

**2D/3D CONTINUUM MODELING OF PROTO-PLANETARY DISKS OBSERVED IN THE C2D SPITZER LEGACY PROGRAM.** K. M. Pontoppidan, *Leiden Observatory, P.O. Box 9513, NL-2300 RA Leiden; Caltech, GPS, MS 150-21, CA 91125, Pasadena*, C. P. Dullemond, *MPIA Heidelberg, Königstuhl 17, 69117 Heidelberg, Germany*, G. A. Blake, *Caltech, GPS, MS 150-21, CA 91125, Pasadena*, E. F. van Dishoeck, *Leiden Observatory, P.O. Box 9513, NL-2300 RA Leiden*, N. J. Evans II, *Department of Astronomy, University of Texas at Austin, 1 University Station, C1400, Austin, TX 78712-0259*, c2d team, *Multiple affiliations*.

We present results obtained from axisymmetric 3D continuum radiative transfer models of young stars with circumstellar disks that are present in the Cores to Disks (c2d) Spitzer Legacy IRS sample (Evans et al. 2003, *PASP*, 115, 965). The models focus on a small sample of proto-planetary disks for which a wide range of observational constraints is available in addition to Spitzer imaging and spectroscopy. By fitting multi-dimensional models to all available data, we show that unique information can be extracted that applies to the entire class of proto-planetary disks. Various questions are currently being addressed (see also presentation by C. P. Dullemond): What is the nature of “embedded disks” and can we study the physical structure of a disk even when it is surrounded by a massive envelope? What is the vertical structure of disks, i.e. does the flaring/non-flaring properties of proto-planetary disks conform with those expected from theoretical considerations? What are the grain properties in disks? Can we constrain processes such as grain growth and settling in specific disks; are dust grains in disks covered by ice mantles and why are some disks dominated by emission from Polycyclic Aromatic Hydrocarbons (PAHs) and other types of Very Small Grains (VSGs)?

We have constructed an axisymmetric model setup based on the Monte Carlo continuum radiative transfer code RADMC (Dullemond & Dominik 2004, *A&A*, 417, 159). The setup can model almost any axisymmetric geometry and now includes a treatment of quantum heating of small grains appropriate to both diffuse nebulosity (low radiation field, single-photon excitation) as well as disks (high radiation field, multiple-photon excitation). This model was used to investigate the bright edge-on disk CRBR 2422.8-2422 for the presence of ice-coated grains in the disk (Pontoppidan et al. 2005, *ApJ*, 622, 463). The setup has also been used to study a number of “disk shadow” sources (Pontoppidan & Dullemond 2005, *A&A*, 435, 595). These are embedded disks that cast a shadow on their surrounding envelope in light from the central star or inner parts of the disk (see also Hodapp et al. 2004, *ApJ*, 601,79; Kurosawa et al. 2004, *MNRAS*, 351, 1134; Semenov et al. 2005, *ApJ*, 621, 853). The most common disk shadows appear in near-infrared scattered light nebulae, but also examples of shadows in various types of exciting radiation such as UV photons are emerging. The morphology of the shadow can form the basis of a detailed study of both the disk structure and the envelope structure. For instance, the opening angle of the disk can be directly constrained, as well as the presence of any inner cavities in the envelope, even if the disk itself is spatially unresolved.

A new candidate in the class of disk shadows is the UX Orionis star VV Ser. This H AeBe star was revealed by Spitzer IRAC and MIPS imaging to be surrounded by a compact neb-

ulosity peaking at  $100 \mu\text{m}$ . Using the model, we show that the nebulosity can be explained by quantum heating of PAHs and VSGs in the surrounding cloud. Additionally, the model constrains the abundance of PAHs in the surrounding nebula to  $3 \pm 1\%$  relative to the total dust mass (Pontoppidan et al., in prep). Imprinted on the nebulosity is a probable disk shadow, which is consistent with the classification of VV Ser as a UX Orionis star since it is expected that disks in such systems are highly inclined.

We also present new Spitzer spectroscopy of the edge-on disk “The Flying Saucer” (Grosso et al. 2003, *ApJ*, 586, 296), and show that the  $5\text{--}40 \mu\text{m}$  spectrum provides a strong indication of the presence of large ( $>1 \mu\text{m}$ ) grains in the disk. Other results using the model setup are presented in posters by Lahuis et al. and Geers et al.

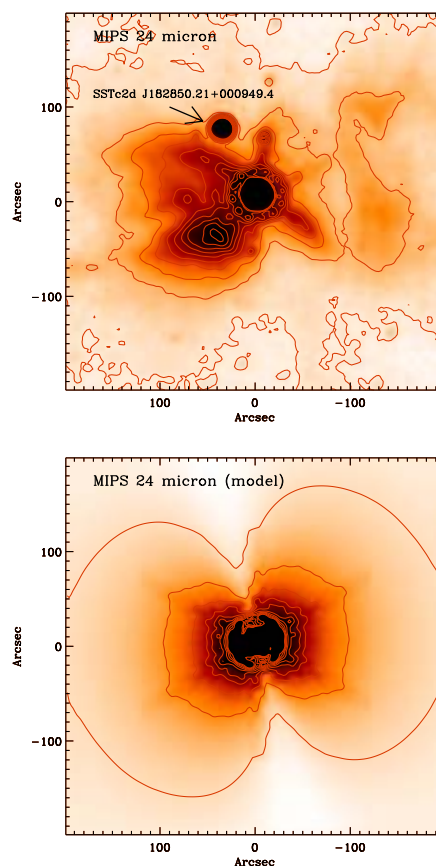


Figure 1: Spitzer-MIPS  $24 \mu\text{m}$  image of VV Ser (top) compared to a radiative transfer model using quantum heated grains (bottom).