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# Planetary Cradles

From Disks to Planets
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## This poster in four sentences (for the lazy)

The aim of this project is to simulate a protoplanetary disk, in the future also taking the presence of planets into account. I will initially be using a set of one-dimensional models including radiative transfer and hydrodynamics (presently hydrostatic) to study the vertical structure of the disk. It will also in the future include detailed microphysics, all in order to obtain testable observables indicating the presence of planets in the disk. The work is currently in its early stages.

## Present modelling status

The present model assumes the disk to be divided into a central, vertically thick "core" and an outer layer that is optically thin. The code is adopted from the dynamic code used by Höfner et al. The structure is one-dimensional with variables depending on the distance from the mid-plane. The modelling is currently done using the static version of the hydodynamical equations and uses grey radiative transfer. Dust is included in the Rosseland mean opacities (Semenov et al). The coupled equations look like this:

$$\frac{dP}{dz} = \frac{GM_{star}}{R^3_{rad}}z + \frac{4\pi}{c}\cdot\kappa\rho H$$

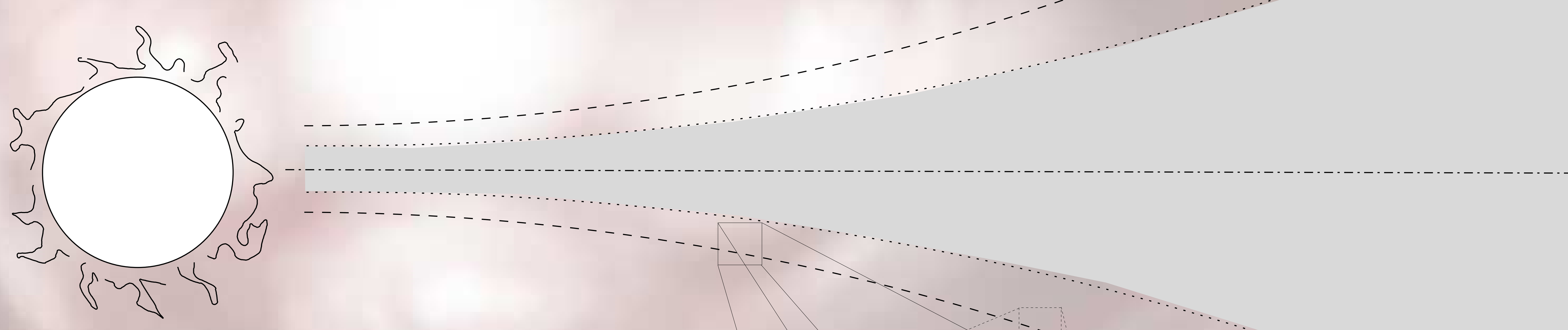
$$\frac{dT}{dz} = \frac{-\pi\rho H}{4\sigma f_{edd}T^3} - \frac{1}{4f_{edd}}\left(\nabla f_{edd} + (3f_{edd}-1)/z\right)T$$

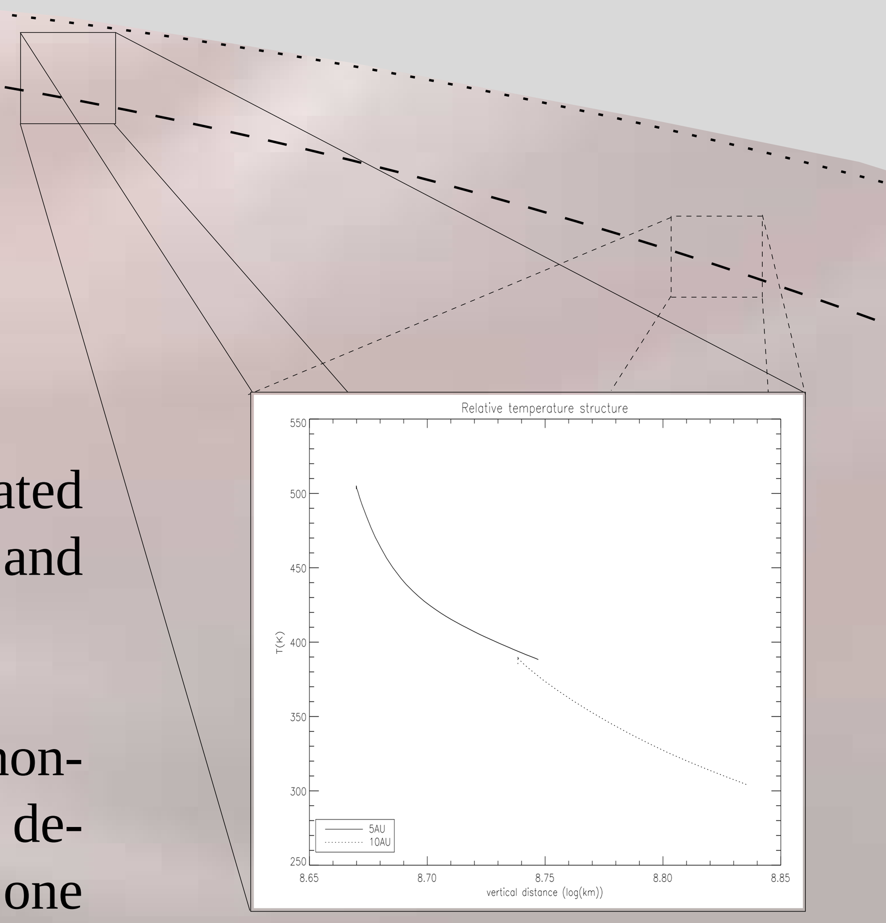
where standard nomenclature is used for pressure, temperature and the first moment of the radiation field $H$. The mass equation does not come into play since we are not including self-gravity. The system is closed using the Eddington factor $f_{edd} = K/J$ and the flux resulting from the solution of the radiative transfer.

The main heating sources in the disk are irradiation by the central star and visous dissipation in the disk plane. Approximate vertical temperature and density structures are calculated over a fixed geometrical depth with temperatures "guessed" at both ends, iterating with varying $f_{edd}$ until convergence is achieved.

This structure is used as a starting point for the next step, where one boundary condition is the temperature at a large optical depth in the disk (this surface is assumed to radiate like a blackbody).

The final structure is thus adjusted, iterating for a consistent total energy flux throughout the structure.





(Example of vertical temperature structures)

## Future goals

The ultimate goal of the project is to obtain observables (simulated spectra) related to the effects of planets forming inside the disk and to test them observationally,

Towards this goal, the modelling will necessarily evolve to use non-grey radiation transport coupled with hydrodynamics. Also, detailed microphysics of the radiation transfer will be included. At one point, the modelling will likely have to move to a two-dimensional description instead of the set of one-dimensional structures used in the first stage described here.

As for modelling the planets themselves, a connection will in the future be made between this work and the three-dimensional planetary formation models used by Wladimir Lyra **(see his poster here at this conference!)**.

## References

Höfner, S., Gautschy-Loidl, R., Aringer, B., and Jørgensen, U. G.: 2003, *aap* **399**, 589

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