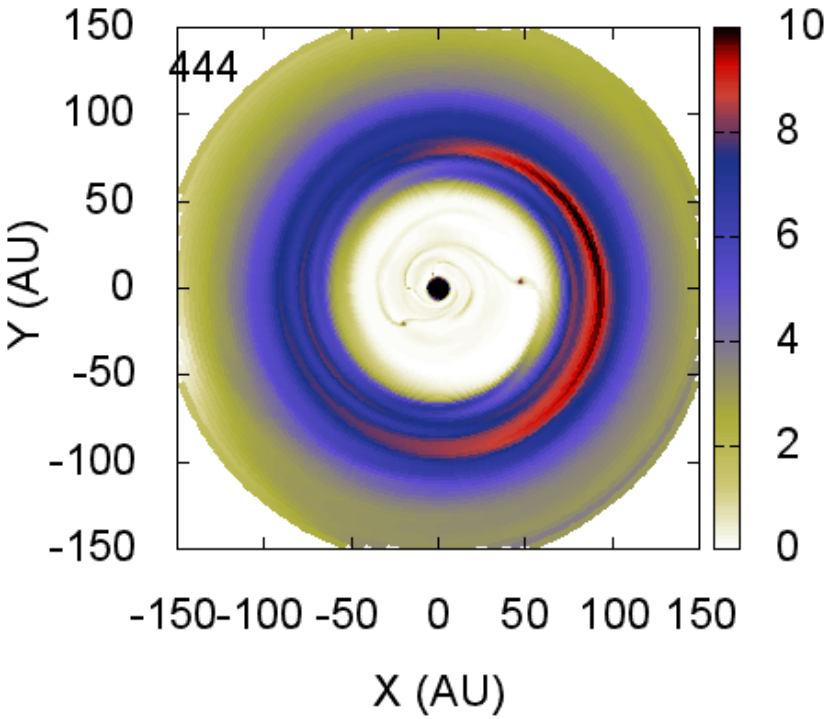
Collaborators: J. Carpenter, L. Ricci (Caltech), L. Perez (Caltech/NRAO), N. Turner (JPL), Claire Chandler (NRAO), Sean Andrews, Katherine Rosenfeld (CFA)

Disk-Planet interaction

1 Giant Planet

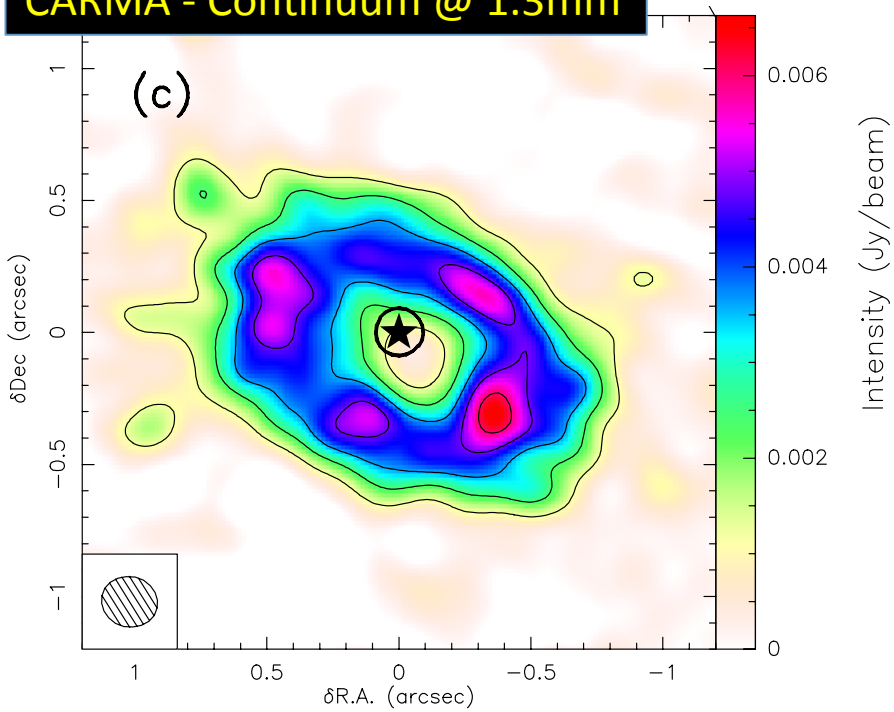


4 Giant Planets



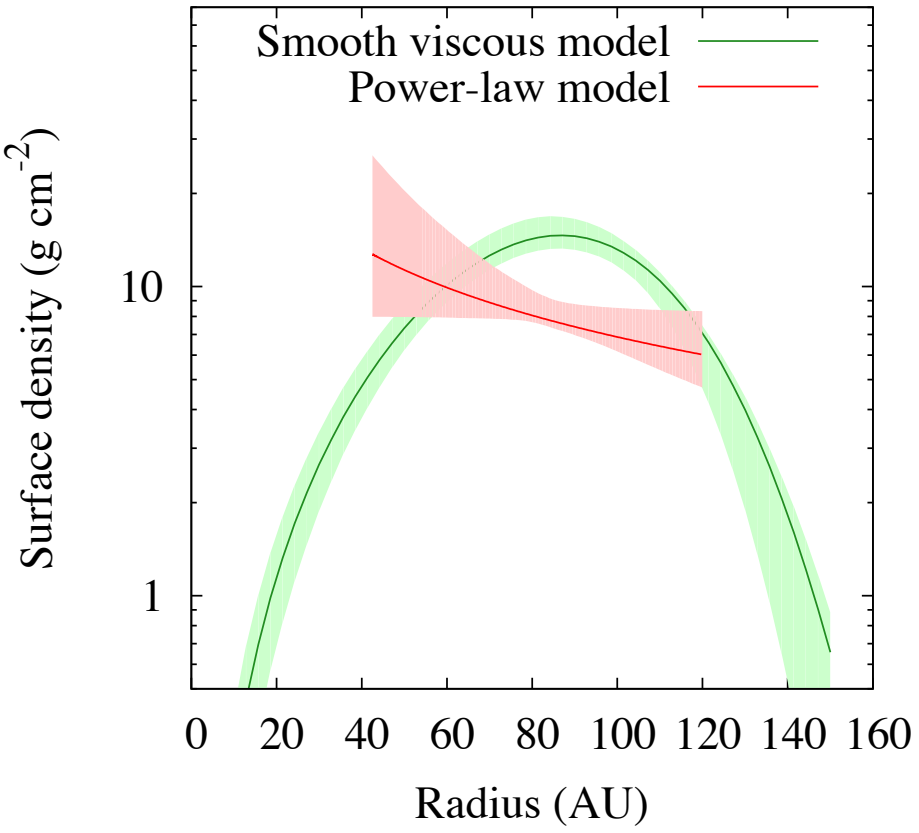
LkCa 15

CARMA - Continuum @ 1.3mm

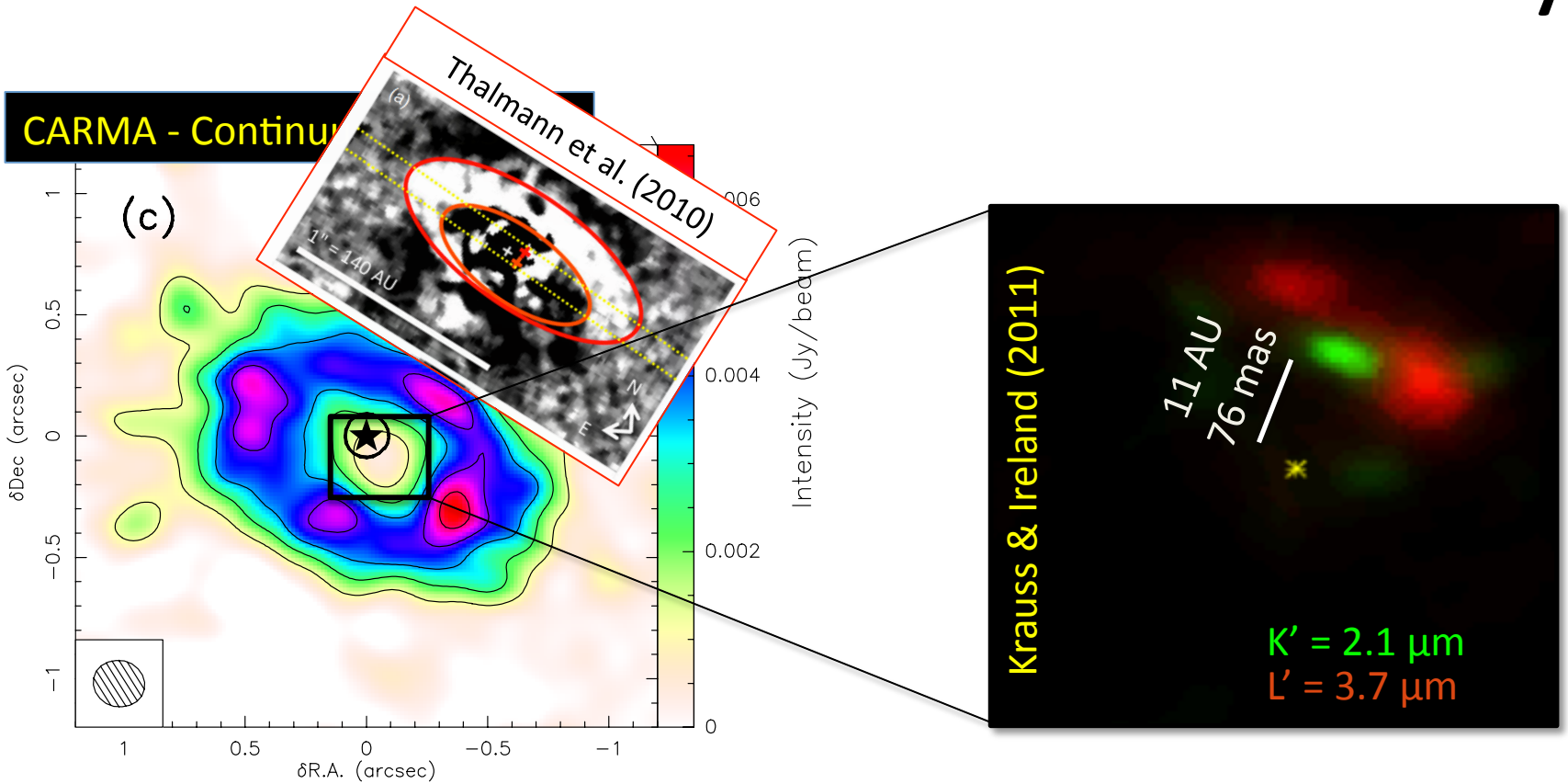


Beam size : 0.15''
20 AU @ 130 pc

Isella A., Perez L., Carpenter J. (2012)



LkCa 15: a wanderful laboratory!



Beam size : 0.15''
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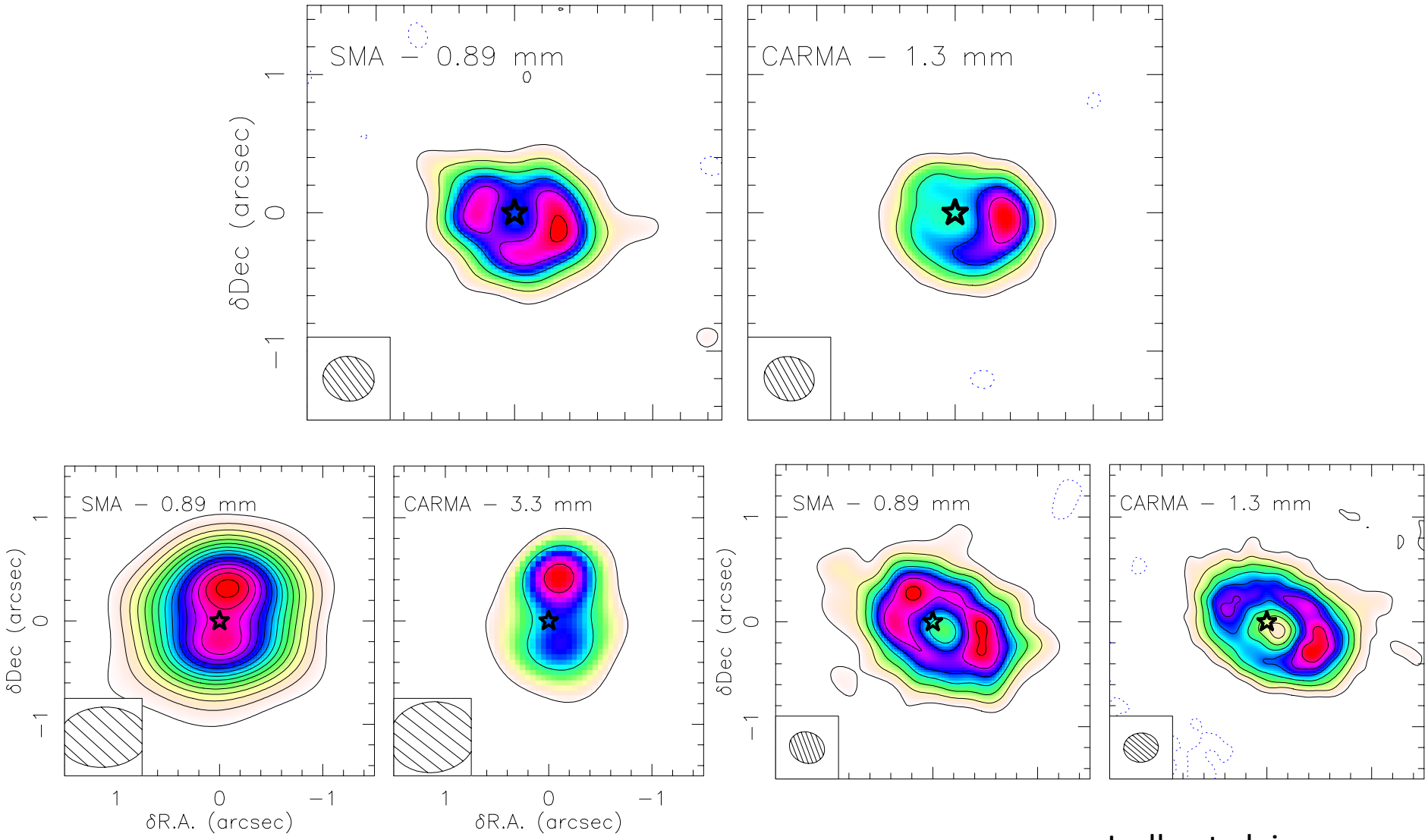
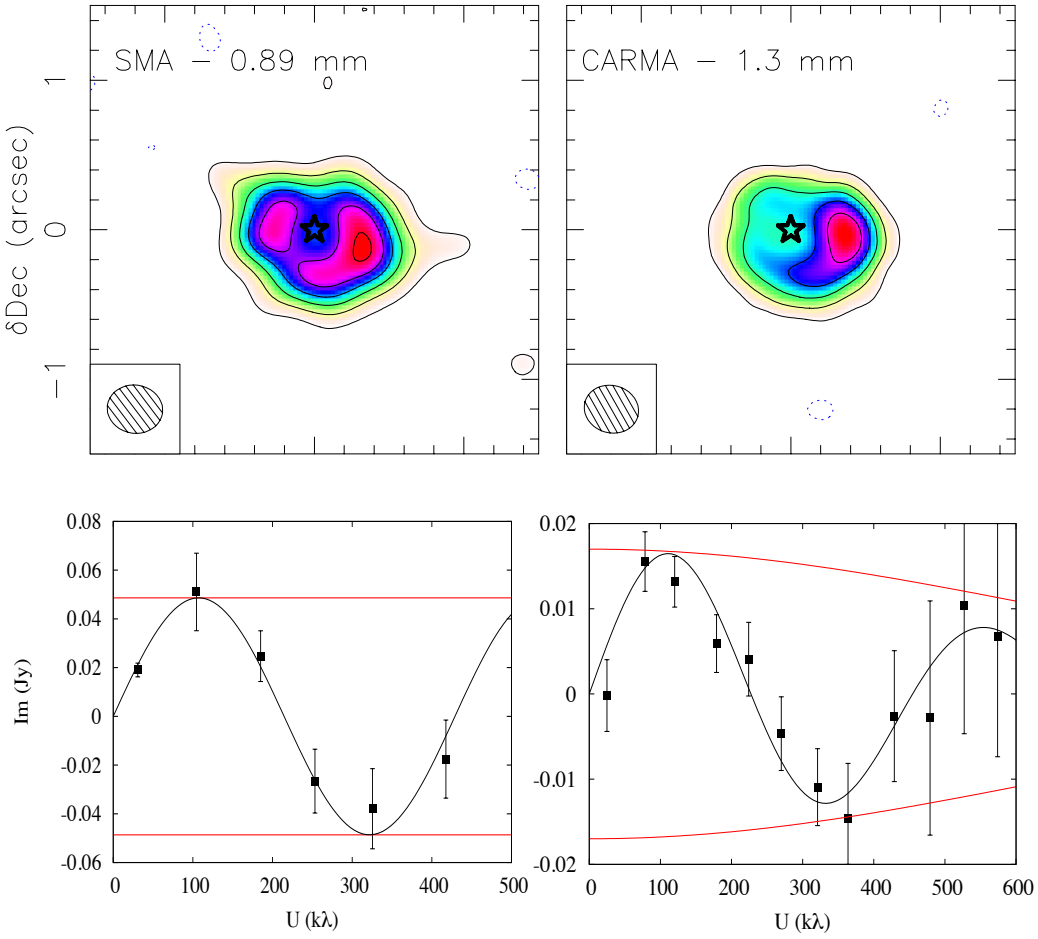
Isella A., Perez L., Carpenter J. (2012)

Asymmetries in the dust emission

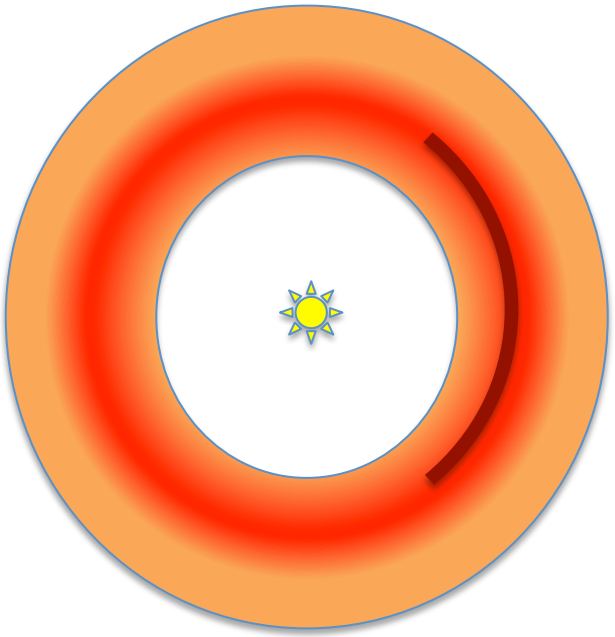


Isella et al. in prep

LkHα 330



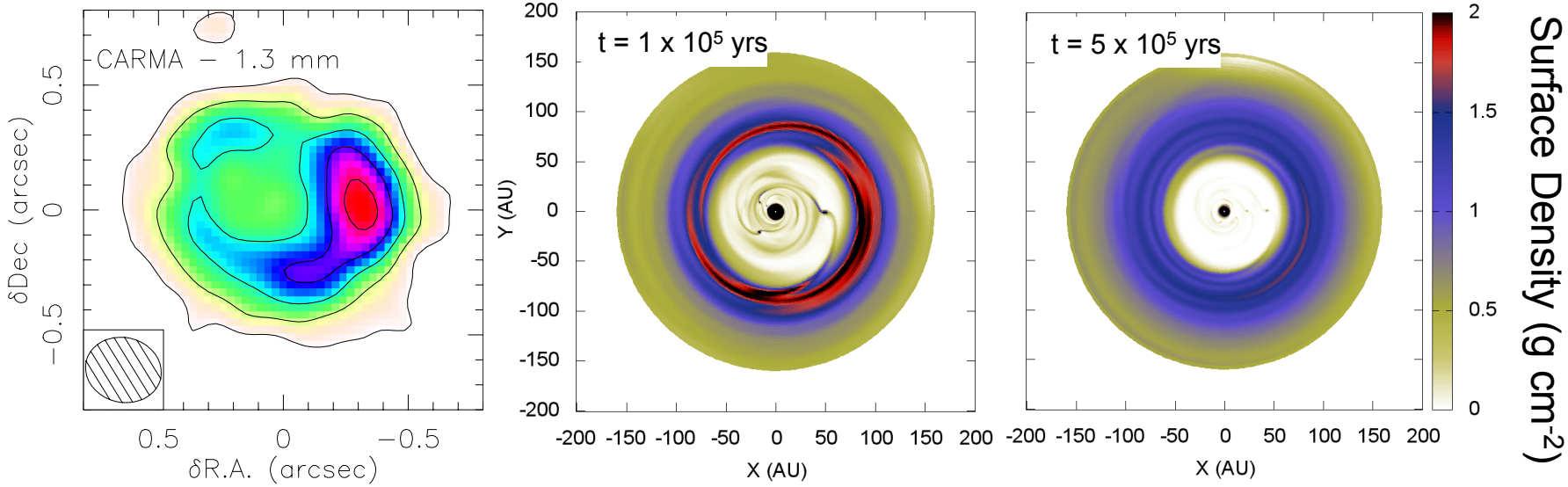
- Gap radius = 70 AU
- Total flux @ 1.3 mm = 50 mJy
- Flux in the asymmetry = 17 mJy
- The asymmetry is narrow along the radial direction (<10AU) and extended in azimuth (100AU)



Isella et al. in prep

LkHα 330: a planetary system in formation?

HD simulations of a forming planetary system

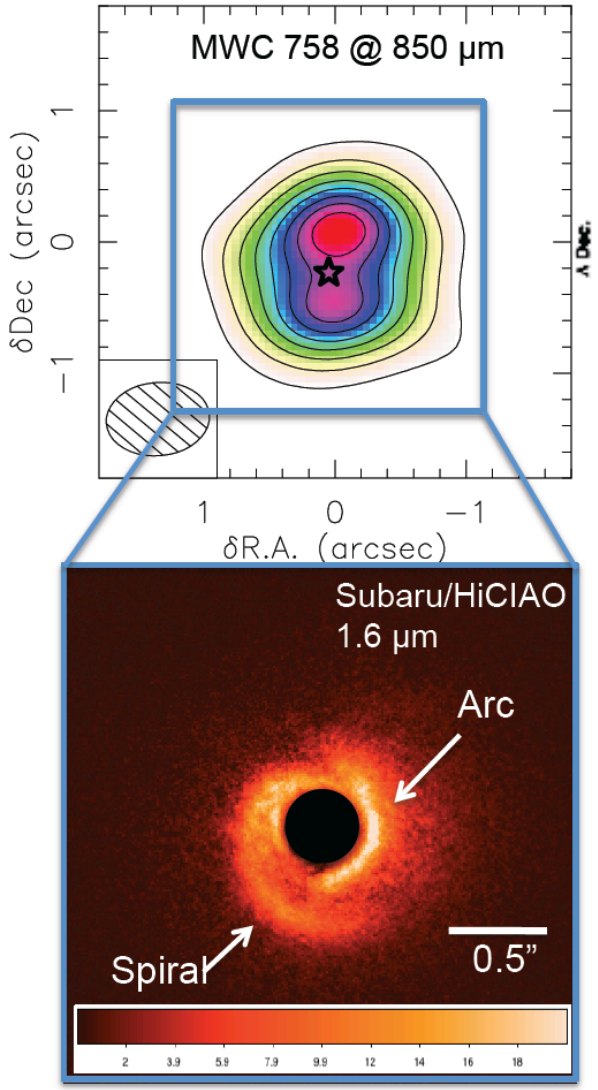


Caution is required to convert dust emission asymmetries is local variation of the dust density due to possible spatial variations in the dust opacity and temperature.

Isella et al. in prep

New frontiers: ALMA

Isella et al. (2010)

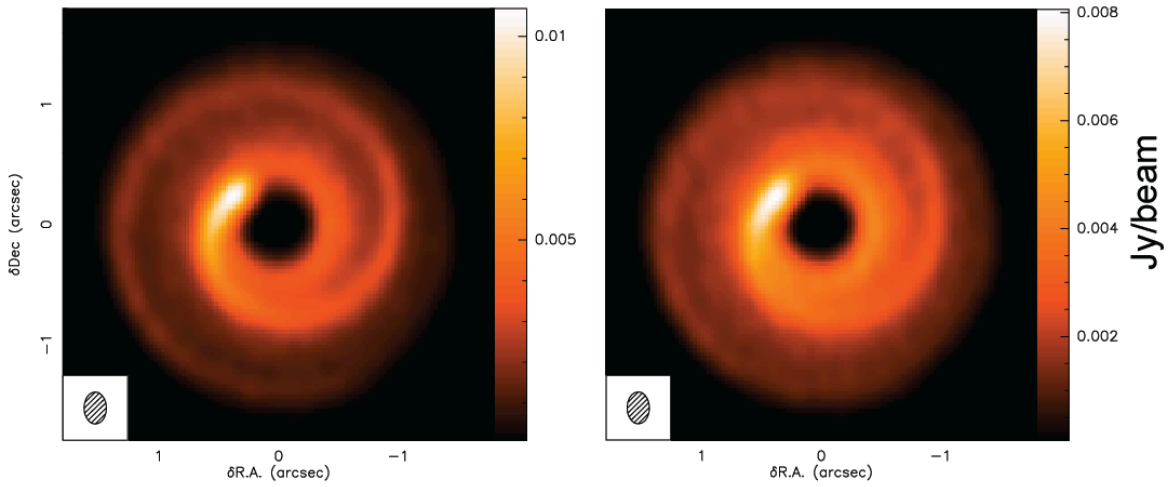


Grady et al. (2012, ApJ, in press)

Density contrast : $\frac{\delta\Sigma}{\Sigma} \approx \frac{GM_p\Omega}{c^3}$ (e.g., Kley et al. 2012)

Shape: $\phi = f(r_p, \phi_p, c_s, h)$ (e.g., Rafikov et al. 2002)

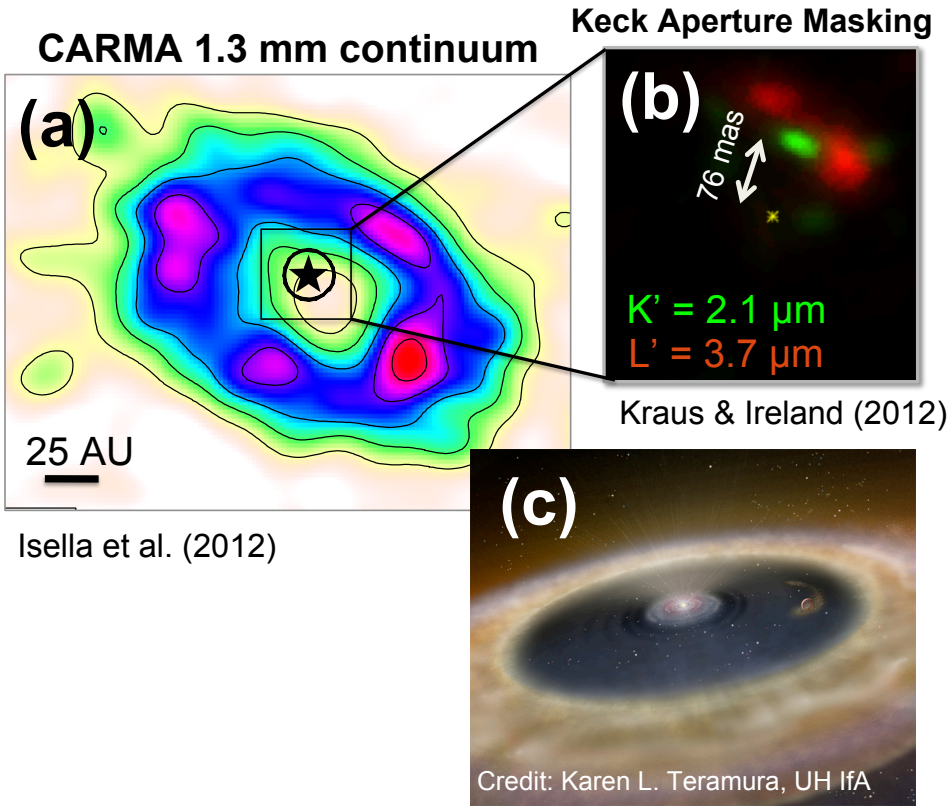
ALMA Band 7 simulated observations of the dust thermal emission



4 M_J @ 50 AU

1 M_J @ 50 AU

New frontiers: VLA

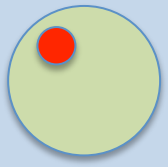


Kraus & Ireland (2012)

Isella et al. (2012)

- Detect LkCa15b circumplanetary disk.
- Measure LkCa15b orbit

VLA beam @ 7 mm = 40 mas



CARMA beam @ 1.3 mm

Sensitivity:
2.5 μJy in 10 hrs -> 3 Lunar masses of dust

Rp = 16 AU -> 12mas/yr = ¼ VLA beam

Ongoing Observations

Summary

- Millimeter-wave telescopes provide the angular resolution and sensitivity required to study the earliest phases of planet formation through the disk-planet interaction

- Large gaps in the dust emission suggest the presence of planetary systems composed by multiple giant planets

- This hypothesis is supported by the detection of asymmetries in the dust distribution

- ALMA and VLA will constrain the mass and orbital radius of newly formed planets.