

# vis-r | fast ALMA radial profile modelling

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## Abstract

vis-r is a method for modelling radial profiles of interferometric observations of asymmetric structures. It uses the Discrete Hankel Transform (DHT) to directly model visibilities. Posterior distributions for parameterised models of high resolution observations, such as those from the ALMA ARKS Large Programme, can be obtained in minutes on a laptop.

## Problem

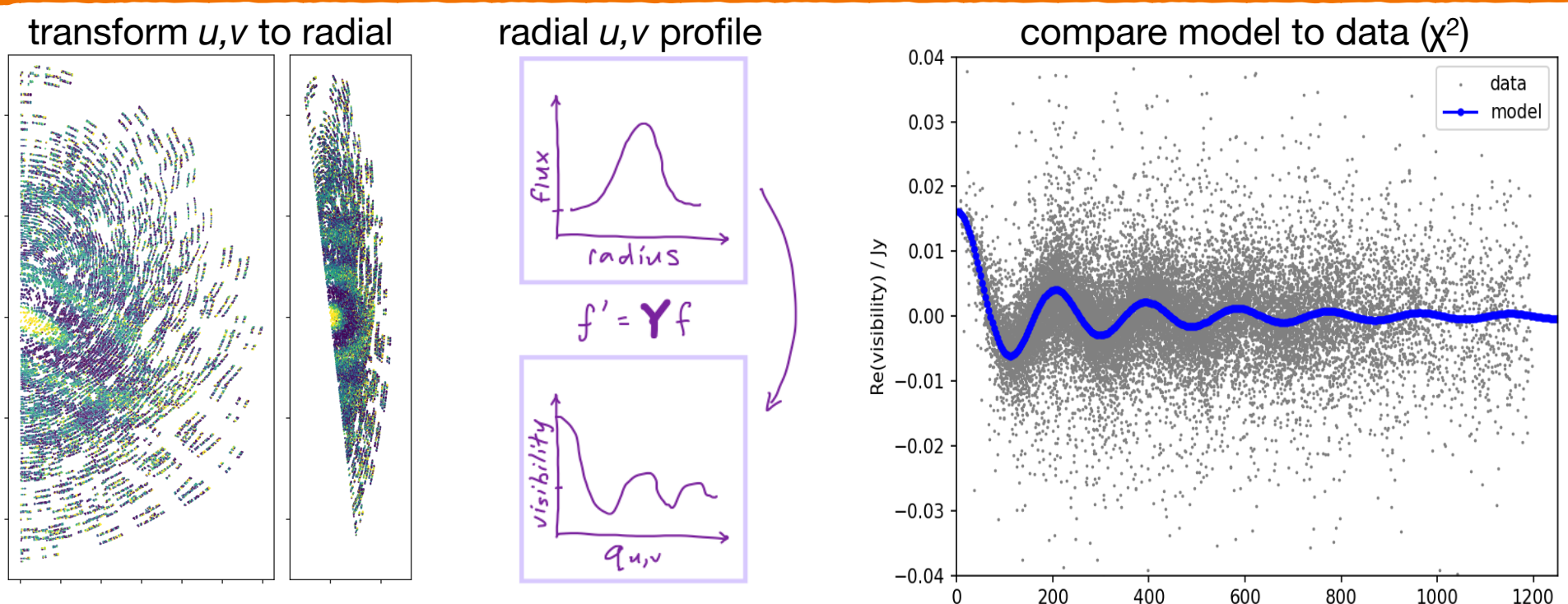
ALMA observations are typically modelled with images, and high resolution ALMA observations require very large images (e.g. 8k x 8k). MCMC sampling to derive posteriors for parameterised models has therefore become very expensive, taking many hours on multi-core servers.

## Ground truths and their implications

- Most debris disks are axisymmetric, or can be modelled as such with a sky offset.
  - ▶ It will be possible to model them in  $u,v$  space with the Hankel Transform.
- Some disks are vertically resolved, but their radial dependence is not well constrained.
  - ▶ It should be sufficient to include vertical structure in a simplified form.
- ALMA data can be binned in  $u,v$  space, which can reduce volumes by 10-100x.
  - ▶ If image generation is no longer the bottleneck, averaging may enable fast computation.

## Solution

vis-r uses the DHT (a matrix multiplication, see Jennings+) to convert a parameterised radial profile to modelled visibilities. Vertical structure, a fixed absolute scale height, is added with a convolution. For modelling the visibility data are first binned in  $u,v$  space, so there are only tens of thousands of points to model. A single model realisation is therefore fast to compute (~1ms).



**Fig 1:** Steps for given set of parameters. Observed  $u,v$  coordinates are transformed given inclination and position angle. Radial profile is computed and converted to visibilities with DHT. Model is interpolated at observed  $u,v$  coordinates and  $\chi^2$  computed. Repeated as necessary for minimisation and/or sampling.

## Outcomes

vis-r models axisymmetric disks, including vertical structure, with results equivalent to image-based modelling, and with  $u,v$  binning can be used to fit ALMA datasets on a laptop in minutes. It can be dropped into extant codes with i) a  $u,v$  binning step, and ii) a new likelihood function.

## References

Jennings et al. 2020 (FRANK), GitHub: <https://github.com/drgmk/vis-r>

## Acknowledgements

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