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Polar circumbinary discs and planets around binary star systems

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Most stars form within dense stellar clusters and reside in binary systems, where circumbinary discs of gas and dust commonly envelop the binary pair. Observations reveal frequent misalignments between these discs and the binary orbital plane. Over time, such misaligned circumbinary discs dynamically evolve toward either coplanar or polar (perpendicular to the binary plane) configurations. Here, I present 3D hydrodynamical simulations incorporating multi-fluid physics (gas and dust) alongside linear theory to investigate the evolution of highly tilted circumbinary discs. A key finding is the formation of localized dust concentration regions—termed "dust traffic jams"—resulting from differential nodal precession between the gas and dust components within the tilted disc. These regions create favorable conditions for the potential formation of misaligned or polar circumbinary planets. This process persists across varied disc and binary parameters, underscoring its robustness. Additionally, I review candidate systems with tentative evidence for the first polar circumbinary planets. These results advance our understanding of protoplanetary disc evolution in binary environments, offering critical insights into planet formation pathways and the diversity of exoplanetary systems.

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