Hyper-Fast Galaxy Travel via Alcubierre's Warp Drive

Fil'chenkov M.L., Laptev Yu. P.

Peoples' Friendship University of Russia, Moscow;

E-mail: Fil'chenkov <fmichael@mail.ru>; Laptev <yplaptev@rambler.ru>;

The exploration of our Galaxy is realizable only by superluminal starships. Since their local velocity cannot exceed the speed of light, it is necessary to find a way of diminishing the distance to be traversed between the points of start and destination.

To solve this problem, M. Alcubierre proposed a warp drive creating a superluminal deformation of space around the starship. The parameters of the warp drive are estimated and the equation of starship geodesics are analysed.

Keywords: Warp Drive, Hypermotion, Galaxy Travel, Negative Energy, Geodesics.

DOI: 10.18698/2309-7604-2015-1-140-143

1. Introduction

If one assumes that our Galaxy has been explored by developed civilizations in the same way as we had been sailing the world's ocean in the Age of Explorations and the Great Navigations, it is necessary for the civilizations to be able to traverse distances separating them.

Mankind created various means to traverse distances, but it is rockets that allowed the Earth to be escaped and the Solar system to be explored. Proxima Centauri, the star nearest to the Sun, is 1.3 pc distant. The Galaxy radius is 15 kpc. The Sun is located at a distance of 8 kpc from the Galaxy centre. Hence it is clear that exploring the Galaxy is practically impossible during human lifetime. While moving with the velocity close to the speed of light (a photonic engine), any distances are reachable due to relativistic time dilation but it is a voyage without return.

Here we arrive at a conclusion that the Galaxy tour would be possible only for a superluminal or hyper-motion. We are dealing with a local velocity, which cannot exceed the speed of light. The only possibility lies in diminishing the distance separating the points of start and destination to be traversed by a starship. A wormhole connecting the start and destination points allows coming to the destination point using a shorter route. Another possibility is to contract space ahead of the starship. This process is performed with the aid of a warp drive proposed by Miguel Alcubierre in 1994 [1].

2. Metric. Energy Density. Alcubierre's Warp Drive Parameters

The distorted space-time is described by the metric:

$$ds^2 = c^2 dt^2 - \left[dx - v_s f\left(r_s\right) dt \right]^2 - dy^2 - dz^2, \qquad (1)$$

Where

$$r_s^2 = \left(x - x_s\right)^2 + y^2 + z^2, \qquad (2)$$

$$v_s = \frac{dx_s}{dt} \ , \qquad (3)$$

$$f\left(r_s\right) = \frac{th\sigma\left(r_s + R\right) - th\sigma\left(r_s - R\right)}{2th\sigma R} \qquad (4)$$

The starship is moving with the velocity v_s in the x −axis direction. A bubble of the radius R and wall thickness $\frac{1}{\sigma}$ has been created around the starship. Inside and outside the bubble the space-time is flat, and in the layer of thickness $\frac{1}{\sigma}$ the space-time is contracted in the forward direction and expanded in the opposite one. Thus the starship brings the place of destination closer due to contraction of the space-time ahead of it. Alcubierre's bubble as well as the wormhole is supported by a negative energy. The energy density to support the bubble:

$$\varepsilon = \frac{c^2 v_s^2 \sigma^2 \rho^2}{128\pi G r_s^2} \ , \qquad (5)$$

where $\rho^2 = y^2 + z^2$; $r_s = \rho$ at $x = x_s$.

The volume of the layer with nonzero density

$$V = \frac{4\pi R^2}{\sigma} \qquad (6)$$

The effective quantities corresponding to $|\varepsilon|$:

the mass

$$M = \frac{v_s^2 \rho^2 \sigma R^2}{32 G r_s^2}, \tag{7}$$

the gravitational radius

$$r_g = \frac{v_s^2 \rho^2 \sigma R^2}{16 c^2 r_s^2}, \tag{8}$$

de Sitter's horizon

$$r_0 = \frac{4\sqrt{3} c r_s}{v_s \sigma \rho} \;. \tag{9}$$

For $R > r_g > r_0$ we have

$$8\sqrt[4]{3}\left(\frac{c r_s}{v_s \rho}\right)^{\frac{3}{2}} < \sigma R < 16\left(\frac{c r_s}{v_s \rho}\right)^2 \tag{10}$$

if $\sigma R > 3$, $\frac{c r_s}{v_s \rho} > \frac{\sqrt{3}}{4}$. Thus the starship mass exceeds $10^{-2}\, M_\odot$, where $M_\odot$ is the solar mass.

3. Starship Geodesics

The equations of geodesics read:

$$\Gamma^0_{00} u^0 u^0 + \Gamma^0_{01} u^0 u^1 + \Gamma^0_{11} u^1 u^1 + \frac{du^0}{ds} = 0 \tag{11}$$

$$\Gamma^1_{00} u^0 u^0 + \Gamma^1_{01} u^0 u^1 + \Gamma^1_{11} u^1 u^1 + \frac{du^1}{ds} = 0 \tag{12}$$

$$ds = cdt\sqrt{1 - \frac{\left(v - v_s f\right)^2}{c^2}} \tag{13}$$

In case $v = v_s$, $f = const$ Christoffel's symbols vanish.

$$ds^2 = c^2dt^2 - (1-f)^2dx^2 - dy^2 - dz^2, \tag{14}$$

$$u^i = \left(\frac{1}{\sqrt{1 - \frac{\left(1-f\right)^2 v^2}{c^2}}}, \quad \frac{v}{c\sqrt{1 - \frac{\left(1-f\right)^2 v^2}{c^2}}} \right), \tag{15}$$

where $v \le \frac{c}{1-f}$, $0 \le f \le 1$.

Here $v_0 = v - v_s f$ is the local velocity of the starship relative to the deformed space-time not exceeding the speed of light, v is the rate of deformation of space-time relative to Minkowski's at the point of starship start, v_s is the starship velocity relative to its start point.

4. Conclusion

The possibility of a negative energy is evidenced by Casimir's effect providing the basis for electron microscopy. The difficulties related to a practical realization of the hyper-motion lie in a too large amount of energy being required.

However, the technical realization has not been dealt so far, we are dealing only with a possibility of hyper-motion in principle. In this case there arise obstacles which seem insuperable nowadays. The conclusions based on the level of modern science are no ultimate. So much is unknown. Contrary to electromagnetism, we cannot control over gravity. When our knowledge becomes more detailed and extensive, it will be possible for us to succeed in revising many problems of gravity including its modern interpretation within the framework of general relativity.

Reference

1. Alcubierre M. (1994). The warp drive: hyper-fast travel within general relativity. *Class. Quant. Grav.*, v. 11-5, 73-77.