Reverberation Mapping of Unified Models of Active Galactic Nuclei

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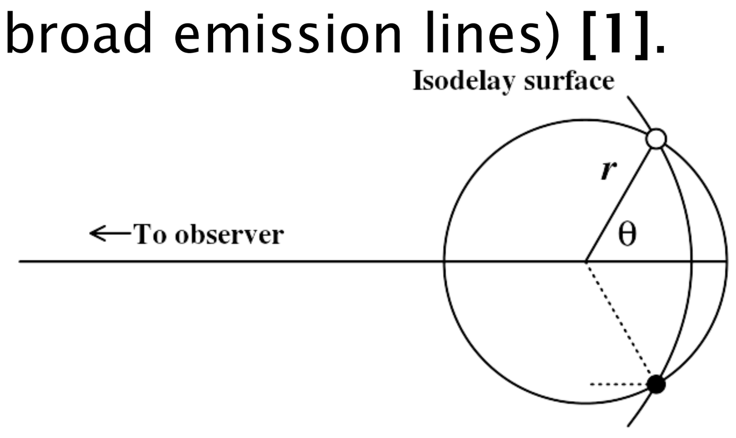
QUARTZ

Introduction

Many of the spectral features of AGN are believed to be generated by reprocessing of continuum radiation produced by the AGN central engine. The reprocessing regions are believed to include disk winds. As the continuum luminosity varies, it is seen by the reprocessing regions with a time-delay that is proportional to their distance from the centre of the AGN (light-days to weeks for broad emission lines) **[1]**.

The delayed response of reprocessed features such as line emission can therefore be used as a probe of the reprocessing region **[2]**.



When combined with the Doppler shifting of line photons from outflowing or orbiting plasma, a transfer function linking a change in continuum luminosity at time *t* to changes in line luminosity at *t'* can be derived.

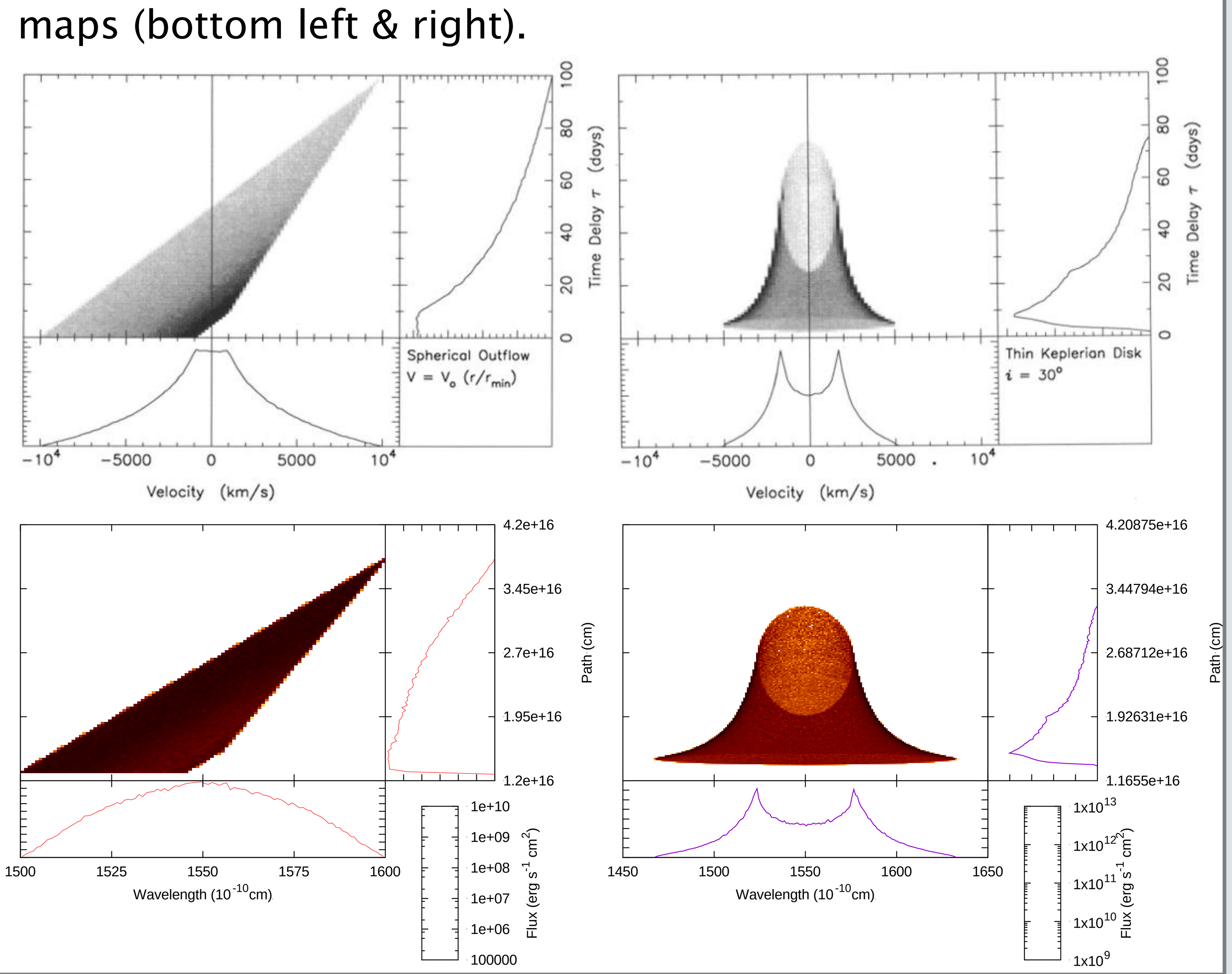
$$L_{line}(t') \propto L(t, v)$$

Transfer functions are highly degenerate, and it is challenging to analytically derive them from observational data. However, forward modelling can be used to generate plots of the expected transfer function for any adopted geometry.

As part of the QUARTZ (**QUA**zar **R**adiative **T**ransfer and ioni**Z**ation) Project, we aim to produce transfer functions for realistic geometries, including rotating biconical disk winds. The method is intended to be generalised, and eventually applicable to radiation-hydro coupled simulations.

Velocity-Resolved Delay Maps

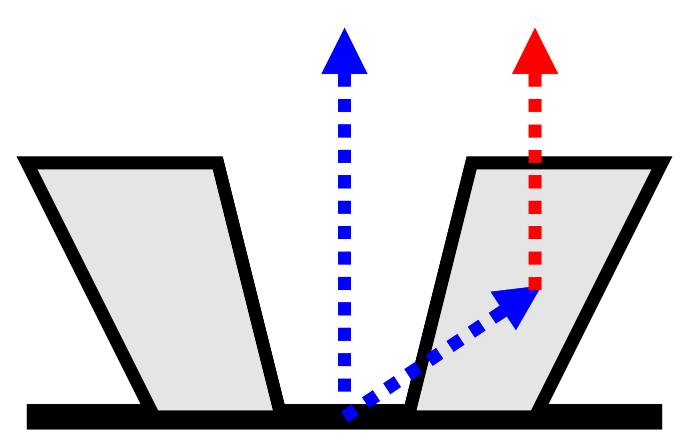
Welsh & Horne **[4]** simulated the expected transfer function delay maps for a range of simple regions, including spherical outflow (top left) and a thin disk rotating with purely Keplerian velocity (top right). The code can reproduce similar maps (bottom left & right).



Methodology

The project has involved a pre-existing self-consistent monte carlo radiative transfer and ionization code for disk winds **[3]**.

It has been modified to track photon paths through the simulation domain. Wind emission takes into account the distribution of paths experienced by each cell of the wind, as the local ionisation state will be proportional to the central engine luminosity at a given delay. Total path length to the observer is then calculated and compared to that experienced by an un-scattered photon.

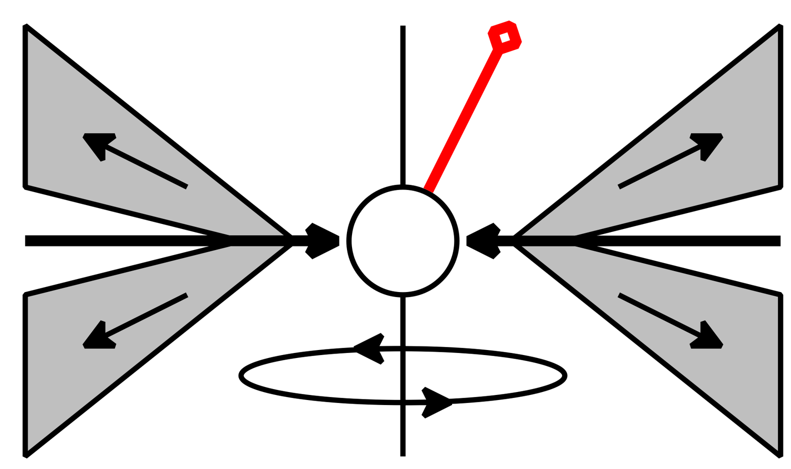


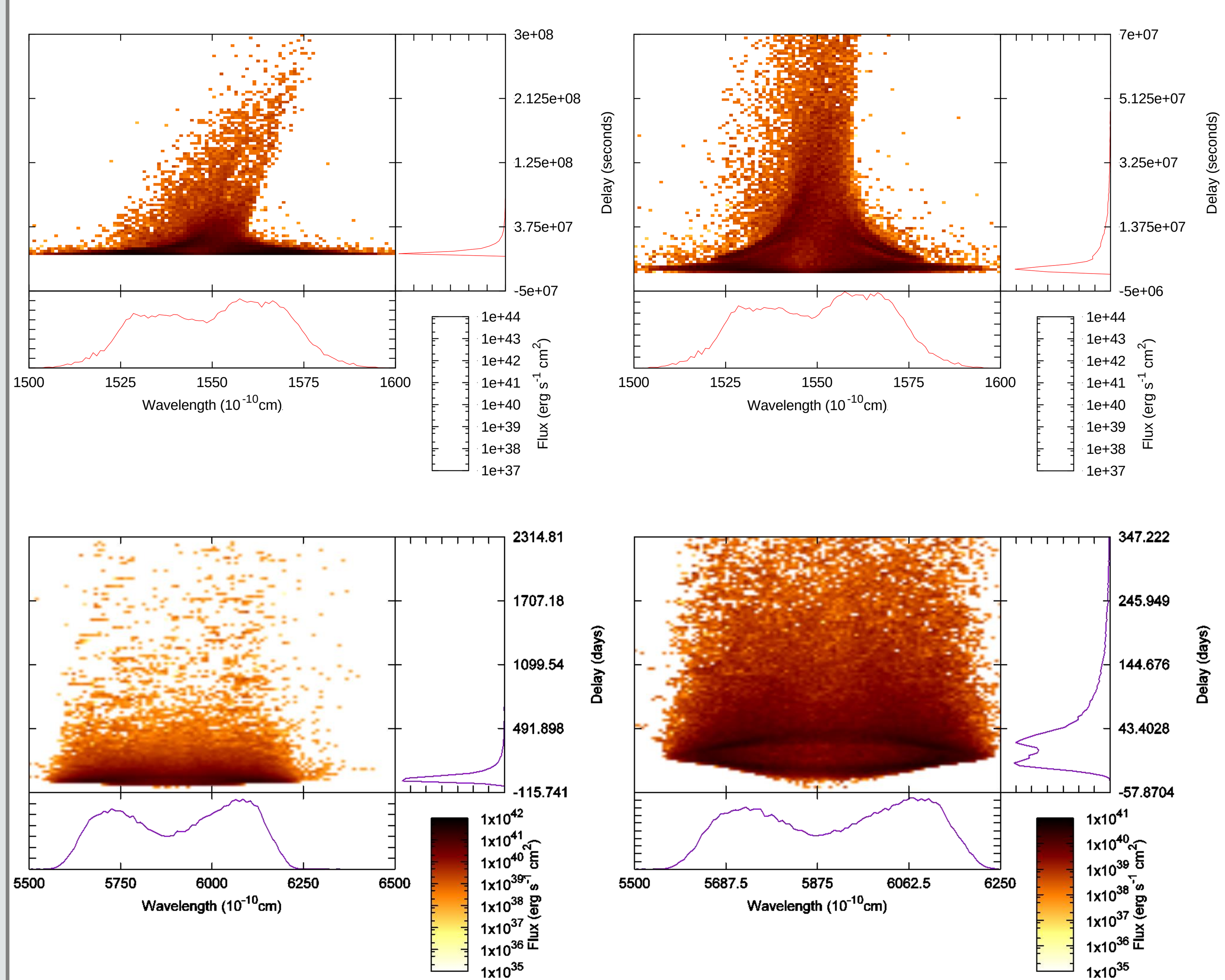
Biconical Wind Models

Transfer function have been produced for a range of rotating equatorial disk wind models from Matthews et al **[5]**.

Featured are plots for two disk geometries viewed from above the disk plane at two scales. Similarities to the transfer function plots of Keplerian disks & spherical outflows are clearly visible.

A cartoon of the wind geometries is shown to the right, with a typical sightline above the disk looking down on the winds represented in red.





[1] B. Peterson & A. Wandel, 1999, *The Astrophysical Journal Letters,* **[2]** B. Peterson & K. Horne, 2004, *Astronomische Nachrichten,* **[3]** K. Long & C. Knigge, 2002, *The Astrophysical Journal,* **[4]** W. Welsh & K. Horne, 1991, *The Astrophysical Journal,* **[5]** J. Matthews, 2015, *MNRAS*, **[Background]** M. Kornmesser, 2002, *Online - ESO*.

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