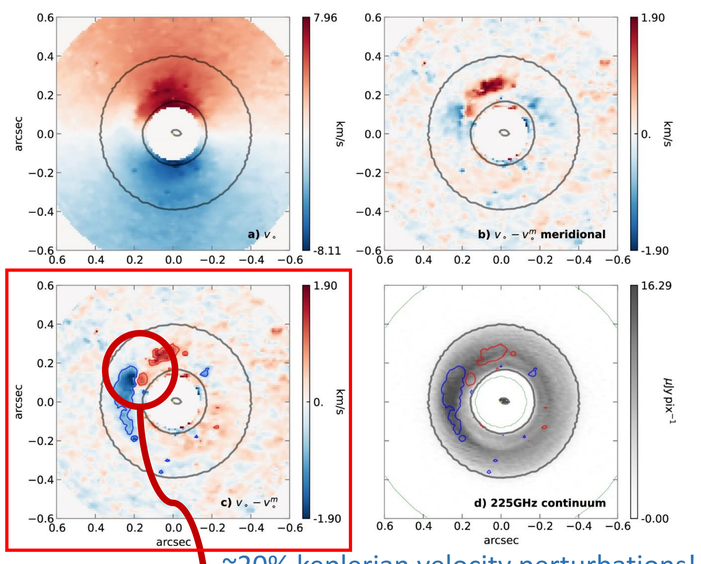
Accretion finds a way through: CPD polar winds shift **accretion flows to the equator** and generate **Doppler Flips**

Circumplanetary Winds:

*A **hydrodynamical** study of **planet formation during planetesimal accretion***

Background

ALMA observations show the so-called "Doppler-Flip" (D-F), which corresponds to a local perturbation in the disk velocity map. The most notorious case that shows this effect is HD100546 and motivates this project. Through three-dimensional hydrodynamics simulations, ***we are investigating winds launched by an embedded protoplanet in the disk, their dynamical consequences for the planet, and its observational signatures****.*



~20% keplerian velocity perturbations!

Doppler-Flip found in Casassus 2022

Method

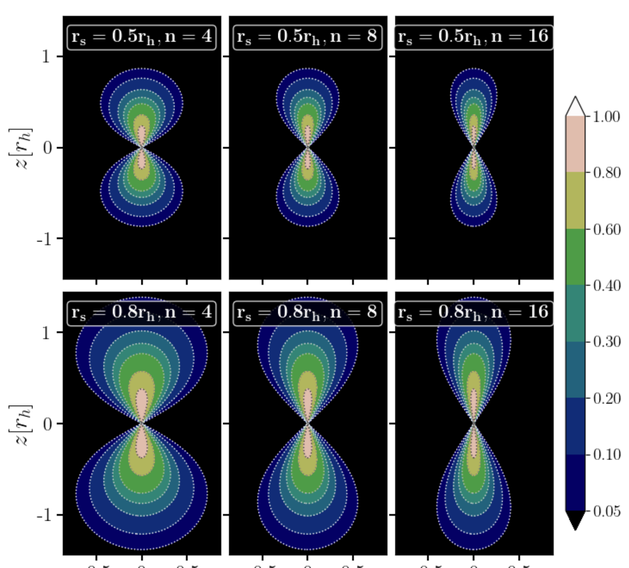
We define a standard disk-planet model, but define the outflow in the planet's position:

$$\vec{\mathbf{\Gamma}}(r', \theta') = \underbrace{\Gamma_0 e^{-r'^2/r_s^2}}_{\text{Strength factor}} \underbrace{\cos^n \theta'}_{\text{Bipolar component}} \hat{r}'$$

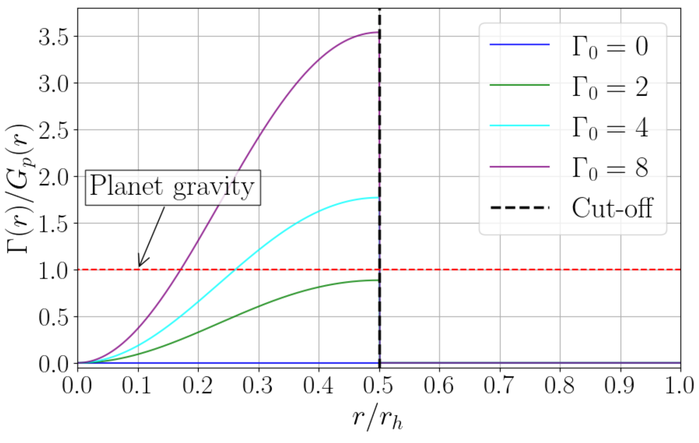
Which we include in the Navier-Stokes equations in FARGO3D

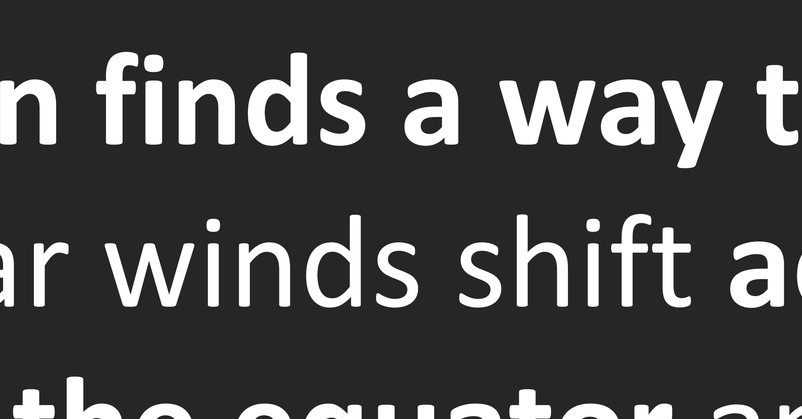
$$\partial_t \mathbf{v} + \mathbf{v} \cdot \nabla \mathbf{v} = -\frac{\nabla P}{\rho} - \nabla \mathbf{\Psi} - \mathbf{\Gamma}$$

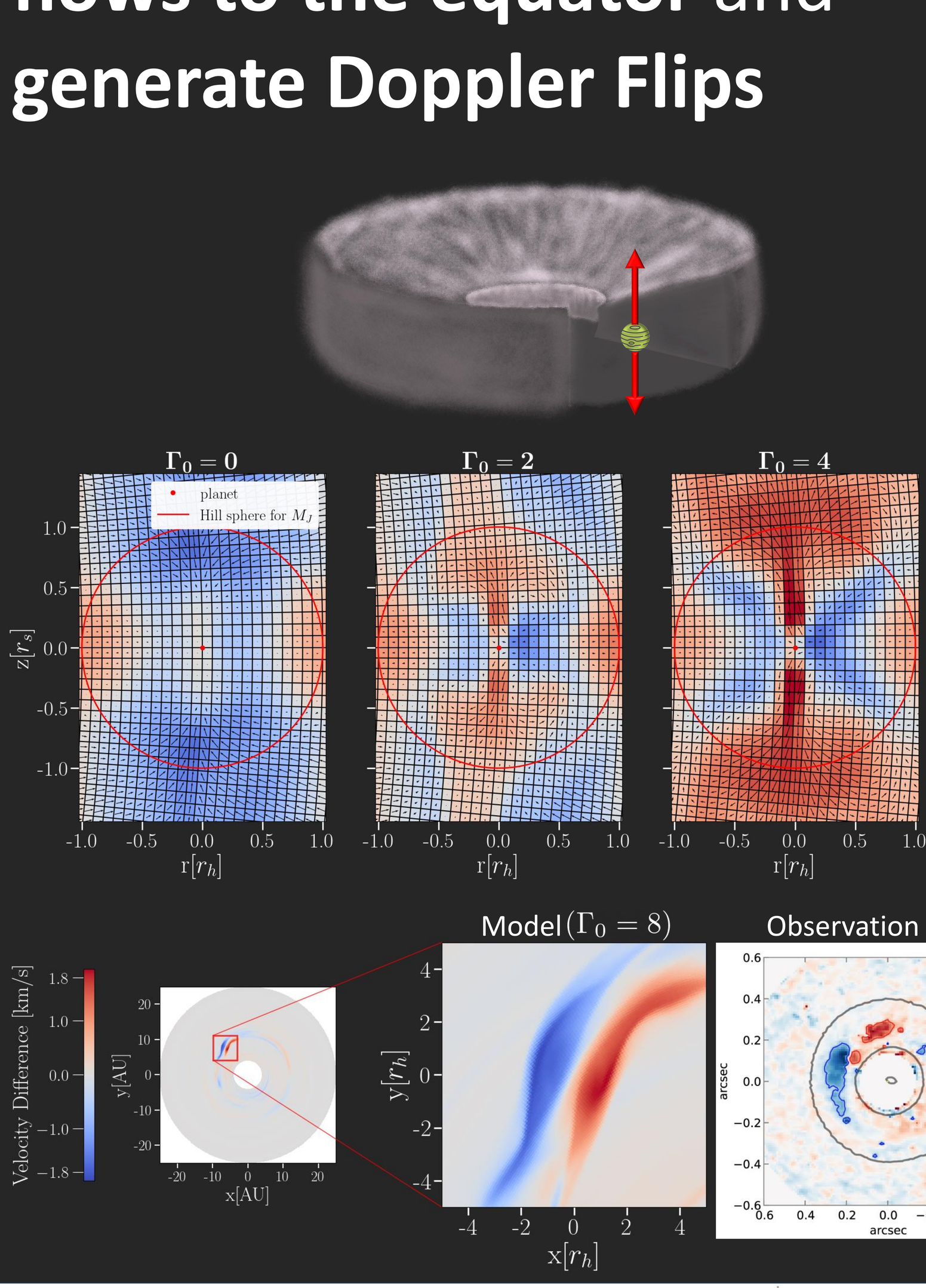
this gives the following bipolar outflow



To introduce winds that have meaningful physical values, we compare $\Gamma(r)$ to the gravitational pull of the planet $G_p(r)$ for different Γ_0 values. We also introduce a cut-off in the wind equation at $r' = r_h/2$, so that the wind effects are transmitted through the ram pressure. The following figure illustrates this effect.







Take-home messages

- **CPD winds alter accretion pathways:** *Circumplanetary winds significantly perturb local velocity maps, shifting accretion vectors from the poles towards regions closer to the equator.*
- **CPD winds influence disk's structure:** *Beyond the local effects, winds can affect the surface density profile of the disk.*
- **CPD winds could indeed be a way to produce Doppler-Flips:** *Our models show perturbations similar to those seen in D-Fs, but whether they are observable remains to be confirmed.*

ToDo list

- **Include accretion** into the simulations and **measure the effect of winds on planet accretion.** Do planets grow differently?
- **Perform Radiative Transfer calculations on the CO 2-1 line** for the disk model to **assess if the Doopler Flip produced by the wind would be detectable.**

Scan the code below to get more details about this project

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