Young Stars & Planets Near the Sun
Proceedings IAU Symposium No. 314, 2015
J. H. Kastner, B. Stelzer, & S. A. Metchev, eds.

doi:10.1017/S1743921315005979

Rings of C_2H in the Molecular Disks Orbiting TW Hya and V4046 Sgr

J. H. Kastner[1], C. Qi[2], U. Gorti[3], P. Hily-Blant[4], K. Oberg[2], T. Forveille[4], S. Andrews[2], and D. Wilner[2]

[1]Lab. for Multiwavelength Astrophysics, Rochester Institute of Technology; jhk@cis.rit.edu
[2]Harvard-Smithsonian Center for Astrophysics
[3]SETI Institute & NASA Ames Research Center
[4]Université Grenoble Alpes & Institut de Planétologie et d'Astrophysique de Grenoble

Abstract. We have used the Submillimeter Array (SMA) to image, at $\sim$1″ resolution, C_2H(3–2) emission from the molecule-rich circumstellar disks orbiting the nearby, classical T Tauri star systems TW Hya and V4046 Sgr. The SMA imaging reveals that the C_2H emission exhibits a ring-like morphology within each disk; the radius of the inner hole of the C_2H ring within the V4046 Sgr disk ($\sim$70 AU) is somewhat larger than than of its counterpart within the TW Hya disk ($\sim$45 AU). We suggest that, in each case, the C_2H emission likely traces irradiation of the tenuous surface layers of the outer disks by high-energy photons from the central stars.

Keywords. protoplanetary disks, stars: individual (TW Hya, V4046 Sgr), stars: pre-main sequence

1. Introduction

Our single-dish radio telescope molecular line surveys of the evolved protoplanetary disks orbiting the nearby, actively accreting T Tauri star systems TW Hya and V4046 Sgr established that both display strong C_2H line emission (Kastner *et al.* 2014). As C_2H is likely the dissociation product of more complex hydrocarbons and organics, it potentially provides a diagnostic of disk irradiation by high-energy (UV and X-ray) photons generated via accretion and coronal activity at the central T Tauri stars. With this as motivation, we have used the Submillimeter Array (SMA) to image, at $\sim$1″ resolution, C_2H(3–2) emission from the TW Hya and V4046 Sgr disks.

2. SMA observations of C_2H emission from TW Hya and V4046 Sgr

TW Hya: The results of SMA imaging of C_2H emission from this single, nearby (D = 54 pc) $\sim$0.8 $M_\odot$ T Tauri star — the namesake of the $\sim$8 Myr-old TW Hya Association — are reported in Kastner *et al.* (2015; hereafter K15). These observations have revealed that the C_2H line surface brightness exhibits a ring-like emission morphology, with an inner hole of radius $\sim$45 AU (Fig. 1). Based on comparison of the SMA C_2H imaging results for TW Hya with previous continuum and line emission imaging and spectroscopy of that disk, it appears that the C_2H abundance is enhanced in warm, low-density, disk surface layers that lie beyond the CO "ice line" (as traced by N_2H^+ emission; Fig. 1).

V4046 Sgr: This close ($\sim$2.4-day) binary system, a member of the $\sim$20 Myr-old β Pic Moving Group, consists of nearly equal, $\sim$0.9 $M_\odot$ components (Rosenfeld *et al.* 2012). The circumbinary molecular disk orbiting V4046 Sgr is somewhat larger than that of TW Hya ($R \sim 350$ AU vs. $R \sim 200$ AU; Rosenfeld *et al.* 2012; Qi et al. 2013), and — in contrast to the nearly pole-on TW Hya — is viewed at intermediate inclination ($i \approx 34°$; Rosenfeld *et al.* 2012). Extended- and compact-configuration SMA observations

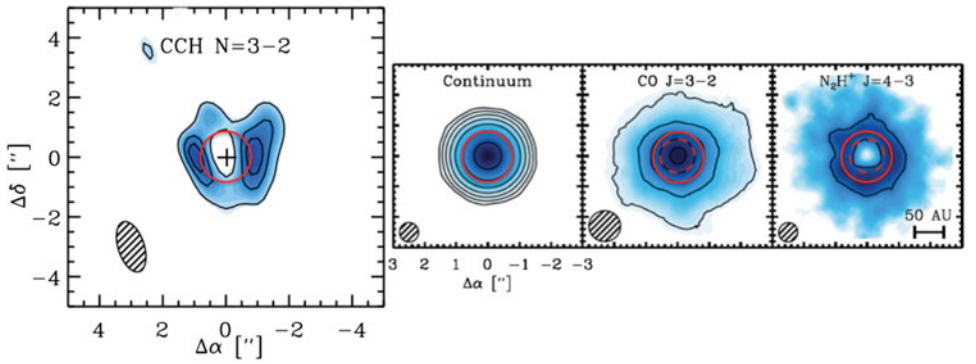

Figure 1. Interferometric imaging of the TW Hya disk. Left panel: SMA C_2H(3–2) image, from K15. Left center, right center, and right panels: ALMA 372 GHz continuum, SMA CO(3–2), and ALMA N_2H^+(4–3) images, from Qi *et al.* (2013). The red circles indicate the ∼45 AU inner radius of the C_2H ring, as determined from model fitting described in K15.

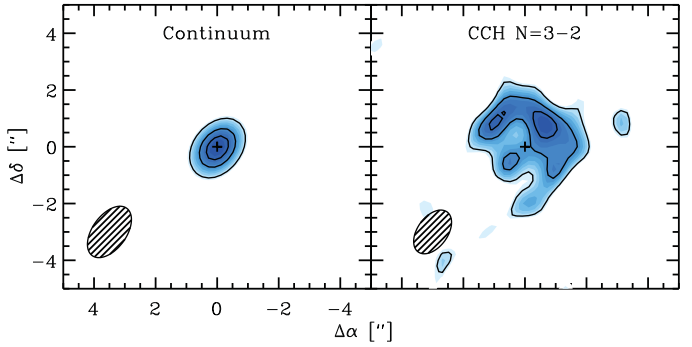

Figure 2. SMA C_2H(3–2) image of the disk orbiting V4046 Sgr (right) alongside the 260 GHz continuum image obtained from the same (extended+compact configuration) dataset (left).

of C_2H(3–2) emission from the V4046 Sgr disk were acquired in 2015 March and May, respectively; the resulting image is displayed in Fig. 2. It is evident that V4046 Sgr, like TW Hya, displays a ring-like C_2H morphology, but with a more asymmetric appearance (perhaps due to its intermediate disk inclination) and somewhat larger inner C_2H "hole" radius (∼70 AU).

3. Remarks

We (K15) have proposed that the C_2H ring in the TW Hya disk may trace particularly efficient photo-destruction of small grains and/or photodesorption and photodissociation of hydrocarbons (principally, C_2H_2) derived from grain ice mantles in the surface layers of the outer disk. Comparative modeling of the two SMA datasets will establish whether the V4046 Sgr C_2H ring is in fact larger and more asymmetric than that of TW Hya and, more generally, should shed further light on the mechanism(s) responsible for production of C_2H in evolved, protoplanetary disks.

References

Kastner, J. H., Hily-Blant, P., Rodriguez, D. R., Punzi, K., & Forveille, T. 2014, *ApJ*, 793, 55
Kastner, J. H., Qi, C., Gorti, U., *et al.* 2015, *ApJ*, in press (arXiv:1504.05980; K15)
Qi, C., Öberg, K. I., Wilner, D. J., *et al.* 2013, *Science*, 341, 630
Rosenfeld, K. A., Andrews, S. M., Wilner, D. J., & Stempels, H. C. 2012, *ApJ*, 759, 119

https://doi.org/10.1017/S1743921315005979 Published online by Cambridge University Press