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Introducing Physical Warp Drives

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Alcubierre warp drive spacetimes allow timelike observers to travel superluminally relative to other timelike observers through the use of negative energy densities. In our study, we develop a general framework for describing warp drives. We show that any such object may be thought of as a shell of inertially moving material that modifies the properties of spacetime enclosed by the shell. Using the framework, we introduce a model of subluminal physical warp drives based on positive energy densities and satisfying the weak, strong and dominant energy conditions. Likewise, we show that all physical superluminal solutions would have to violate the dominant energy condition. We demonstrate the diversity of warp drive spacetimes by constructing example solutions in which the time or the volume deformation in the enclosed area may be chosen in a controlled manner. Our study, and the recent studies by other groups, show that the full diversity of warp drive classes is yet to be uncovered.

Primary authors: BOBRICK, Alexey (Lund University); Mr MARTIRE, Gianni (Applied Physics)

Presenter: BOBRICK, Alexey (Lund University)

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