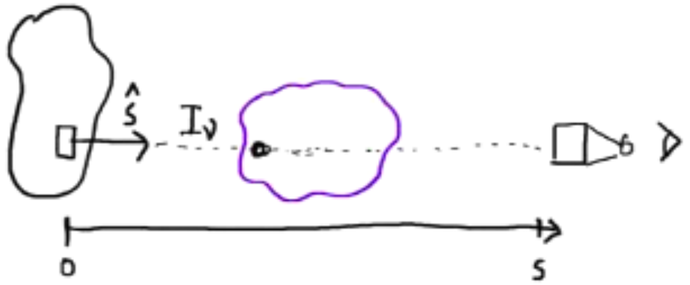
Emulating CO Line Radiative Transfer with Deep Learning

- **What is Radiative Transfer Equation?** RTE governs the radiation propagation through a medium along line of sight.

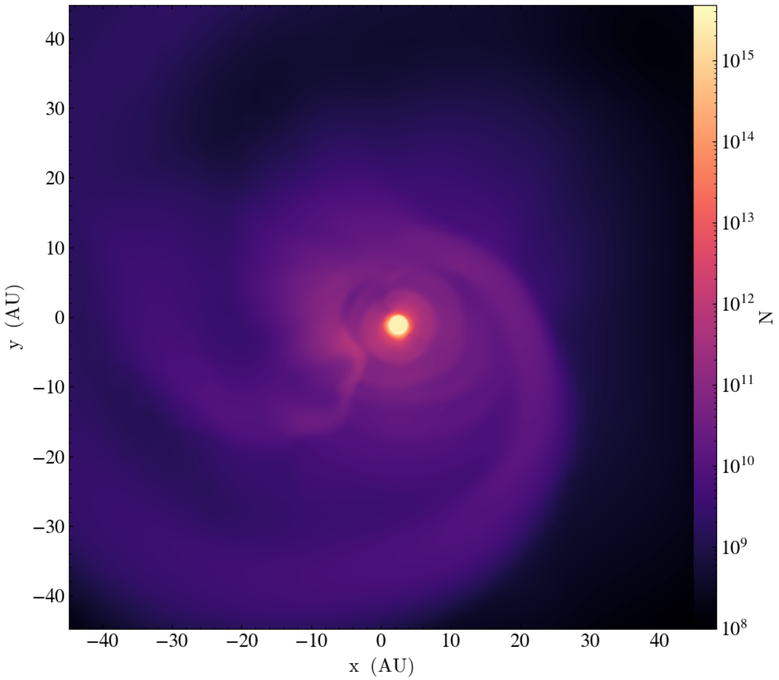
Emissivity Absorption

$$\hat{\boldsymbol{n}} \cdot \nabla I_\nu(\boldsymbol{x}, \hat{\boldsymbol{n}}) = \eta_\nu(\boldsymbol{x}) - \chi_\nu(\boldsymbol{x}) I_\nu(\boldsymbol{x}, \hat{\boldsymbol{n}})$$

Change of intensity



Intensity [W m^{-2} sr^{-1} HZ^{-1}]



- **What is the bottleneck?** Fitting models to observations requires repeated RTE computations—CPU-bound and slow across large parameter spaces.

- **What is the solution?** COEmuNet - deep learning surrogate models for fast, accurate simulation.

COEmuNet Achievements

- **High accuracy**:

  7% relative error

- **Massive speed up**:

  1000x speed up on GPU

- **Implication**:

  Enables integration into real-time observational pipelines.

- **Future plan**:

  Physics-informed ML to improve model generalizability