RADIATIVE TRANSFER MODELING OF SVS13 BINARY DWARF PROTOPLANETARY DISKS

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ABSTRACT

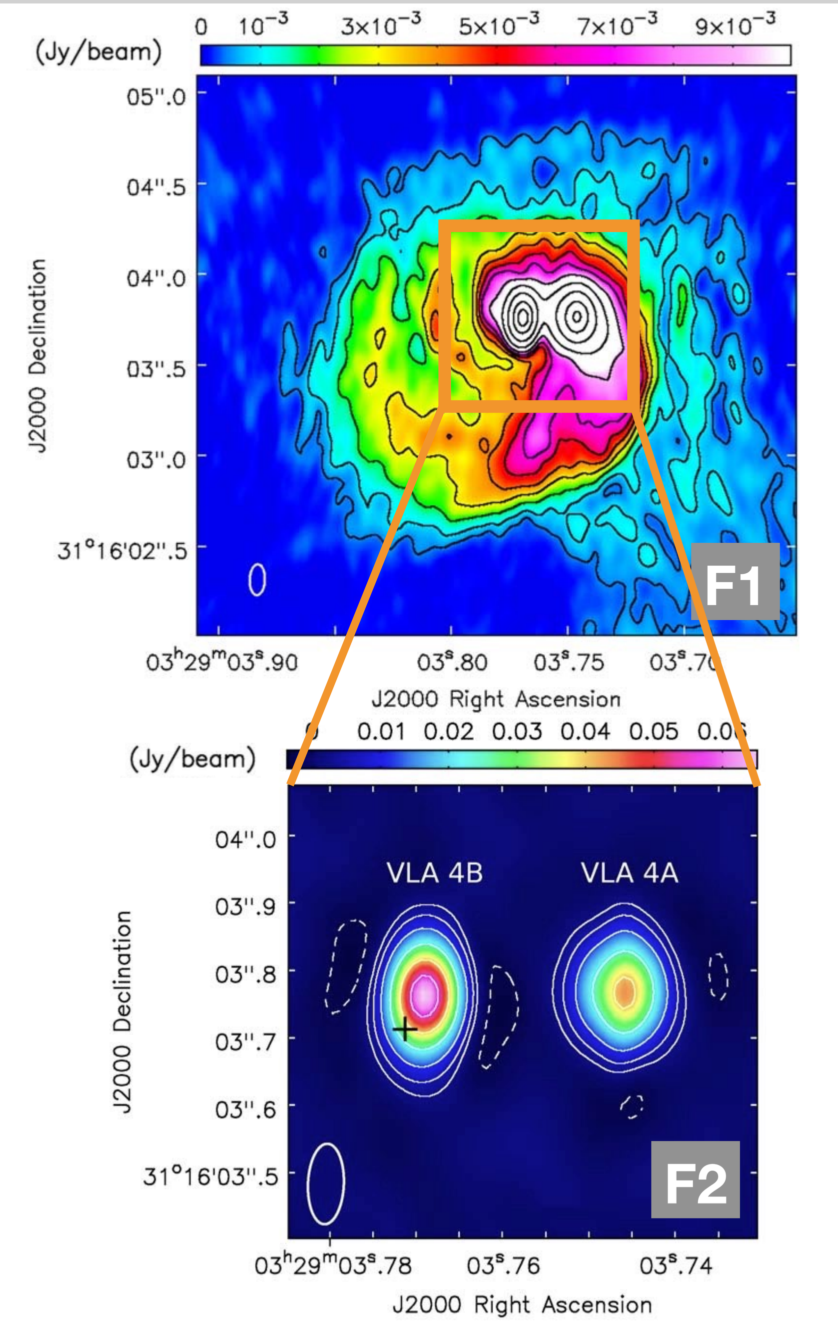
Protoplanetary disks are accretion driven structures conformed of dust and gas that can be found around young stars. A good understanding of their properties can help predict where and what type of planets will be formed, if the system is stable against collapse...

A careful modelling of dust emission using auto-consistent radiative transfer models has been performed in this work using the D'Alessio Irradiated Accretion Disks (DIAD) code, described in *D'Alessio+06*. This code takes into account stellar irradiation and heating by viscous dissipation which allows to infer the temperature as a function of disk radius and scale height in a self-consistent way, provided the stellar properties are known.

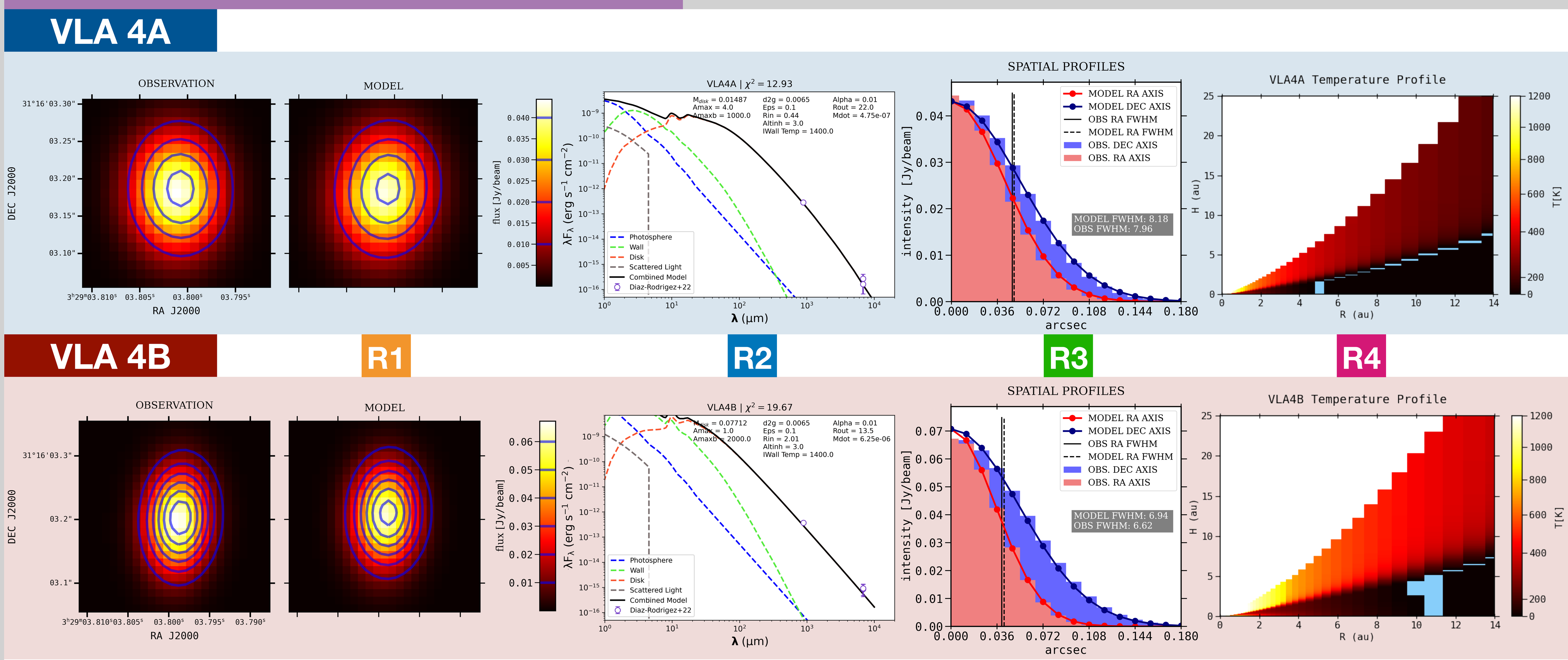
ABOUT THIS WORK

Recent VLA and ALMA observations of the close (0."3 ~90au separation) protobinary system SVS13 were presented in *Díaz-Rodríguez+22*. Observations reveal two small circumstellar disks, one associated to the radio source **VLA 4A** and another one to **VLA 4B**. Both disks are encircled by a large circumbinary disk with prominent spiral arms and appear to be in the earliest stages of star formation. Dust emission is more compact and has higher optical depth toward **VLA 4B**, while column density is lower toward **VLA 4A.**

F1 shows ALMA 0.9mm **dust continuum** emission as shown in *Díaz-Rodríguez+22*, from ALMA cycle 3 observations. Two circumstellar disks that are surrounded by a spiral circumbinary disk can be seen. F2 shows a detail of the circumstellar disks, **filtering** the **extended emission** by using only baselines $> 750k\lambda$, 0.9mm image and flux and 7mm flux will be used as constraint to the DIAD models. Work is **still in progress**, but preliminary results suggest that radiative transfer modeling is crucial to understand the complex phenomenology of systems such as SVS13.



METHOD & RESULTS



Simultaneous **SED fitting** R3 using radio wavelength data from *Table 2* of *Díaz-Rodríguez+22*, and **image fitting** R1 using data from F2 (Figure 8 from *Díaz-Rodríguez+22*) has been performed. SED fitting R2 was used to obtain a ballpark model but **spatial profile fitting** R3 and **residual** analysis fixed the values of physical parameters detailed in T1, assuming a dust to gas ratio of 0.0065.

A careful processing of the model output using `simobserve` and `tclean` that replicates most **observing conditions** p.e. antenna configuration, band, and **UV-range** has been performed. It has proven to be **critical** for an adequate spatial profile fitting.

Uncertainties have been roughly estimated using the minimal variation that modifies noticeably the goodness of fit. Although a generous exploration of parameter space has been made, all results and uncertainties correspond to the best fitting parameter set found in *this work*.

2D **temperature profiles** R4 (and density, not shown) have been derived, and the position of water snow lines (135K ~ 145K) has been marked in blue.

	VLA4A	VLA4B
$M_{dust}[M_\oplus]$ [1]	[30]	[170]
R_{disk}[AU]	22±5	14±5
i[°] [2]	32±5	41±5
$\dot{M}/\alpha[M_\odot/yr]$ [3]	[5e−5]	[6e−4]
R_{wall}[AU] [4]	0.44	2.01

T1 : SED + image fitting results. **[1]** Disk dust mass (in Earth masses) is calculated auto-consistently within DIAD code, that is why no uncertainties are provided. Also, this parameter might be **overestimated** due to the fitting+modeling process (p.e. differences between DIAD and literature opacity values, contamination with free-free emission from the circumbinary disk specially at 7.0mm and very large optical depth at 0.9mm). Mass should be treated as an indicator that optically thin calculations underestimate mass values and that a careful modelling is needed. Differences between SVS13 results from *Díaz-Rodríguez+22* and the star mass vs. disk mass relationship from Fig. 6 of *Pascucci+16* may arise from the autoconsistent opacities that DIAD derives and the non-isothermal model (as shown in R4). **[2]** i is calculated assuming a PA of 0° for **VLA 4A** and 60° for **VLA 4B**. This has been determined by comparing the model spatial profiles to the partially resolved ones from Figure 8, *Díaz-Rodríguez+22*. **[3]** Only the quotient between mass accretion $\dot{M}$ and disk viscosity α (stress-pressure parameter) can be derived due to a degeneracy in the model. Mass accretion $\dot{M}$ is thought not be well characterised with the present analysis as detailed in [1]. **[4]** The radius of the sublimation wall is the position where the disk's temperature equals the wall sublimation temperature (1400K). This parameter is determined by DIAD models.

CONCLUSION

Mass of the disks has been found to be significantly **higher** than the upper limit presented in Díaz-Rodríguez+22 (11% higher for **VLA 4A** and >100% higher for **VLA 4B**). This might indicate that the mass of the disks may have been sub-estimated by assuming an isothermal and optically thin model at 0.9mm. Parameters such as mass and accretion rate that are derived almost directly from 0.9mm ($> 750k\lambda$) image fitting can suffer from different effects that result in a noticeable **overestimation**. These results undoubtedly suggest that **detailed radiative-transfer modeling is key** to **understand** physical properties of complex such as SVS13.

REFERENCES

- A. K. Díaz-Rodríguez et al 2022 ApJ 930 91
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- I. Pascucci et al 2016 ApJ 831 125

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