

Exotic circumbinary discs: misaligned, polar and anti-aligned systems

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Turbulent molecular clouds during stars formation can lead to multiple stars system and **misaligned circumbinary disc** can be formed with respect to orbital plane of binary. Under **certain conditions**, misaligned **circumbinary discs can become polar**.

$$I_{crit} = \arctan \sqrt{\frac{1 - e_b^2}{5e_b^2}}$$

$$\Lambda = (1 - e_b^2) \cos^2 I - 5e_b^2 \sin^2 I \sin^2 \Omega.$$

Polar Alignment conditions :

- $\Lambda < 0$
- $I_{crit} < I < 180 - I_{crit}$

These conditions constrain the values of the twist angle Ω .

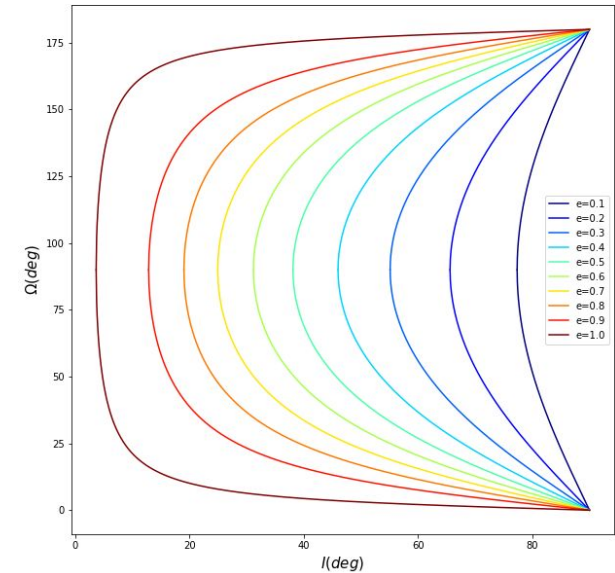


Figure 1. Value for I and Ω where the disc will tend to become polar for different eccentricities.

Inclination evolution of the disc

Analysis of inclination evolution of a gas disc through **SPH simulation** (code PHANTOM)

Initial condition :

Run 1 : $i=60^\circ$ $\Omega=0^\circ$

Run 2 : $i=60^\circ$ $\Omega=90^\circ$

As expected from the theory, if both criteria are respected (run2) the disc will tend to polar inclination. Otherwise the disc will return coplanar.



This is not true for retrograde cases. See poster by Nicolás Cuello

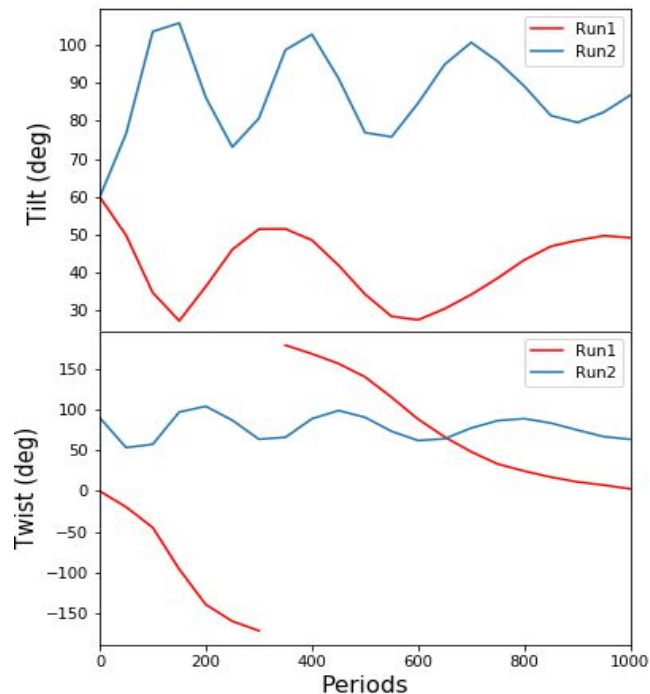


Figure 3. Disc inclination (upper panel) and twist (lower panel) evolution

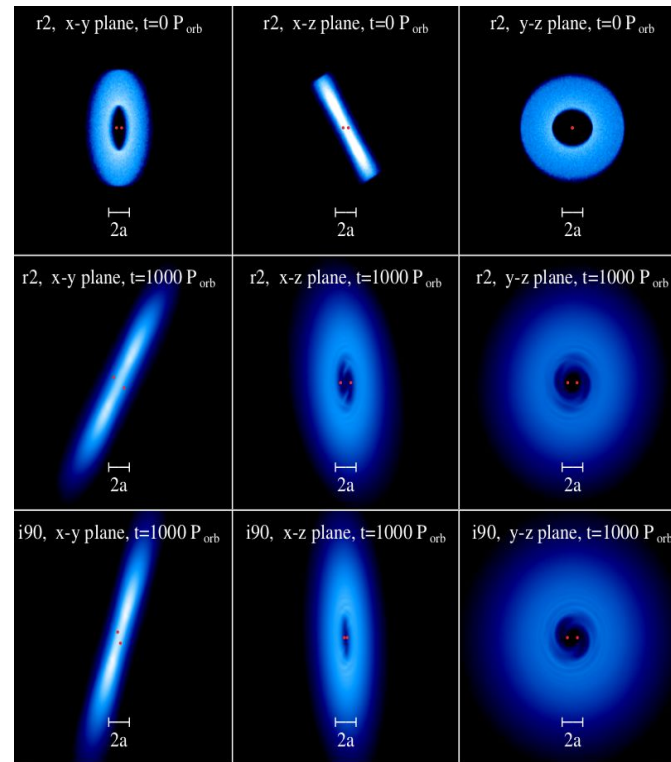


Figure 4. Comparison between the Run2 at $t=0$ (upper panel) and $t=1000$ binary orbits (middle panel) and the polar case at $t=1000$ binary orbits (lower panel)

Morphological effects of the polar and coplanar alignment on the disc

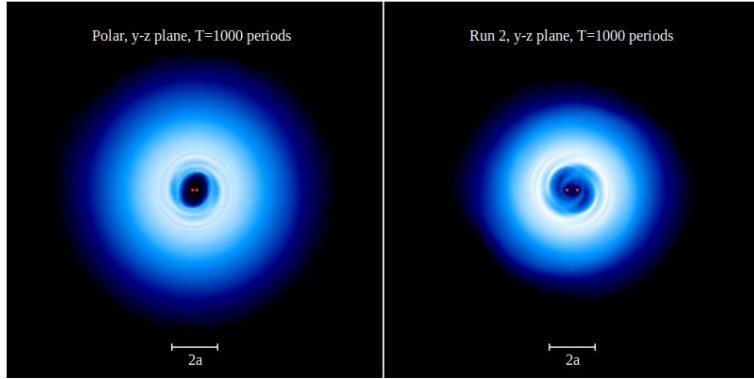


Figure 5. Comparison between polar disc (left panel) and misaligned disc which became polar (Run 2, right panel).

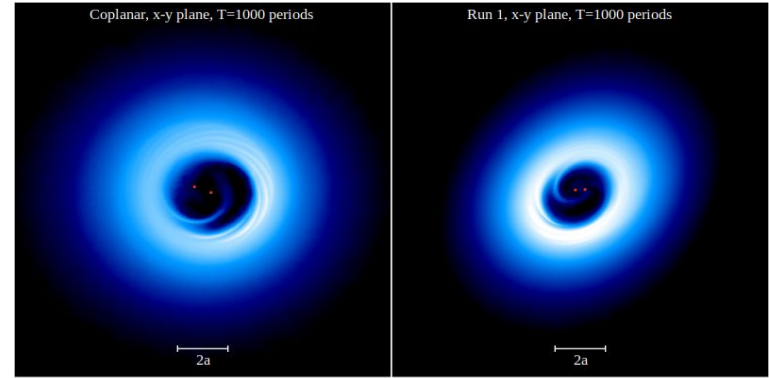


Figure 6. Comparison between coplanar disc (left panel) and misaligned disc which became coplanar (Run 1, right panel).

The resulting disc structures after alignment are similar to those that have not experienced such alignment.

We can notice that the inner cavity is smaller for polar discs.
Polar configurations are stable over time ---> Poster by Nicolás Cuello

So we can imagine planet formation in these exotic systems, with a planet closer to the binary compare to coplanar case due to smaller inner cavity.