

Marcelo B. Ribeiro's Page on Warp Drive Theory



The *Warp drive* is a type of propulsion system capable of driving ships at speeds higher than the speed of light. According to science fiction literature, such speeds are possible by a mechanism capable of generating a distortion in the spacetime such that it is folded, or "warped". If a spaceship possesses a device capable of generating around herself such a distortion, or warp field, she is then able to reach speeds faster than light, making it possible interstellar trips.

Until recently, warp drive was only associated with science fiction, but in 1994 Miguel Alcubierre presented a paper which theoretically described a physical mechanism where a spaceship could be propelled by a method similar to what is described in science fiction books. The most interesting aspect about Alcubierre's method was the fact that it was entirely based on known physics, on the theory of **general relativity**, and his proposal included a **warp metric**. Alcubierre's paper can be considered a scientific landmark in the sense that it effectively opened the way for discussing warp drive propulsion in physical terms, since from that moment on warp drive was no longer only a fiction, but also became a scientific issue.

Inspired by Alcubierre's proposal, other physicists started to research and discuss his ideas, modifying the original proposal and advancing new ones. Then, as the scientific literature below can testify, a new branch of research in physics was born: **warp drive theory**. It is still small, but given the interest already generated, it will certainly grow in time.

Warp drive is not yet a reality, and as the papers below state by themselves, physicists are not even sure if such a thing as a warp drive propelled starship can ever be constructed. There are many formidable theoretical obstacles, which, perhaps, may prove insurmountable. But, perhaps not. Physicists have not yet reached a conclusion. In any case, one thing is certain: if we find out that the known physics does not prohibit faster than light travel via warp drive, then building a ship with warp drive propulsion capabilities becomes a technological problem. It may take centuries to do so, but perhaps we can in time build the necessary technology. The way is now open for serious research.

This page aims at bringing together the still rather small scientific literature on this subject, such that one can learn what has been done on warp drive theory. Its primary audience are professional physicists, and my aim at creating this page was at providing a useful reference collection which could perhaps be a starting point for the visiting professional physicist's own contributions to the subject. It is also my hope that the interested layman may find this page informative. The papers listed below represent the contributions made so far to the subject, which, due to its small size and age, may well encompass almost everything that has been published until now. Of course, there are other methods proposed for interstellar trips within general relativity, such as wormholes, but this page attempts to focus only on warp drive theory. Thus, papers on other related subjects are listed here only if I am convinced that they bring results and/or discussions relevant to warp drive theory. I have also added at the end of this page some links which show how seriously interstellar propulsion concepts, including warp drive, are taken by some organizations.

If you think that there is something that should appear here, perhaps a particular paper that I missed, or an important topic that I did not mention, please e-mail me at the following address (spelled for protection against

spam robots): mbr at if dot ufrj dot br. But, notice that this is a **scientific** page, and, therefore, although fascinating, I will not be providing links to topics or discussions on science fiction literature issues.

The paper that started it all

- **The warp drive: hyper-fast travel within general relativity**

Miguel Alcubierre

e-print: [gr-qc/0009013](#);

[LaTeX](#); [dvi](#); [postscript](#); [eps figure](#); [pdf](#);

Classical and Quantum Gravity, vol. 11, L73-L77, (1994)

The follow-up papers *

1. **Photon propagation in a stationary warp drive space-time**

Claes R. Cramer

e-print: [gr-qc/9510018](#), (1995)

2. **Some thoughts on the Implications of Faster-Than-Light Interstellar Space Travel**

I.A. Crawford

Quarterly Journal of the Royal Astronomical Society, vol. 36, 205-218, (1995)

3. **Physical and Cosmological Implications of a Possible Class of Particles Able to Travel Faster than Light**

Luis Gonzalez-Mestres

e-print: [hep-ph/9610474](#);

Contribution to the 28th International Conference on High Energy Physics, Warsaw (Poland), (1996)

4. **Warp drive and causality**

Allen E. Everett

[pdf](#); *Physical Review D*, vol. 53, 7365-7368, (1996)

5. **A Superluminal Subway: The Krasnikov Tube**

Allen E. Everett & Thomas A. Roman

e-print: [gr-qc/9702049](#); [postscript](#); [pdf](#);

Physical Review D, vol. 56, 2100-2108, (1997)

6. **Quantum effects in the Alcubierre warp drive spacetime**

William A. Hiscock

e-print: [gr-qc/9707024](#); [postscript](#); [pdf](#);

Classical and Quantum Gravity, vol. 14, L183-L188 (1997)

7. **The unphysical nature of "Warp Drive"**

Michael J. Pfenning & L.H. Ford

e-print: [gr-qc/9702026](#); [postscript](#); [pdf](#);

Classical and Quantum Gravity, vol. 14, 1743-1751, (1997)

8. **On the Possibility of a Propulsion Drive Creation Through a Local Manipulation of Spacetime Geometry**

Vesselin Petkov

e-print: [physics/9805028](#);

Presented at the 34th AIAA/ASME/SAE/ASEE Joint Propulsion Conference, (1998)

9. **'Operational' energy conditions**

Adam D. Helfer

[pdf](#); [postscript](#); *Classical and Quantum Gravity*, vol. 15, 1169-1183, (1998)

10. **No warp drive**

D. H. Coule

[pdf](#); [postscript](#); *Classical and Quantum Gravity*, vol. 15, 2523-2527, (1998)

11. **Quantum Inequality Restrictions on Negative Energy Densities in Curved Spacetimes**

Michael John Pfenning

e-print: [gr-qc/9805037](#); *Doctoral Dissertation*, (1998)

12. **Hyperfast Interstellar Travel in General Relativity**
S. V. Krasnikov
e-print: [gr-qc/9511068](#); [postscript](#); [pdf](#);
Physical Review D, vol. 57, 4760, (1998)
13. **Superluminal travel requires negative energies**
Ken D. Olum
e-print: [gr-qc/9805003](#); [postscript](#); [pdf](#);
Physical Review Letters, vol. 81, 3567-3570, (1998)
14. **Hyper-fast travel without negative energy**
Eric Baird
e-print: [gr-qc/9903068](#); (1999)
15. **Warp drives, wavefronts and superluminality**
Eric Baird
e-print: [physics/9904019](#); (1999)
16. **A traversable wormhole**
S. Krasnikov
e-print: [gr-qc/9909016](#); (1999)
17. **Speed Limits in General Relativity**
Robert J. Low
e-print: [gr-qc/9812067](#); [postscript](#); [pdf](#);
Classical and Quantum Gravity, vol. 16, 543-549, (1999)
18. **Null geodesics in the Alcubierre warp drive spacetime: the view from the bridge**
Chad Clark, William A. Hiscock & Shane L. Larson
e-print: [gr-qc/9907019](#); [postscript](#); [pdf](#);
Classical and Quantum Gravity, vol. 16, 3965-3972, (1999)
19. **A 'warp drive' with more reasonable total energy**
Chris Van Den Broeck
e-print: [gr-qc/9905084](#); [postscript](#); [pdf](#);
Classical and Quantum Gravity, vol. 16, 3973-3979, (1999)
20. **On the warp drive space-time**
Pedro F. Gonzalez-Diaz
e-print: [gr-qc/9907026](#); [postscript](#); [pdf](#);
Physical Review D, vol. 62, 44005-44012, (2000)
21. **On the (im)possibility of warp bubbles**
Chris Van Den Broeck
e-print: [gr-qc/9906050](#);
Summary of talk delivered at STAIF-2000, (2000)
22. **Reduced Total Energy Requirements for a Modified Alcubierre Warp Drive Spacetime**
F. Loup, D. Waite & E. Halerewicz Jr
e-print: [gr-qc/0107097](#), (2001)
23. **Warp Drive With Zero Expansion**
Jose Natario
e-print: [gr-qc/0110086](#); [postscript](#); [pdf](#);
Classical and Quantum Gravity, vol. 19, 1157-1166, (2002)
24. **A Causally Connected Superluminal Warp Drive Spacetime**
F. Loup, R. Held, D. Waite, E. Halerewicz, Jr., M. Stabno, M. Kuntzman & R. Sims
e-print: [gr-qc/0202021](#), (2002)
25. **Weak Energy Condition Violation and Superluminal Travel**
Francisco Lobo & Paulo Crawford
e-print: [gr-qc/0204038](#), (2002)
26. **On the Problems of Hazardous Matter and Radiation at Faster than Light Speeds in the Warp Drive Space-Time**
C.B. Hart, R. Held, P.K. Hoiland, S. Jenks, F. Loup, D. Martins, J. Nyman, J.P. Pertierra, P.A. Santos,

M.A. Shore, R. Sims, M. Stabno & T.O.M. Teage
e-print: [gr-qc/0207109](#), (2002)

* The dates indicated within parenthesis refer to the last known uploaded or published version of the paper.

Related Links

- [NASA Breakthrough Propulsion Physics Program](#)
- [The British Interplanetary Society](#)
- [Starlab's Page on Warp Drive](#)

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