Episodic Accretion as seen by the ngVLA

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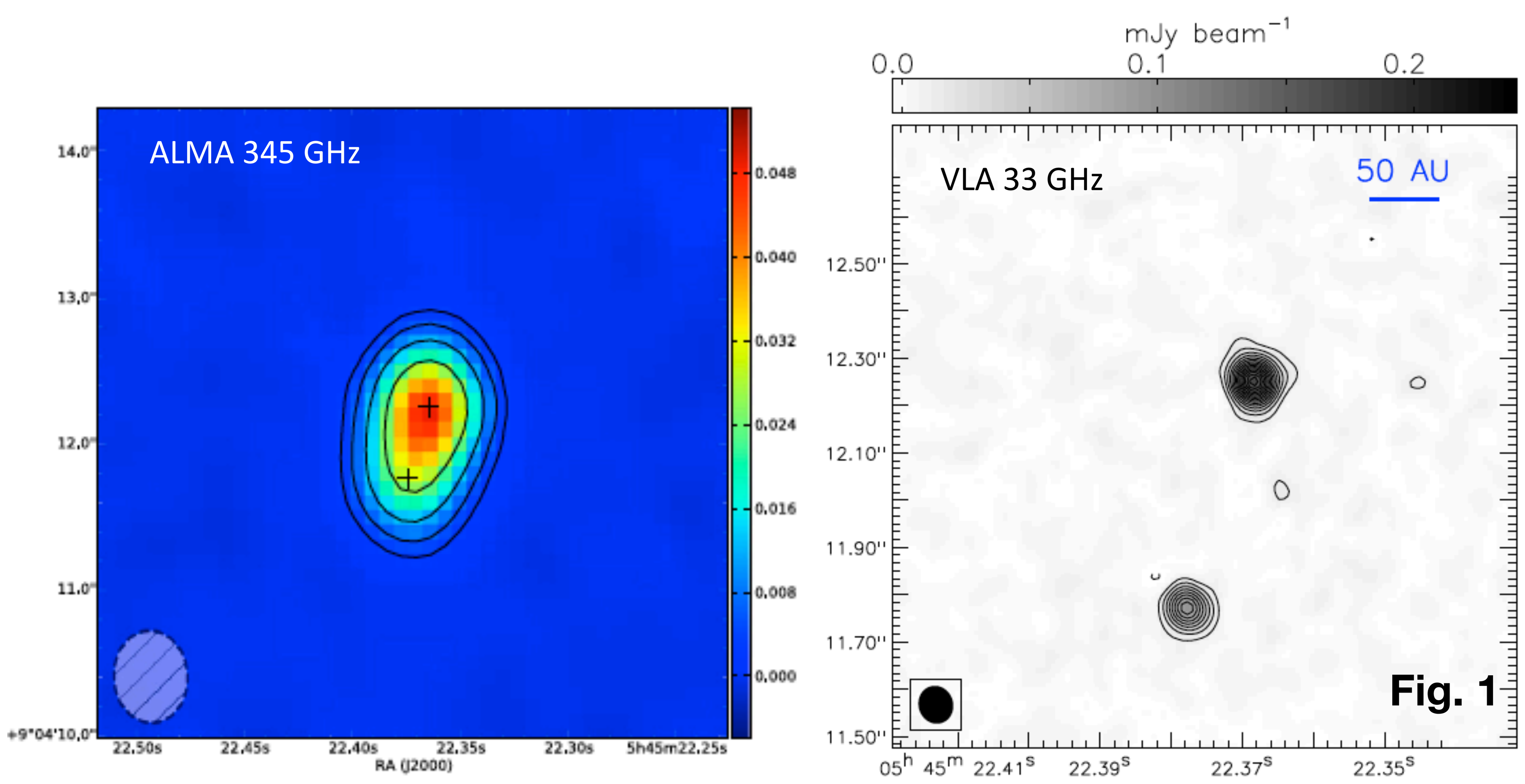
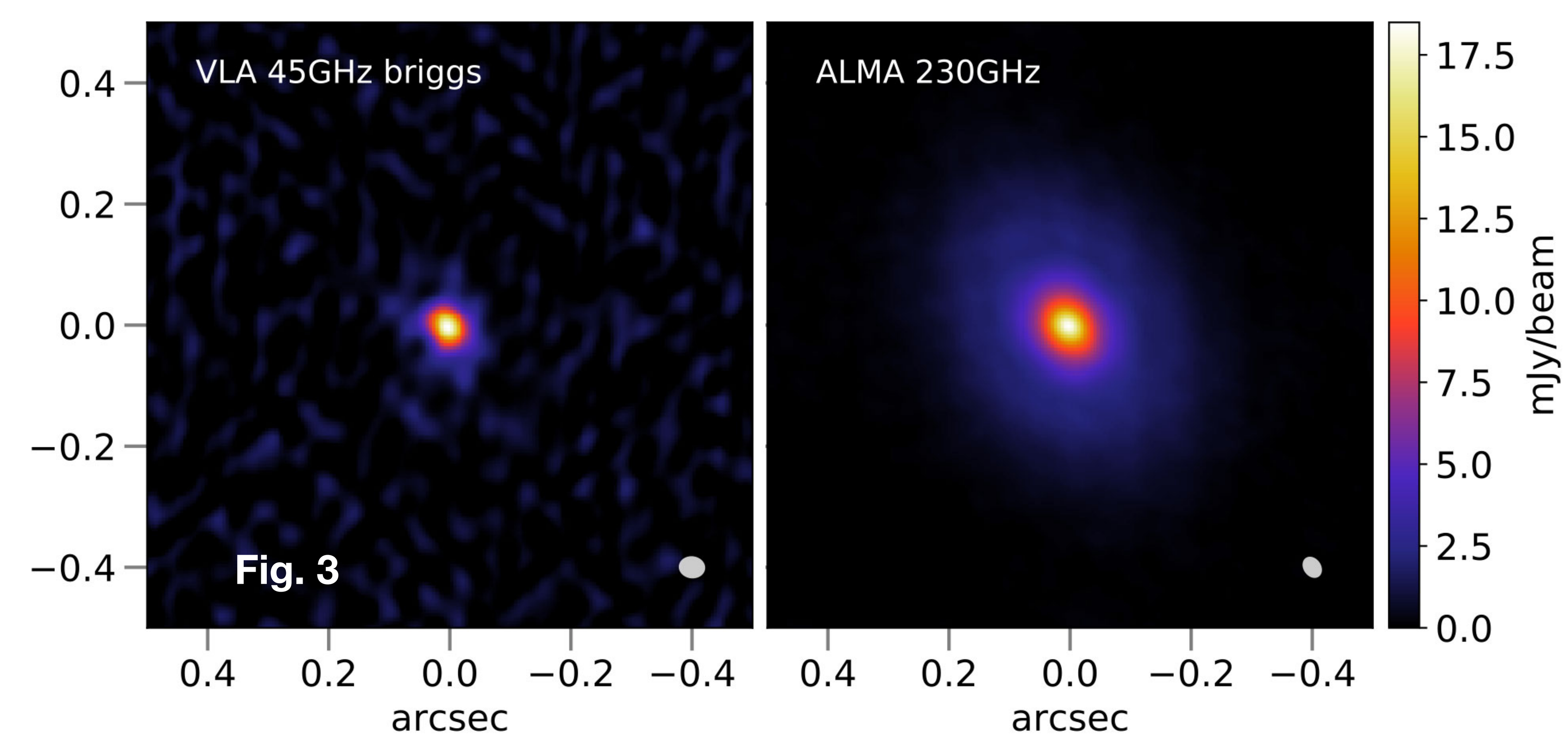
The ngVLA will open a new regime for studying episodic accretion in FU/EX Ori objects. Despite growing rapidly and becoming highly popular in the last 15 years, the process leading to episodic accretion is still poorly understood. Its relevant to many highly popular fields like low-mass star formation, binary formation, as well as planet formation. From recent ALMA and eVLA results (e.g. Cieza et al 2016, Liu et al 2017), it is becoming clear that very high resolution is needed in order to image the very compact disks that surround these objects, to understand the instability processes that are driving the outburst. Particularly, multi-wavelength observations at lower frequencies are needed in order to penetrate the disks, which are optically thick even at millimeter wavelengths, and understand better the disk properties and what physical processes are driving the instabilities. By imaging the inner regions we would be able to fit the temperatures and masses to attempt to get a better estimate of Toomre's Q in the inner regions to see if they should be unstable. The very low frequencies of the ngVLA will allow to measure and correct for non-thermal contribution from the disk winds, which is crucial for estimating the disk temperatures in the optically thick bands. In addition, the ngVLA high resolution will be able to image the instabilities directly and look for the clumps, fragments and spirals predicted in the different simulations. So far ALMA has been unable to detect this in any EX/FUor source.





Gravitational and thermal instabilities, disk fragmentation, forming planets and stellar encounters are some of the different proposed triggering mechanisms for the outburst. The archetypical FU Ori system, FU Oriorins itself, is a known binary composed of two disks, barely resolved by ALMA in Cycle 0 (Hales et al. 2015; Figure 1).

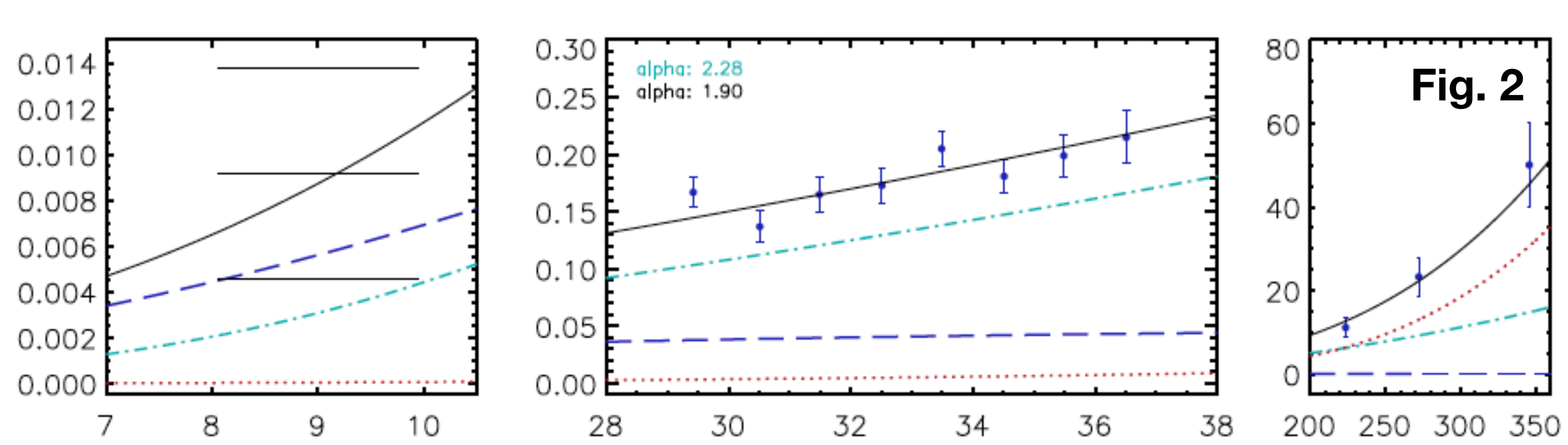
The Karl G. Jansky VLA's allowed to separate the two disks at 33 GHz, but was unable to resolve them at 0.08"x0.07" resolution (Liu et al. 2017). Combining these observations with lower 8-10 GHz data, the SED of FU Ori revealed a complex circumstellar structure which can be explained by the free-free emission from ionized gas, and thermal emission from optically thicker and optically thinner dust components (Figure 2).

Recent observations show that compact, optically thick disks are common around Class I objects (e.g. Yen et al. 2017; Li et al 2017). In some cases the **dust emission is likely very optically thick even at ~1 mm wavelengths**. In order to determine the dust disk properties around these relatively actively accreting objects, **observations at wavelengths longer than 6 mm and with resolutions better than 0.1" are critical.** Next Generation VLA improved sensitivities will allow to **detect the more numerous fainter targets**, enabling in-band spectral index measurements.

V883 Ori is a perfect laboratory to exemplify that viscous accretion heating is relevant in protoplanetary disks. A passive disk has a temperature profile slope much shallower than what it is observed in V883 Ori with ALMA band 6 (Figure 3).

The inner 50 au of the V883 Ori disk are optically thick at 230 GHz wavelengths, preventing ALMA to see what is inside the core. Thanks to the Karl G. Jansky VLA's extended configuration, we resolved the hot dust in the active disk at 45 GHz. We found the emission to be more radially compact than the optically thick emission core seen by ALMA (Cieza et al. 2016), allowing us to better constrain the physical conditions (e.g temperature) inside the water snowline.

Next Generation VLA will allow, with its dramatic increase in collecting area and baseline reach, resolving inside the water snow line of V883 Ori to probe for both, radial and azimuthal structures. It will also enable the study of water snow lines in other scaled-down systems. Observations at radio frequencies are crucial to **subtract the free-free contribution** and hence determine the contribution of other sources of heating in the inner regions of the disk to quantify the extra sources of heating. The **ngVLA will provide a factor of 5-10 better resolution than currently achievable with the VLA** (as we have demonstrated for the case of V883; Figure 4).



Fiducial SED model for FU Ori North (from Liu et al. 2017). Dotted lines show the fluxes of the optical thinner and cooler dust components; dashed-dotted lines show the fluxes of the optically thicker hot dust components; dashed lines show the fluxes of the ionized components; solid curves show the integrated fluxes. The horizontal bars in the left panels are provide here the 1, 2 and 3-sigma upper limits at X band (8-10 GHz). The plotted 224 GHz and 272 GHz data assume that the flux ratio between FU Ori and FU Ori S is identical to that at 33 GHz. Axis units are mJy and GHz.