# *The Possibility of FTL Space Travel by using the Quantum Tunneling Effect through the Light Barrier*

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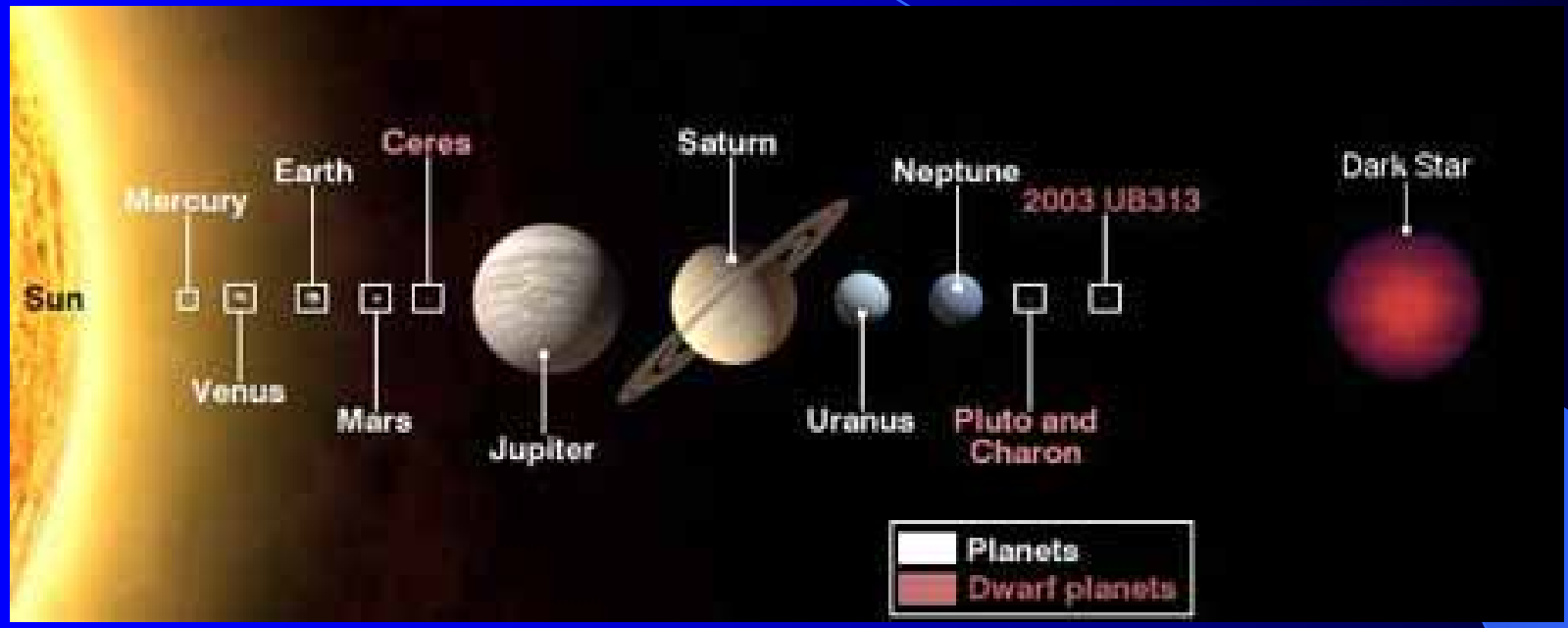
# Time required for reaching to the rime of the Solar system

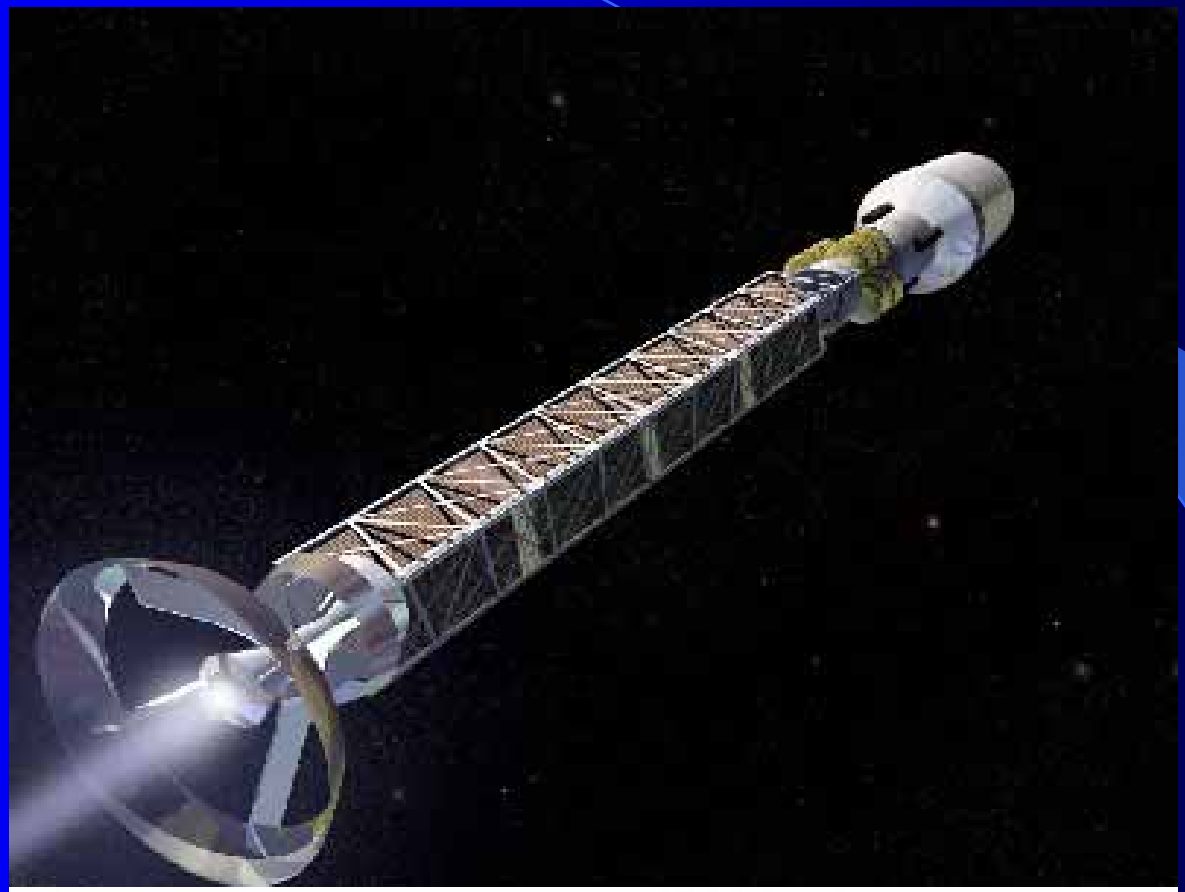
237.5AU*

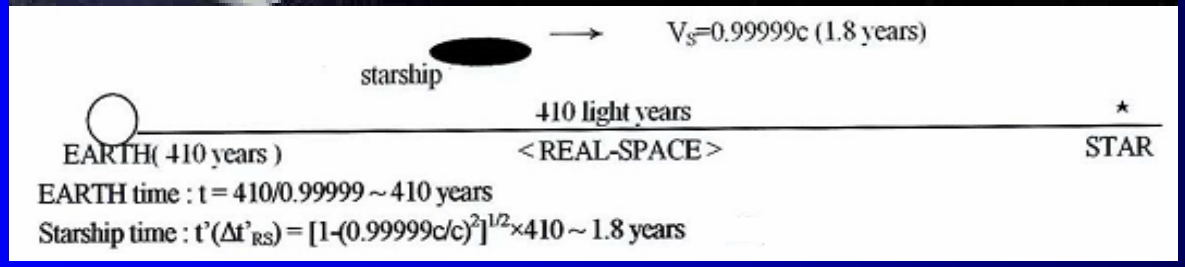



**Chemical Rocket with the speed of 16.2km/s.**

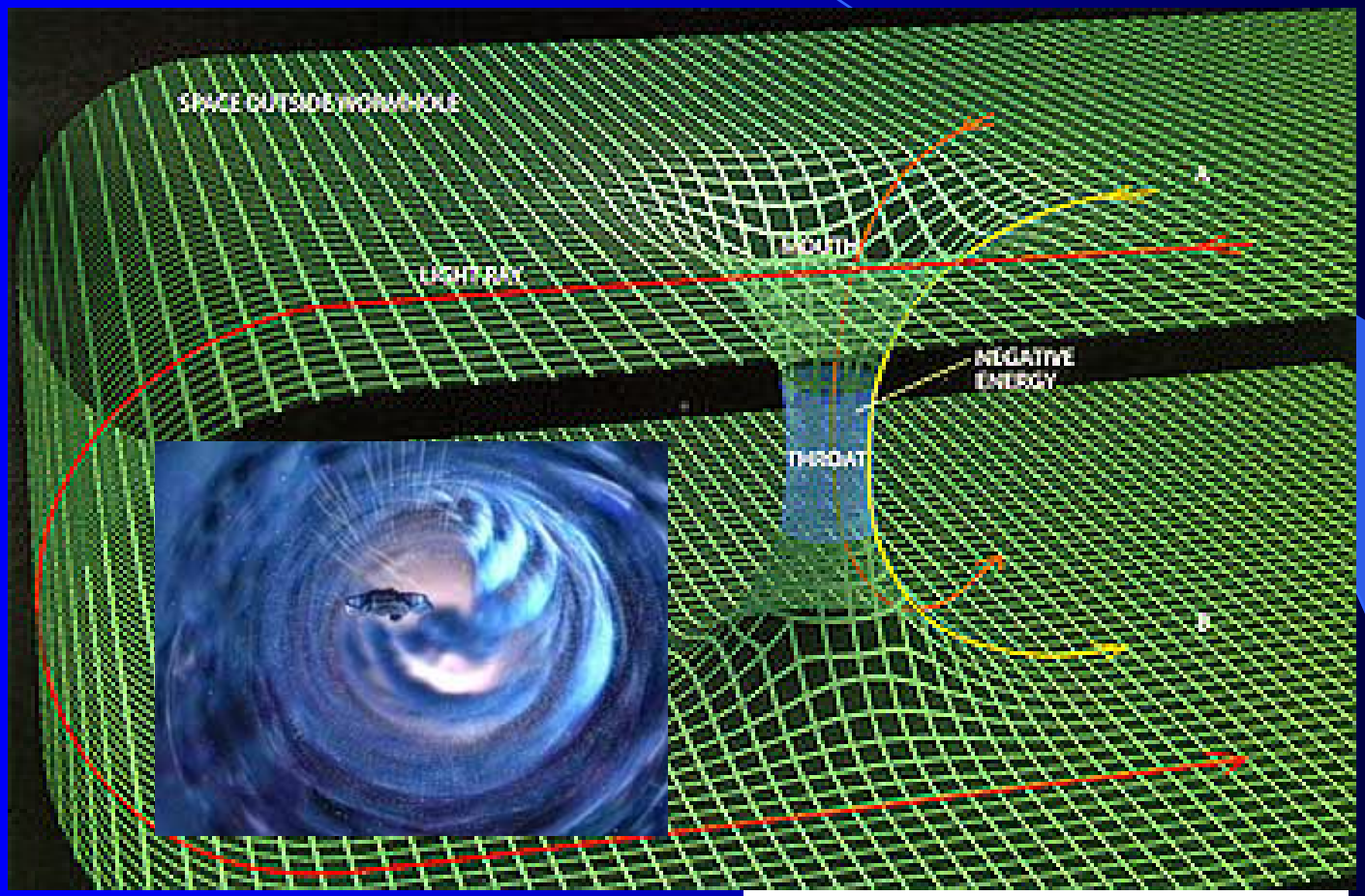
**Time=60 year**

# Photon rocket





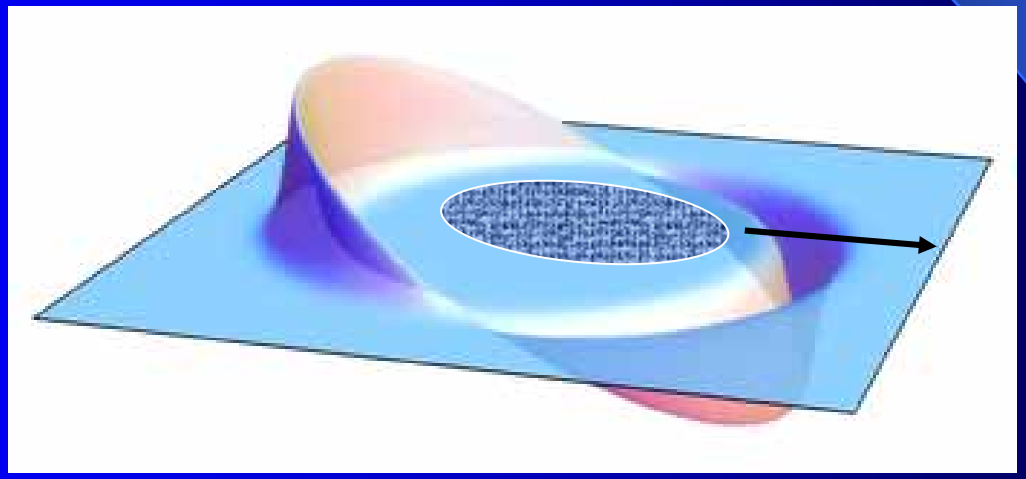
# FTL Travel by Wormhole

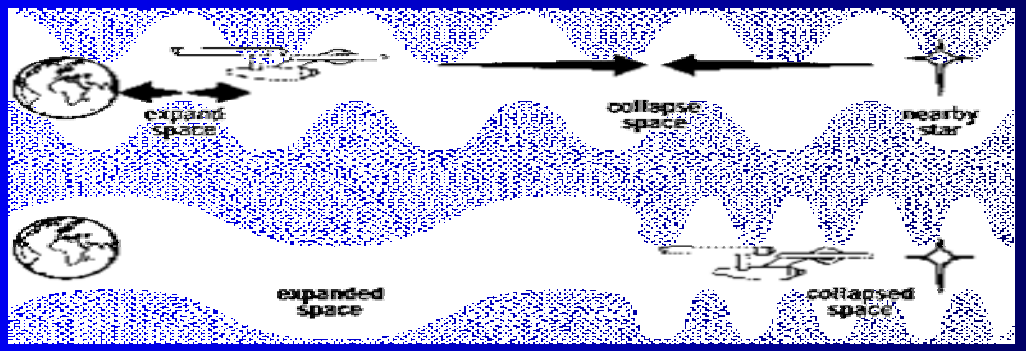



$$M_{wh} = -\frac{r_{throat} c^2}{G} = -0.709 M_{jupter} r_{throat}$$

# Warp Drive Propulsion

**Alcubierre's proposed Warp Drive Propulsion System in 1994.**
The proposal which supplies to motion faster than light seems to be a kind of navigation theory for the purpose of interstellar travel rather than propulsion theory.

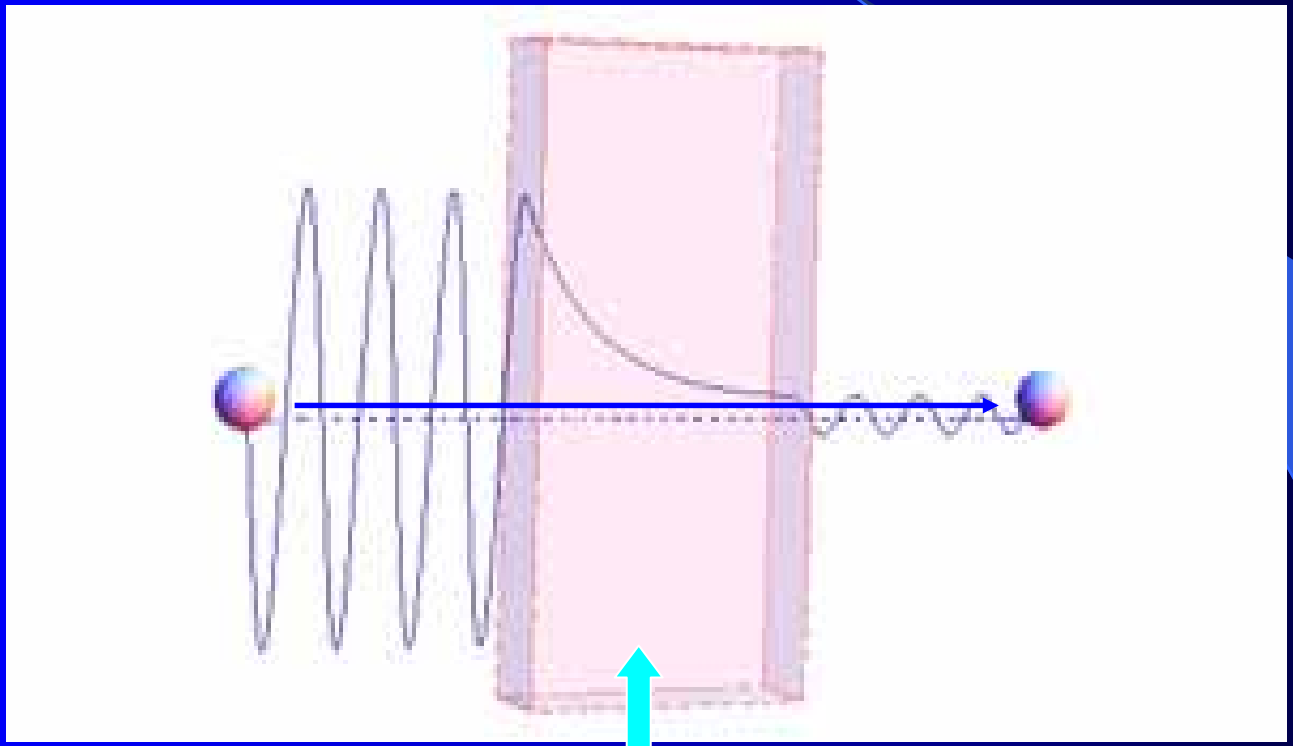




# Current Problems of the Warp drive

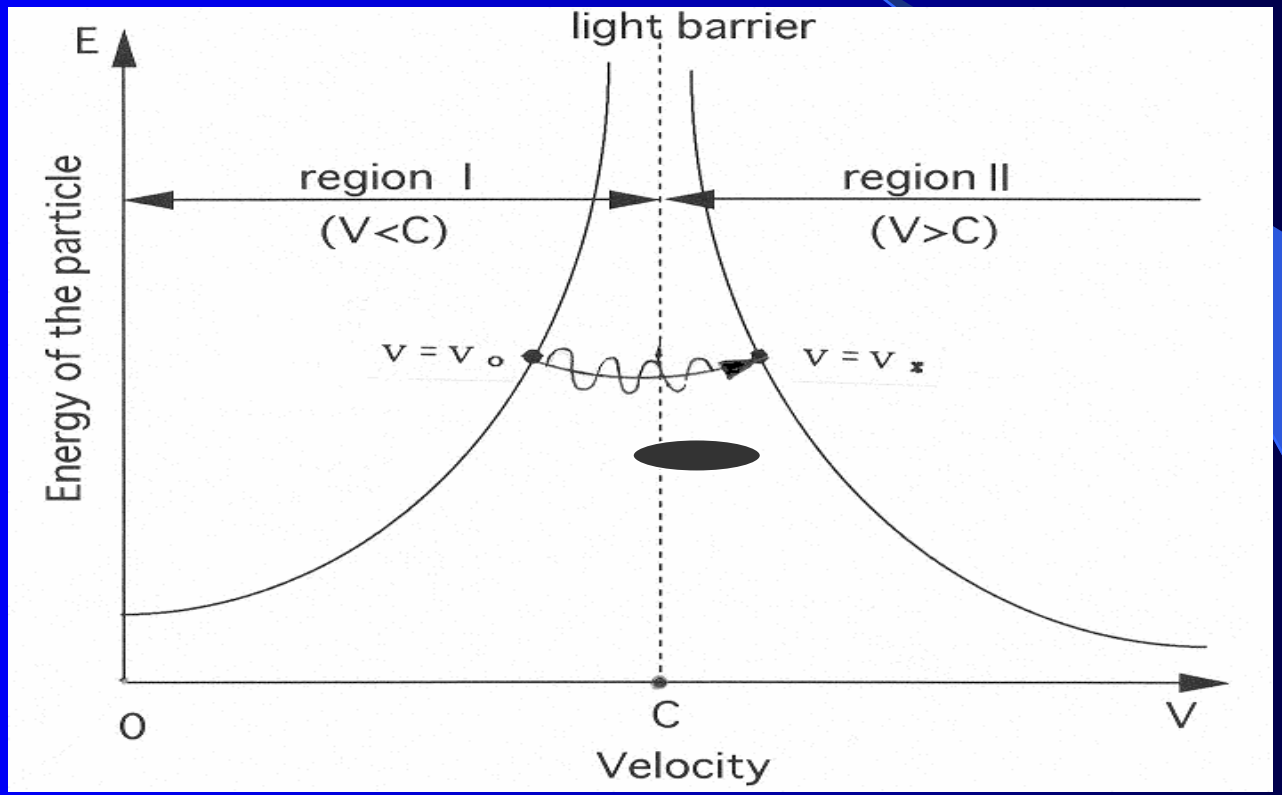
- How this bubble would be created is still a mystery.
- Absurdly gigantic energy requirement to transport a small ship across the galaxy (the energy equivalent the mass of $10^{64}$kg).
- Energy violation such as exotic energy banned by the theory of General Relativity.

# Quantum Tunneling Effect



Potential Barrier

# Quantum tunneling through the light barrier

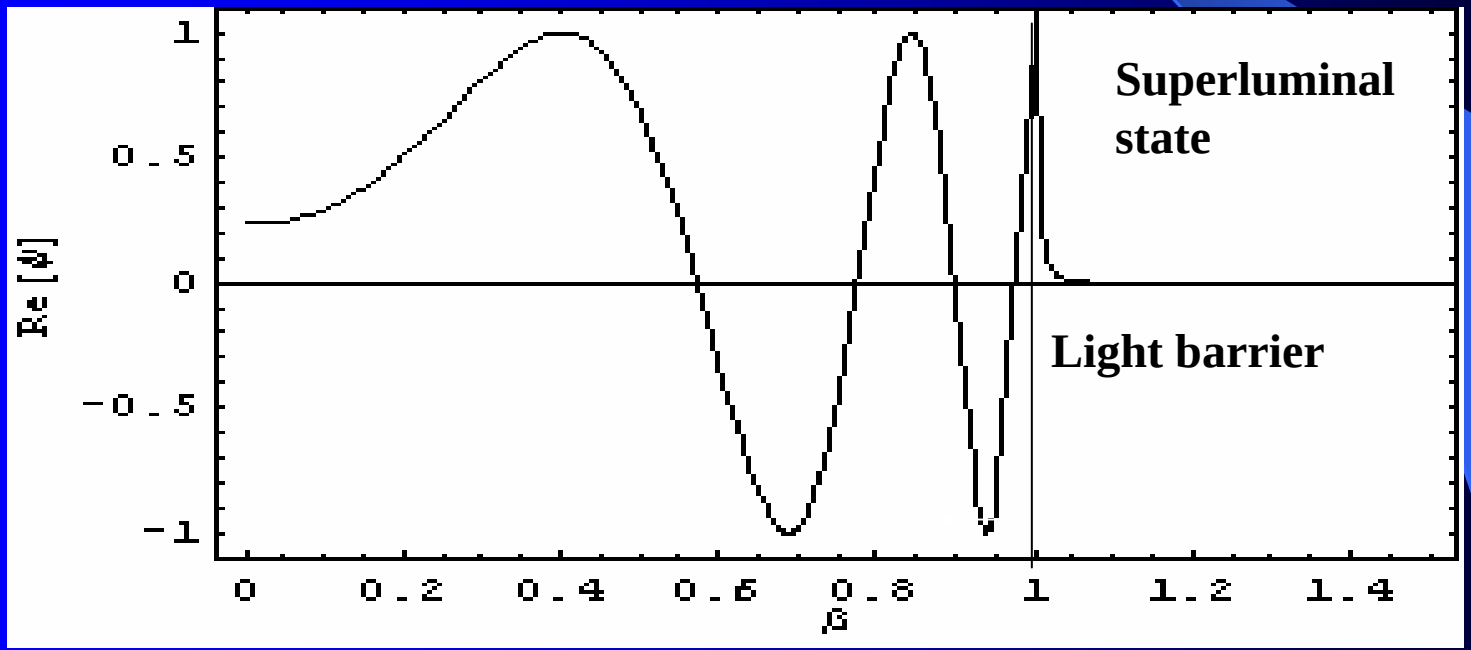



**Is it possible to penetrate the infinite light barrier?**

# Wave function through the light barrier

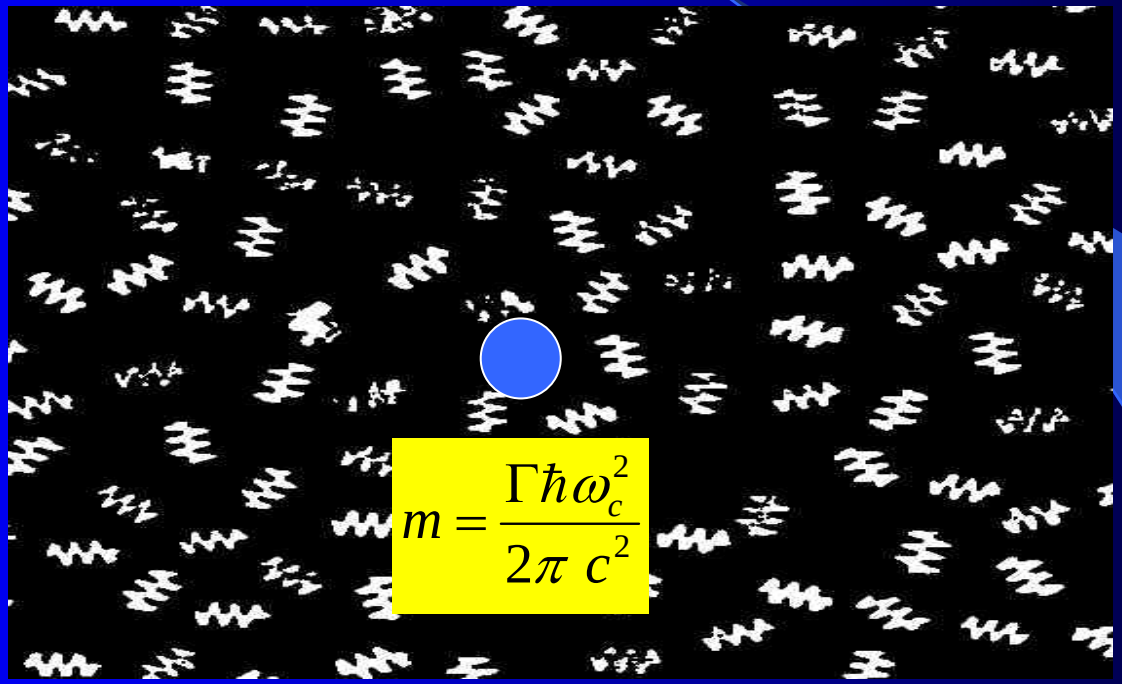
**Klein-Gordon equation with the acceleration**

$$\frac{\partial \psi}{\partial p} = \mp \frac{i}{ma\hbar} \sqrt{p^2 c^2 + m^2 c^4}\, \psi$$




$$\psi = C \cdot \exp\left[ \pm i \frac{\sqrt{1-\beta^2}}{4\beta} \frac{mc^2 \omega_c}{\hbar} \frac{\Delta t}{\Delta \omega} \left( \frac{\beta}{1-\beta^2} - \log(mc) - \frac{1}{2} \log\left( \frac{1+\beta}{1-\beta} \right) \right) \right]$$

# ZPF field in a space and the inertial mass




**Inertial mass is originated to the interaction of sub-elementary particles with the vacuum ZPF field.**

# Acceleration of the moving body by the manipulation of ZPF frequency

$$m = \frac{\Gamma \hbar \omega_c^2}{2\pi\, c^2}$$

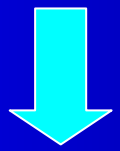
$$a = -\frac{1}{m_0}\frac{dp}{dt} = -\frac{\pi c^2}{\Gamma \hbar \omega_c^2}\frac{d}{dt}\frac{m_0 v}{\sqrt{1 - v^2/c^2}} = -\frac{c\beta}{\sqrt{1-\beta^2}}\frac{2\dot{\omega}_c}{\omega_c}$$

$$\approx \frac{2\beta c}{\sqrt{1-\beta^2}}\frac{\Delta\omega}{\omega_c \Delta t}$$

# Probability of the warp drive by the quantum tunneling

**Tunneling probability**

$$T \approx |\psi_*|^2 / |\psi|^2 = \exp\left[ \pm \frac{\sqrt{1-\beta^2}}{2\beta} \frac{m_0 c^2 \omega^2}{\hbar \omega_c} \frac{\Delta t}{\Delta \omega} \left( \frac{\beta_*}{\beta_*^2 - 1} - \log\left( \frac{m_0 c \omega^2}{\omega_c^2} \right) - \log\left( \frac{\beta_* + 1}{\beta_* - 1} \right) \right) \right]$$

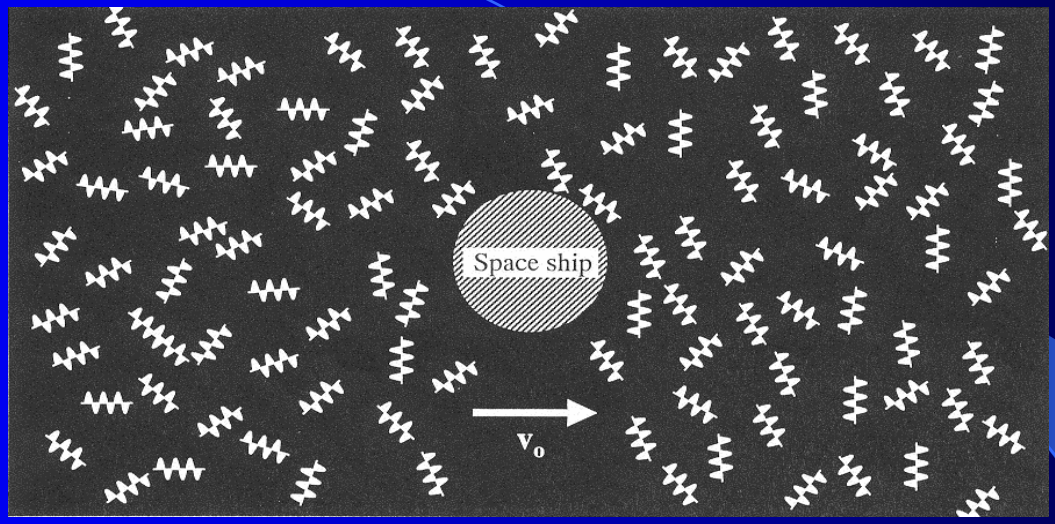


**approximation**

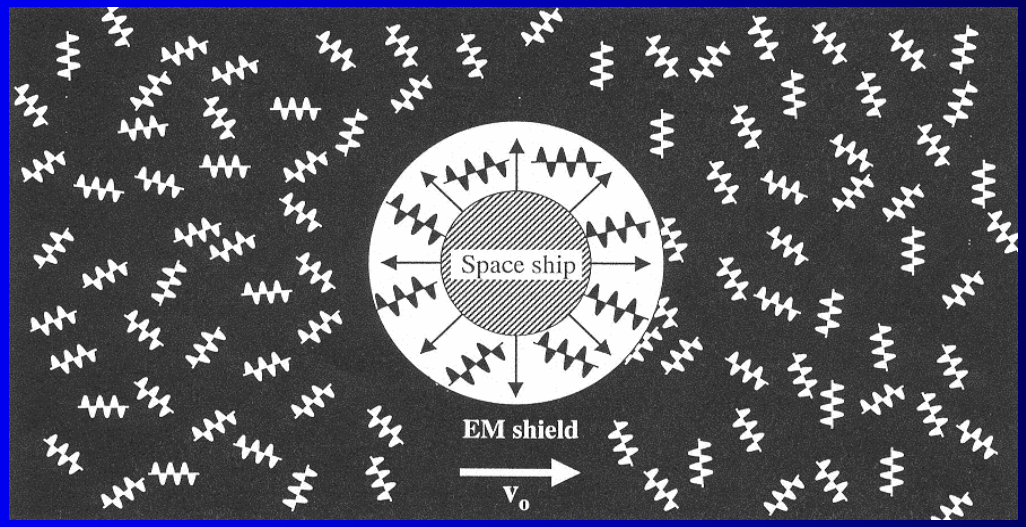
$$T \approx \exp\left[ \frac{\sqrt{1-\beta^2}}{2\beta} \frac{m_0 c^2 \omega^2}{\hbar \omega_c} \frac{\Delta t}{\Delta \omega} \log\left( m_0 c \frac{\omega^2}{\omega_c^2} \right) \right]$$

# Three Steps of the ZPF Warp Drive

**Step.1**

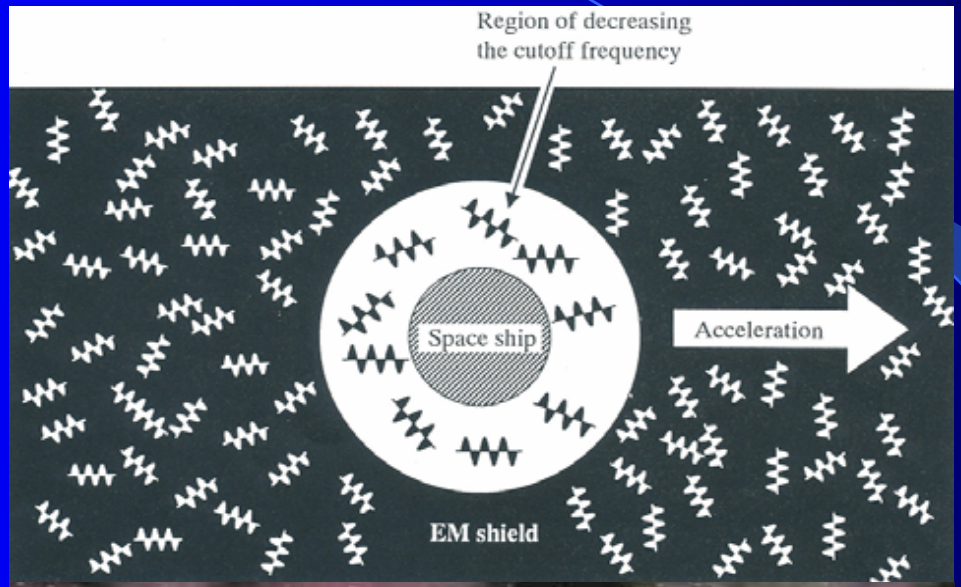



**Step.2**



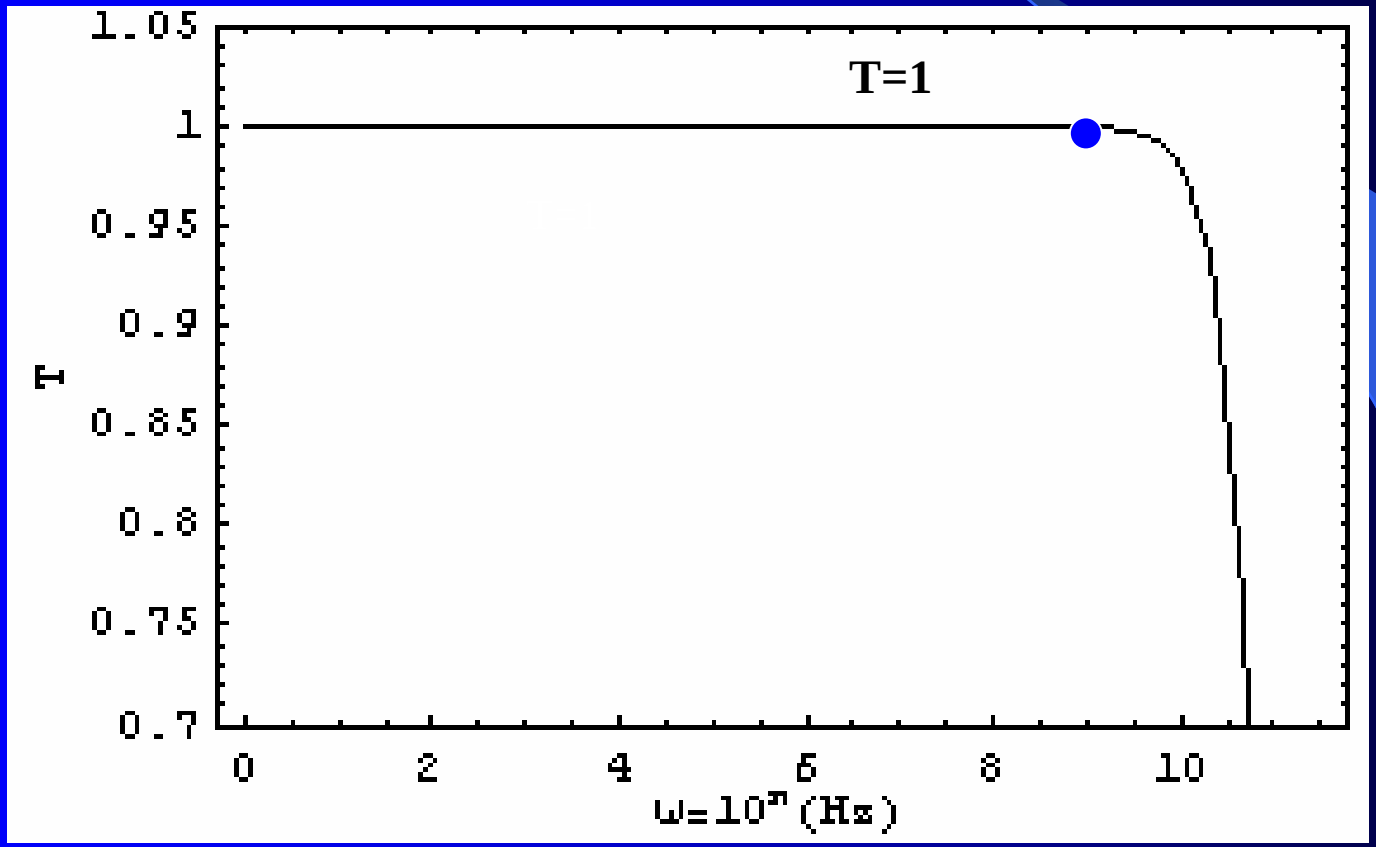
# Acceleration created by the ZPF Field

**Step.3**

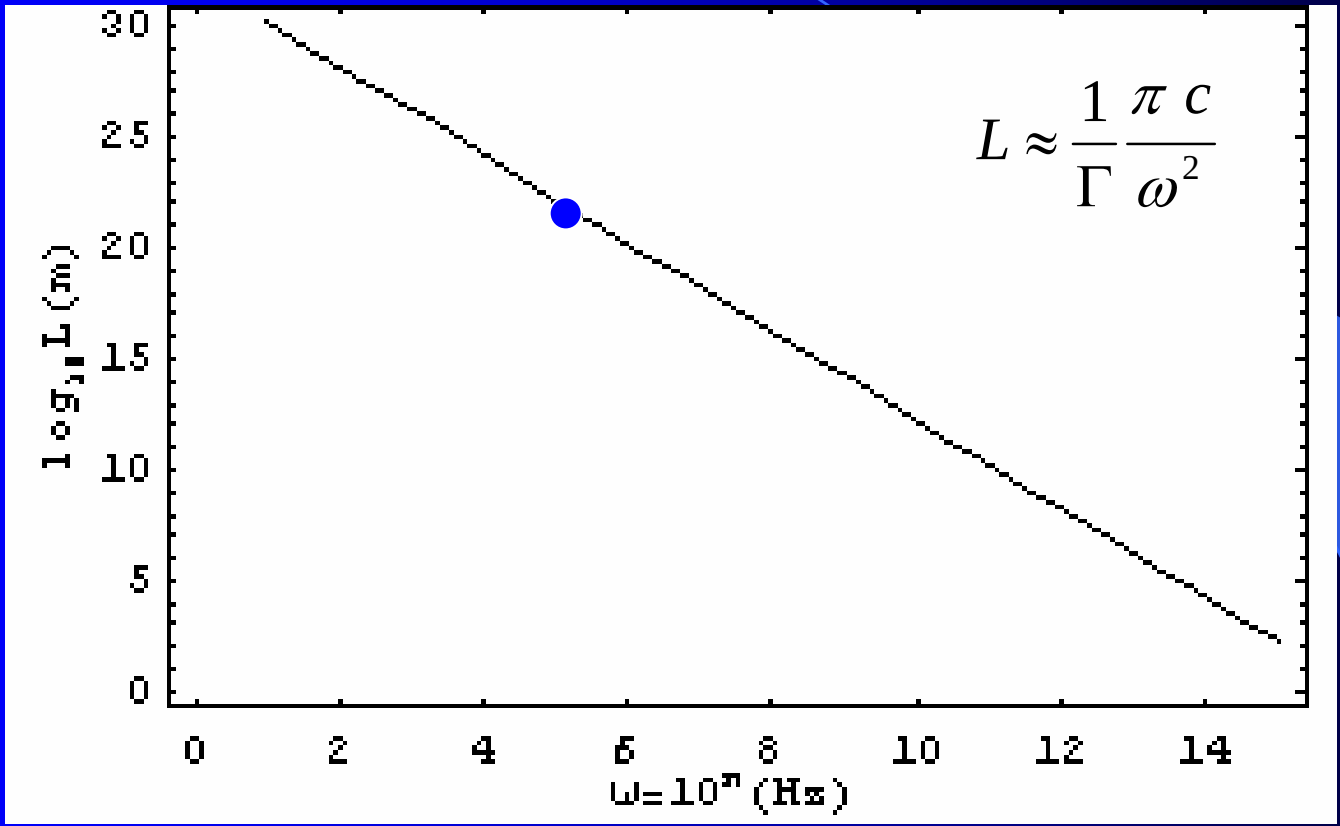



**FTL travel in a tachyonic mode**

# Tunneling probability of the Spaceship through the light barrier vs. Cutoff of the ZPF field

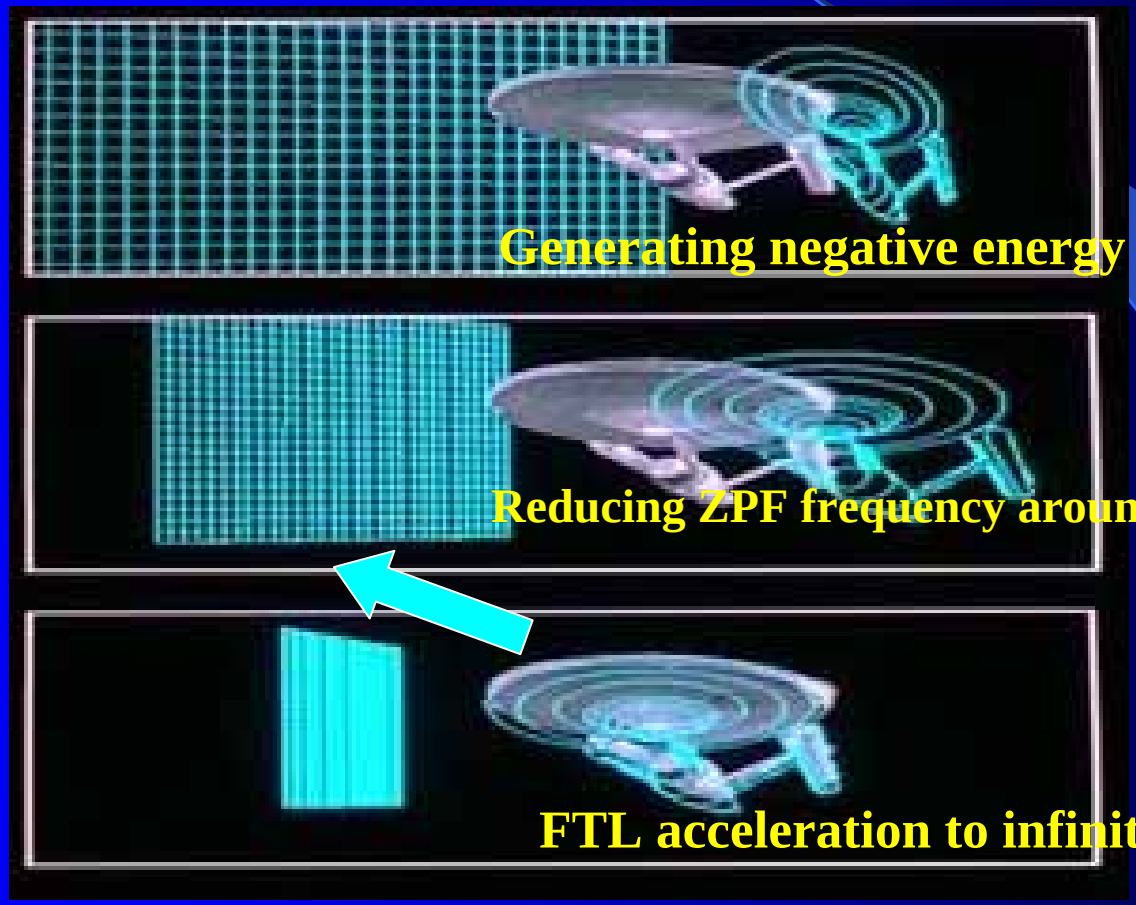


# Traveling Distance vs. Cutoff frequency of ZPF field




**ZPF frequency inside the volume surrounding ship is reduced to $10^5$/s for the ship moving with the speed of 1% of light velocity, the spaceship can warp over the distance the twice of the diameter of our galaxy.**

# Concept of the ZPF Warp drive



# Energy required for the ZPF Warp Drive

$$E = \frac{4\pi}{3} R^3 \int_{\omega_0}^{\omega_c} \frac{\hbar \omega^3}{2\pi^2 c^3} d\omega = \frac{\hbar R^3}{6\pi c^3} (\omega_c^4 - \omega_0^4)$$

**If we suppose R=50m, the negative energy for canceling the ZPF energy required for the warp travel becomes the order of $2 \times 10^8$ Joule, which is the energy equivalent to the mass of 23 kg.**

# Quantum tunneling through the light barrier

**FTL speed travel would make us possible to explore far distant galaxies in the Universe.**

# Conclusions

- In this presentation, the author presents an advanced theory that the spaceship can be traveled at FTL speed by applying the theory on ZPF field proposed by Puthoff.
- From the theoretical analysis, it can been seen that the FTL travel can be achieved by the quantum tunneling effect induced by the manipulation of the ZPF energy around the spaceship.


The End