PAVING THE WAY FOR MODELING

~~On~~ the observational appearance of eccentric protostellar discs

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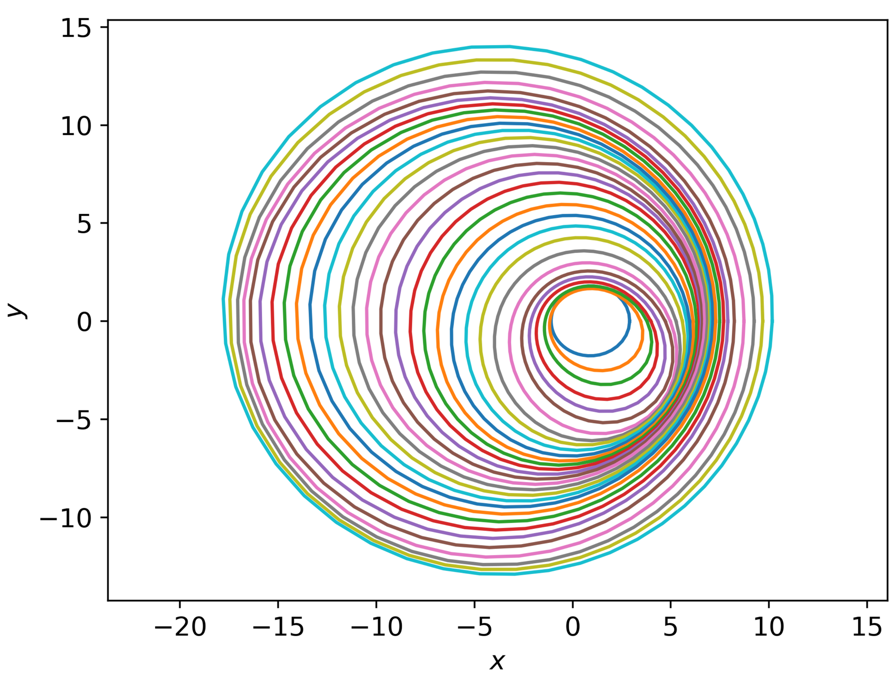
WHY ECCENTRIC DISCS?

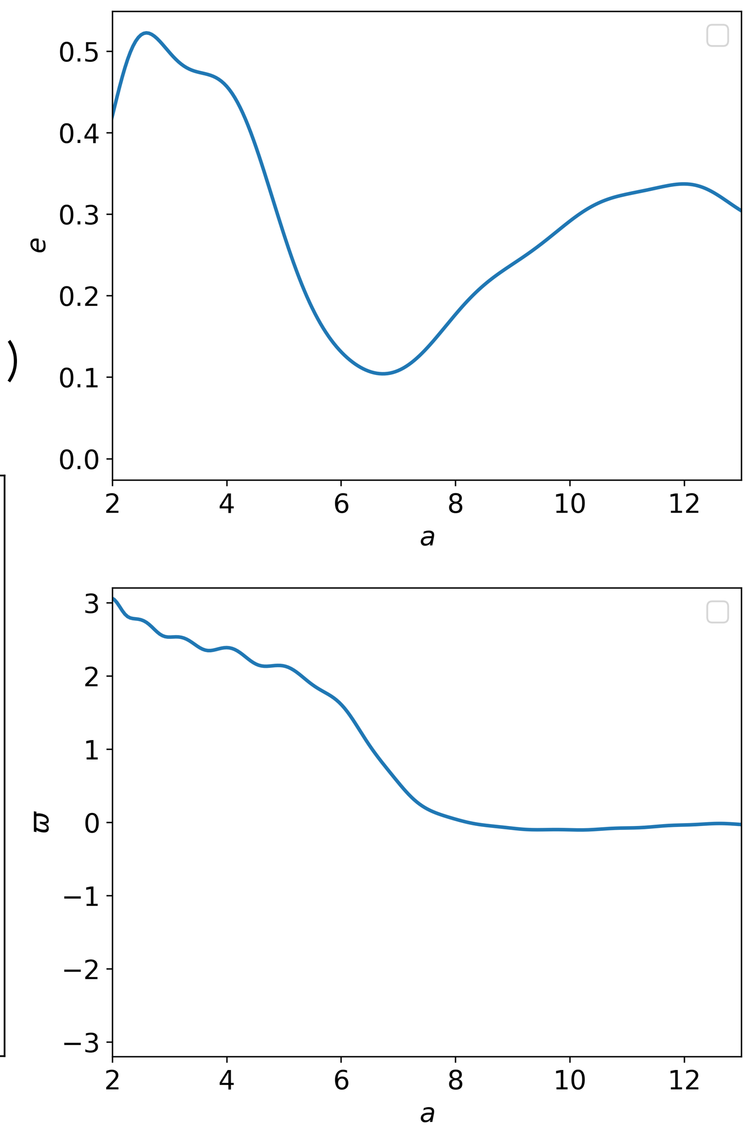
- Numerous possible causes for eccentric discs:
  - Binaries and planets (e.g. Ragusa et al. 2020)
  - Flybys (e.g. Cuello et al. 2020)
  - Non-spherical collapse
- Interest beyond protostellar discs:
  - Eccentric debris discs (Olofsson et al. 2019)
  - Discs around white dwarfs (e.g. Manser et al. 2014)
  - Tidal disruption events (e.g. Bonnerot et al. 2016)
  - X-ray binaries (e.g. Lubow 1991)
- Key to understand dissipation in accretion discs:
  - Turbulence /= viscosity
  - Why discs are so damn circular then?!

HOW TO MODEL THEM? ECCENTRIC KEPLERIAN DISCS

- Set of multiple Keplerian nested ellipses
  - For fixed semi-major axis:
    - $e(a)$
    - $\varpi(a)$
- Most used formalism (e.g. Ogilvie 2001)

$$E(a) = e(a)e^{i\varpi}$$





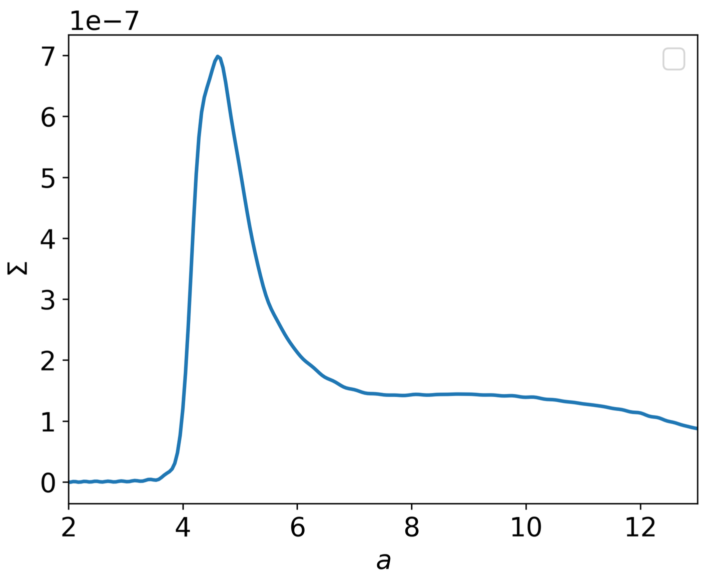
PRESSURE EFFECTS

The negative pressure gradient makes the disc sub-keplerian. We find that a reasonable approximation is:

$$v_{\phi,\mathrm{press}} = v_{\mathrm{k},\phi} + \delta v_{\phi,\mathrm{P}}$$

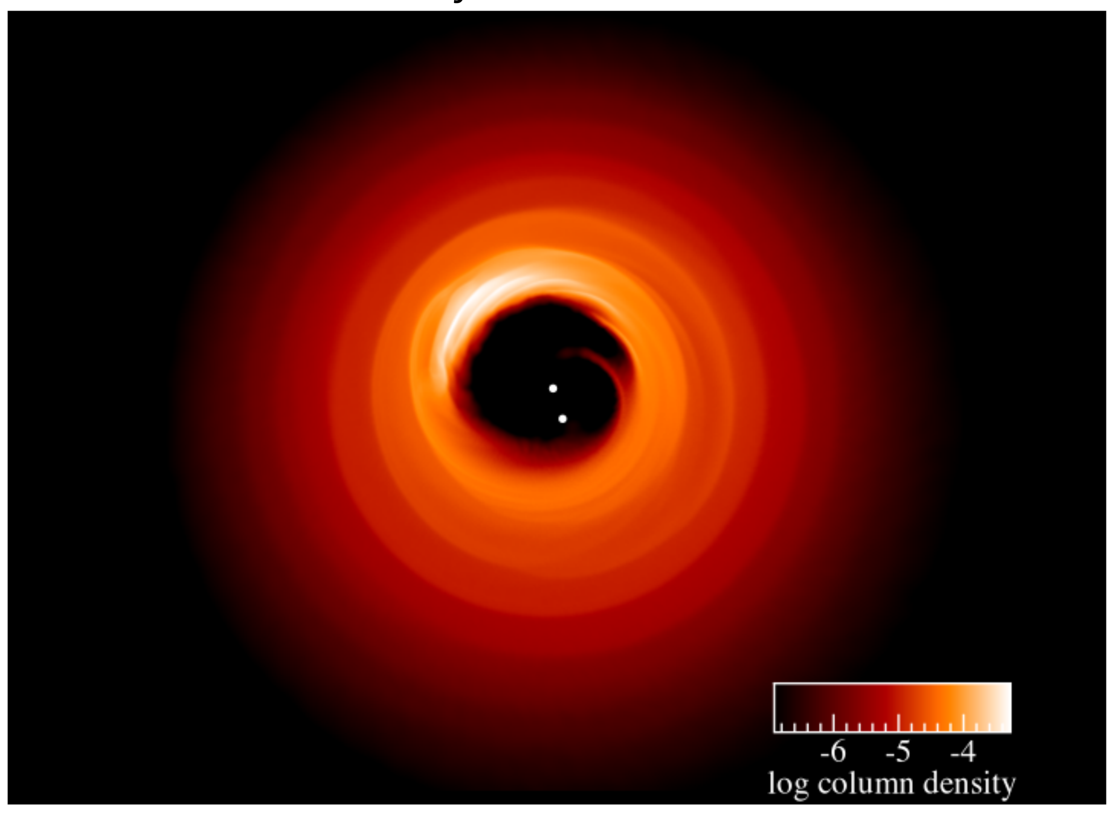
$$\delta v_{\phi,\mathrm{P}} = -\frac{a}{\Sigma}\frac{\mathrm{dP}}{\mathrm{da}}$$

$$P = c_s^2\Sigma$$



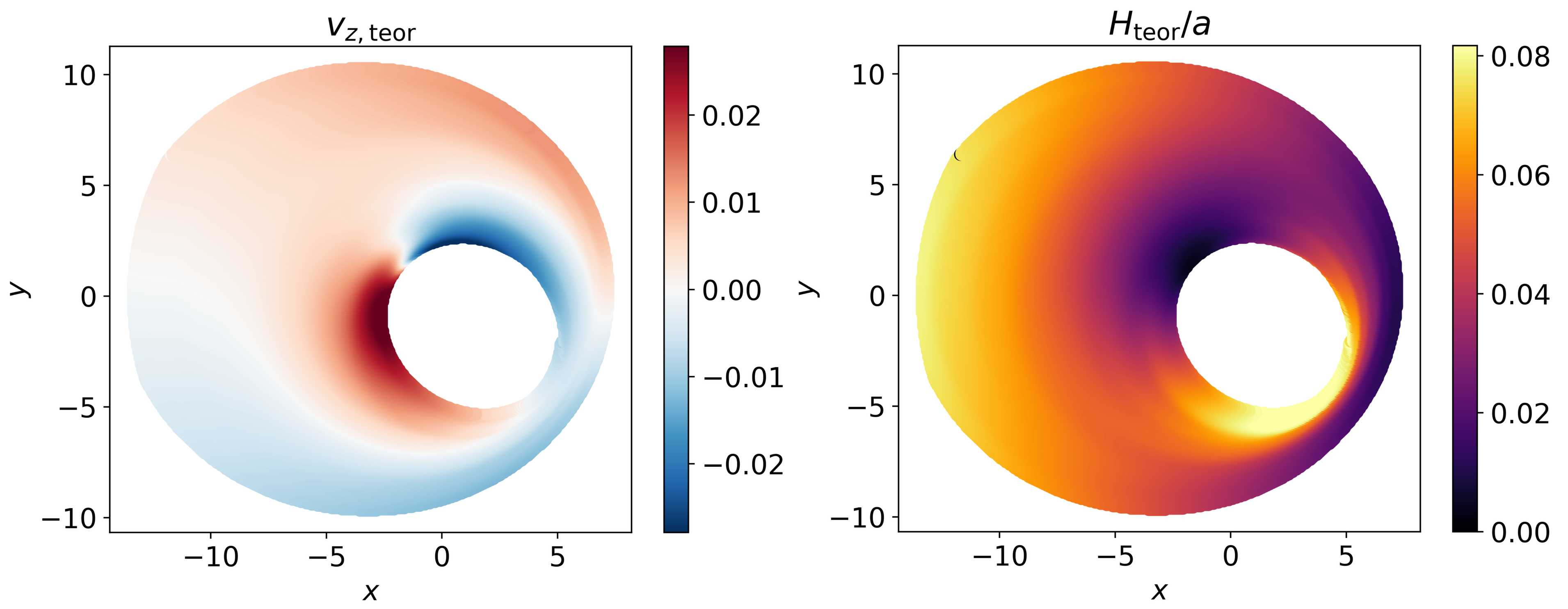
PROOF OF PERFORMANCE

We compare the dynamics of a 3D SPH numerical simulation (PHANTOM, Price et al. 2018) of an eccentric circumbinary with the model.



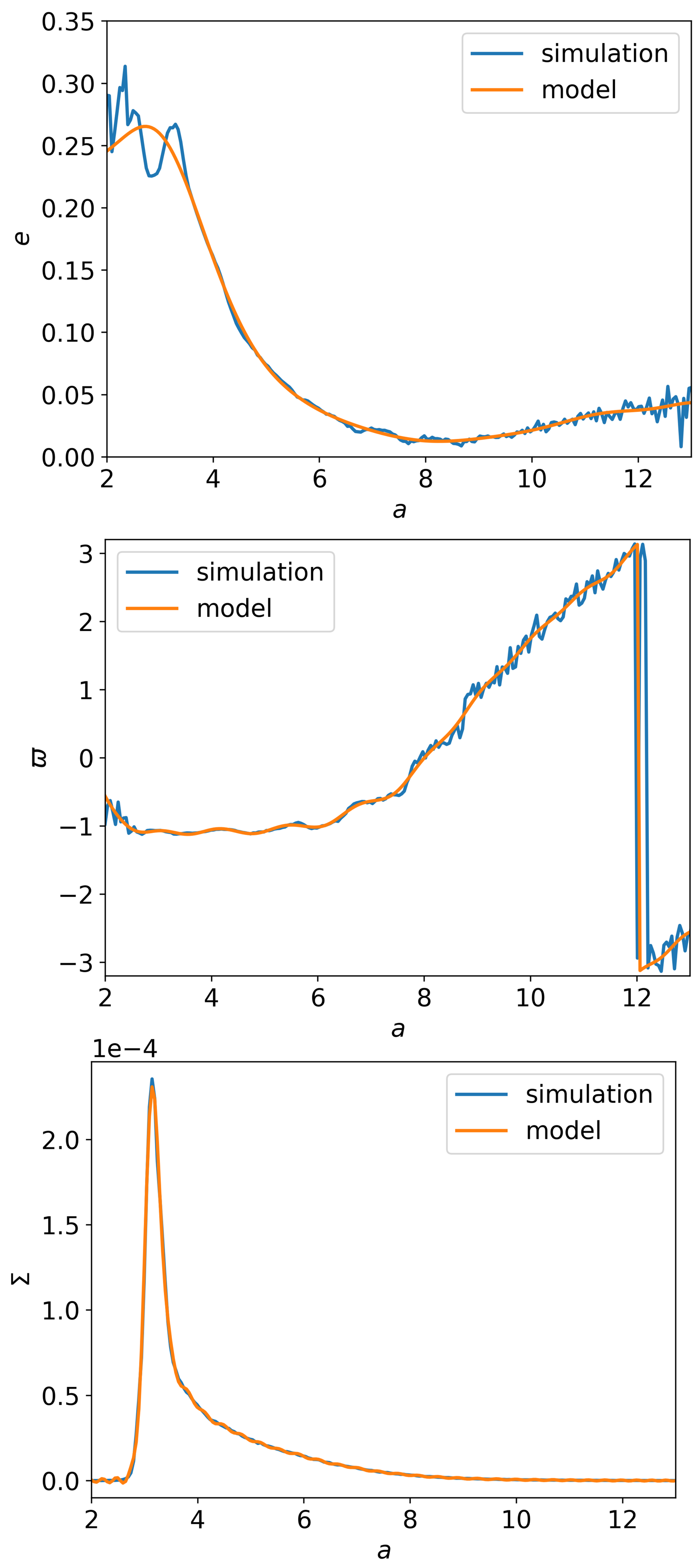
VERTICAL MOTION

Orbit compression at pericentre and apocentre introduces vertical motion along the orbit

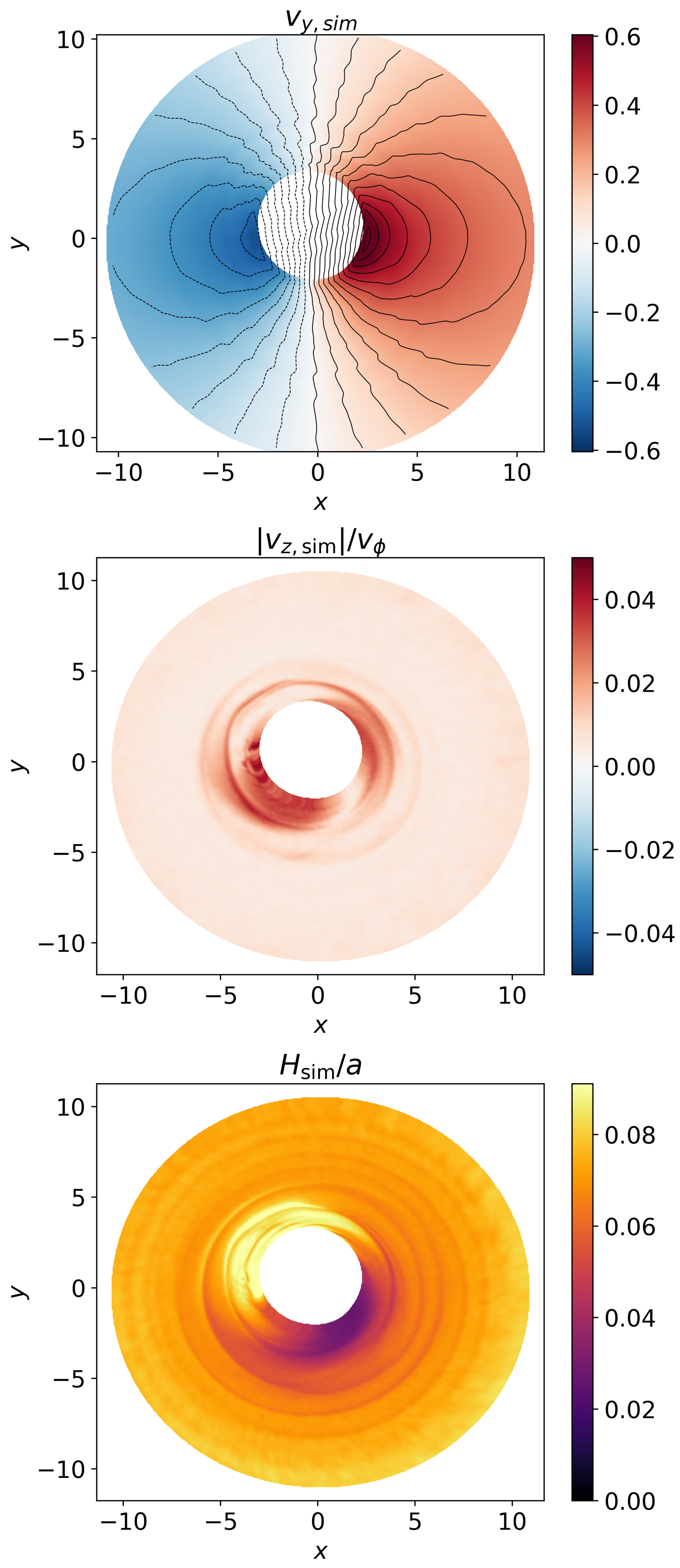


ANALYTICAL MODEL

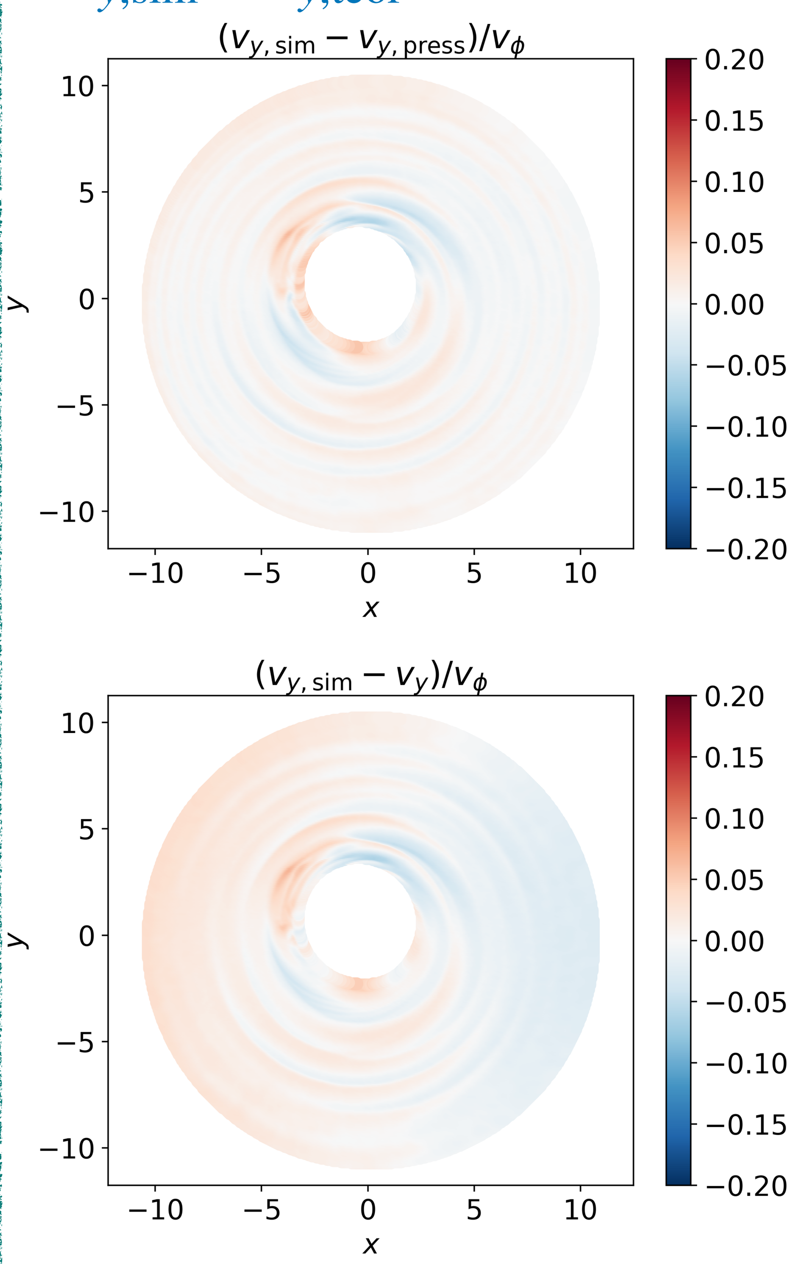
We create an analytical **model** from the values $e(a)$, $\varpi(a)$, $\Sigma(a)$ extracted from the **simulation**



SIMULATION

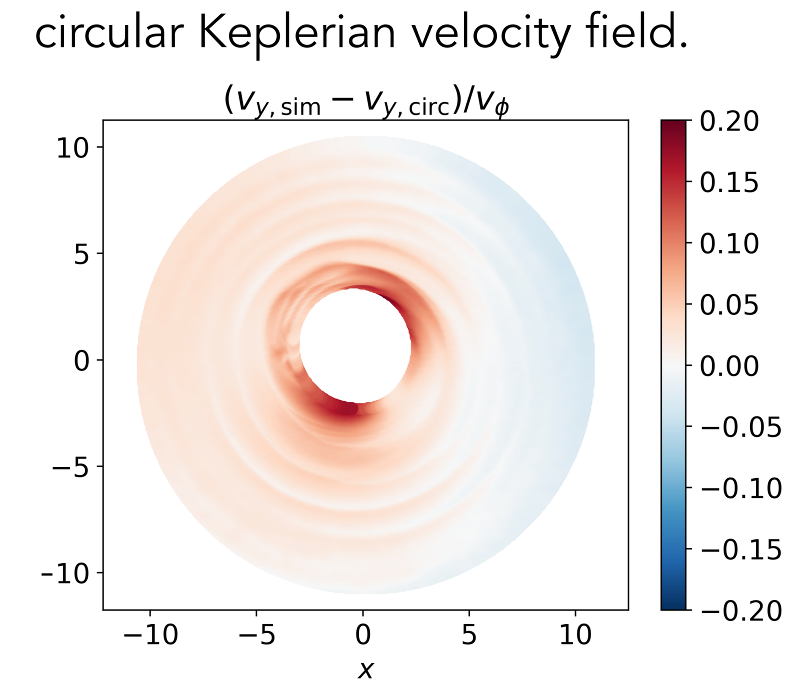


$v_{y,\mathrm{sim}} - v_{y,\mathrm{teor}}$ RESIDUALS

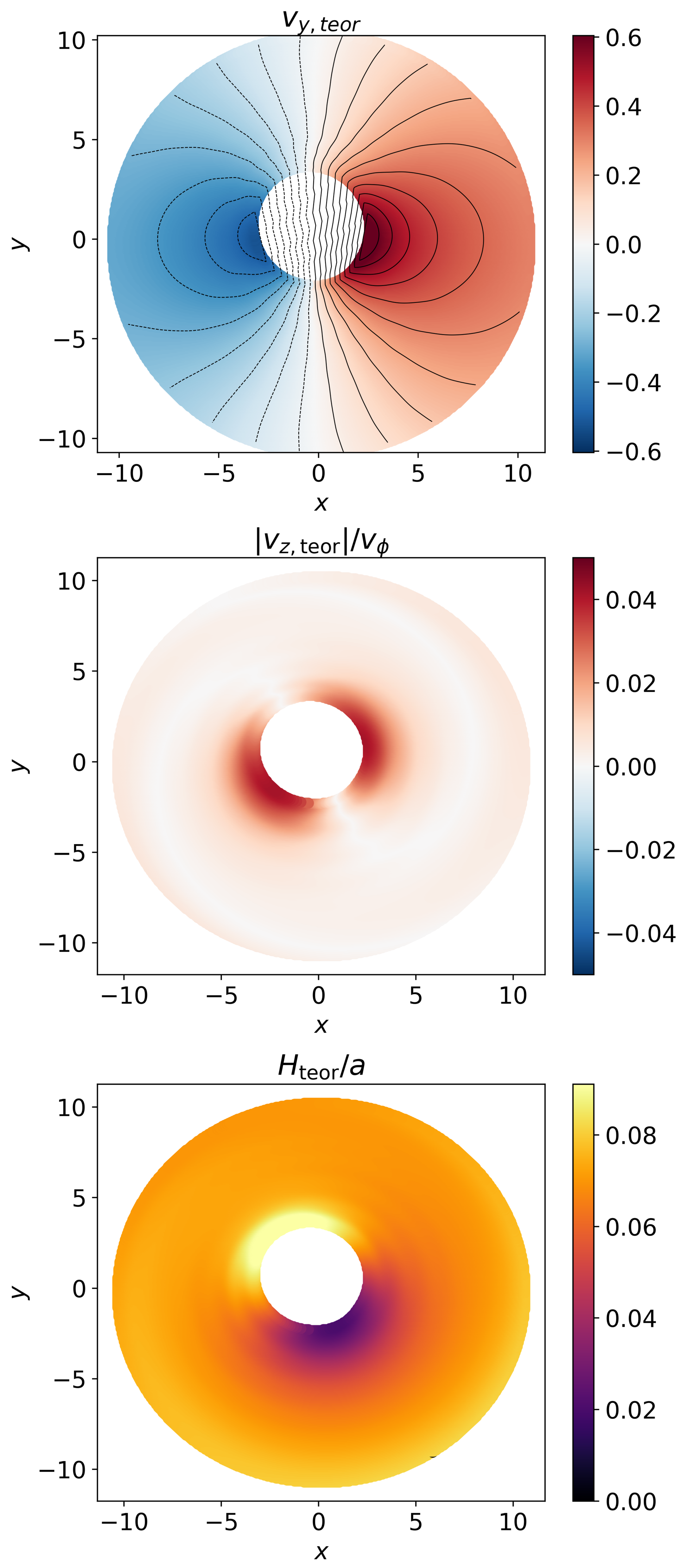


What if circular Keplerian?

For comparison, here below the residuals obtained subtracting a circular Keplerian velocity field.



ANALYTICAL MODEL



References:

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HYDRO CODE

PHANTOM, 3D SPH

Price et al. (2018), PASA, 35, 31