# A SPACE-TIME
# AS A PERFECT FLUID SINK FLOW

Bayarsaikhan Choisuren [1, *]

*[1] Institute of Physics and Technology, Mongolian Academy of Sciences,*
*Postal Office-51, 15-r Bair. Toot-14, Bayanzurkh District, Ulaanbaatar 13344, Mongolia*

## Abstract

This paper assumes that an extraordinary invisible spatial perfect fluid sink flow that has a *critical flow speed* equal to light speed *c,* which can be treated as four-dimensional Minkowski continuum. As considering all elementary particles act as spatial perfect fluid sinks of infinitesimally small strengths, Newtonian dynamics can be extended while theoretically deriving formulas of the relativistic mass increase and the inverse square law of gravity, with an additional term that may represent the Pioneer anomaly.

A mass-generation mechanism is alternatively explained on base of the spatial perfect fluid space.

Scientific interpretations of concepts of mass and electric charges, and also accelerating expansion of the Universe, cyclic model of Big Rip and Bing Bang, are made.

**Key words:** Lagrange points, *Critical flow speed,* Stable and unstable manifolds, Hyperbolic equilibrium point, Null homotopic heteroclinic orbit, Isocline, Nullcline, Lagrangian representation, Eulerian description, Reynolds Transport Theorem, First Mean Value Theorem

_____

∗ Electronic address:  bayarsaikhan@ipt.ac.mn , ch.bayarsaikhan@yahoo.com

## 1.  INTRODUCTION

In this paper, we assume space-time as an extraordinary invisible perfect fluid filling all available free space throughout the entire Universe, while flowing inward toward all material objects and having created all subatomic particles in a form similar to a singular sink. A fundamental property of the space-time as a perfect fluid sink flow field is characterized by a *critical flow speed* equal to light speed $c$, above which a viscosity is locally generated in shearing flow, while producing infinitesimally small singular sinks in a form of spinning bubble (i.e. here it is preferred as *critical flow condition or superluminal relative flow condition* of spatial fluid). Here sub-atomic particles such as electron and quarks, etc. are envisioned as a singular sink of the spatial fluid with an infinitesimally small sink strength and their relativistic mass increase is caused by a change in their sink rates of spatial fluid. Gravitational force fields including inertial force are described by superposition of spatial fluid uniform flow and spatial fluid sink flow fields generated by the gravitating bodies and also its Lagrange points are presumed to be hyperbolic equilibrium points within the resulting flow fields for a system of the gravitating bodies. The relative motion in Special and General Theory of Relativity is perceived to be a motion of a material object relative to its ambient spatial fluid (i.e. relative to space itself). If one assumes it, the equivalence principle in the Special Theory of Relativity, the accelerating expansion of the universe, galaxy rotation problem, astrophysical jets and Pioneer anomaly and etc. may become clear and uncomplicated physical phenomena.

## 2. MASS

If one ideally imagines as a single body exists completely alone in free space, the body may be maintained in an equilibrium position due to equal pressures exerted upon it from all directions. In an ideal case, a body is at rest relative to an observer in a reference frame fixed to a faraway spatial fluid being at rest relative to the body. The spatial fluid being at rest can thus be treated as an absolute space. In other respects, one could conceive that the position of the body at absolute rest may be uncertain with respect to the absolute rest frame, while the velocity of the body relative to the absolute rest frame is definitely equal to zero.

Moreover, one may ideally imagine both the rest body and all the spatial fluid flowing inward toward the body as forming a single closed dynamical system bounded by an outermost spherical surface of an "infinite" radius $R_\infty$, through which the spatial fluid flow velocity $\vec{V}(R_\infty)$ is zero, as shown in Fig. 1. The outermost spherical surface could correspond to the initial position of the spatial fluid flowing toward the mass center of a body from its initial position, for when the body was once primarily created at an initial time. From the Lagrangian representation for fluid flow, the outermost spherical surface can be modeled as a spherical Lagrangian material surface that has moved inward toward the absolute rest body while following the spatial fluid that initially flowed toward the body.

The Lagrangian time will be denoted by $t_L$. Purely for the convenience of mathematical calculation, the accelerated velocity of the inward flow can be treated abstractly as if the flow subsequently attained the *critical flow velocity, c* equal to light speed, in the vicinity of the center of mass of the rest body in an "infinite" time.
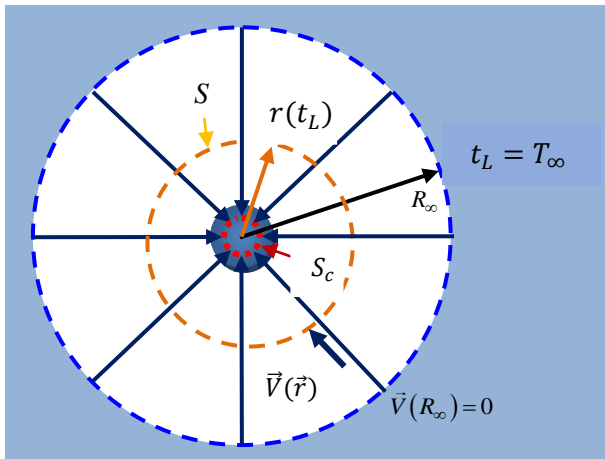


FIG. 1. (Color) A body at absolute rest in free space. The dashed blue circle illustrates the ***outer most equipotential surface***. The orange dashed circle illustrates a current equipotential surface $S$. The red square dot circle illustrates the ***horizon surface*** $S_c$. The light blue background illustrates an unmoving or a stationary spatial fluid being far away from the body.

Within this abstract description, another spherical equipotential surface, through which the flow speed equals the *critical flow speed, c* along its streamlines normal to it, can be formulated: this abstract equipotential surface is called here as a closed *horizon surface* $S_c$ of radius $r_0$, as shown in Fig. 1. And then, we consider the Lagrangian time $T_\infty$

that can be the same for every material object, for which spatial fluid has flowed to the *horizon surface $S_c$* from its initial position at rest and an initial time. By applying the abstract scenario, the constant Lagrangian time $T_\infty$ may also give rise to the age of the universe. If the spatial fluid flow is assumed to be incompressible and inviscid (i.e. potential flow) exterior to the *horizon surface $S_c$*, all the spatial fluid flowing towards the body sinks into the region bounded by the closed *horizon surface $S_c$*. For the body at absolute rest in free space, we define an average mass density function $\bar{\rho}_m(r)$ over an arbitrary volume $\Omega(r)$ bounded by the current concentric spherical surface $S(r)$. In this case, the non-vanishing mass density function $\bar{\rho}_m(r)$ is defined as $\bar{\rho}_m(r) = m_0/\Omega(r)$, where $m_0$ is a rest mass of the body. The rest mass of the body for the closed dynamical system can be evaluated by spatially integrating the average mass density function $\bar{\rho}_m(r)$ over a volume $\Omega(R_\infty)$ in the center-of-mass frame. The rest body produces a spatial fluid flow field that is spherically symmetric with respect to its center of mass. Taking into account the spatial fluid potential flow, the volume integral can be converted into a product of an integral over a current equipotential surface $S(t_L)$ and a definite integral over the Lagrangian time interval $[0,T_\infty]$ by using First Mean Value Theorem for definite integrals. The rest mass is thus expressed in the center-of-mass frame as follow

$$m_0 = \int_{\Omega(R_\infty)} \bar{\rho}_m(r)d\Omega = \int_0^{R_\infty} \int_{S(r)} \bar{\rho}_m(r)(d\vec{s}\cdot d\vec{r}) = -\int_0^{T_\infty}\left[\int_{S(t_L)} \bar{\rho}_m(r(t_L))(\vec{V}(\vec{r}(t_L))\cdot d\vec{s})\right]dt_L$$

$$= -\oint_S (\vec{V}(\vec{r})\cdot d\vec{s})\int_0^{T_\infty} \bar{\rho}_m(r(t_L))dt_L = 4\pi\bar{\rho}_m T_\infty r^2 V(r) = 4\pi\rho_\infty n T_\infty r_0^2 c \tag{1}$$

where the radial vector element along a streamline is written as $d\vec{r} = -dt_L\vec{V}(\vec{r}(t_L))$ and $\vec{V}(\vec{r}(t_L))$ is the Lagrangian flow velocity through the current equipotential surface $S(r)$, $r_0$ is the radius of the spherical *horizon surface $S_c$* and $\vec{r}(t_L)$ is Lagrangian position vector in the center-of-mass frame. $\rho_\infty = \bar{\rho}_m/n$, $\rho_\infty$ is considered as a density of spatial fluid and $n$ is for the spatial fluid flow that spanned time of $T_\infty$ occurred $n$ times for the age of universe and $\bar{\rho}_m$ is an average density of the body over the volume $\Omega(R_\infty)$. The age of universe is defined as $nT_\infty$.

$$\bar{\rho}_m \equiv \lim_{r\to R_\infty} \bar{\rho}_m(r) = \lim_{t_L\to T_\infty} \frac{m_0}{\Omega(r(t_L))} = \bar{\rho}_m(T_\infty)$$

The mass of any material object is defined as the amount of spatial fluid that has been being accumulated within the object since a time the atoms and subatomic particles, etc., were created. From Eq.1, the mass of any material object can be represented in the form of a Gaussian surface integral as follows

$$m = -\rho_\infty T_\infty \oint_S (\vec{V}(\vec{r})\cdot d\vec{s}) \tag{2}$$

where $S$ is an arbitrary closed surface enclosing the material object. We have taken as $n=1$ for $\rho_\infty = \bar{\rho}_m/n$, $\rho_\infty$ is a density of spatial fluid and $T_\infty$ can be considered as the age of universe.

## 3. INERTIAL AND GRAVITATIONAL FORCES

For a body uniformly moving through an unmoving stationary spatial fluid, the resulting flow field can be described as superposition of a spherical symmetric sink flow of spatial fluid and a uniform spatial fluid flow at speed of $v$, which the stationary spatial fluid can be seen as a uniform flow at the speed of $v$ relative to the uniformly moving body through, shown in Fig. 2. As for the body initially at rest relative to an unmoving spatial fluid being far away from it, when it undergoes an uniform motion or started to accelerate uniformly from its initial position at rest, the spherical symmetric sink flow field as shown in Fig.1 is topologically transformed into an axial symmetric flow, depicted in Fig. 2 We consider that this topological transformation of the spatial fluid flow occurs at speed of light, $c$ for a time interval $\Delta t$ in order to be that its displacement occurs at its maximum speed of $c$ of frictionless motion.

$\vec{v}$

A

Here, the relative speed, between the flow to the body and a rotating motion of the "*Motionless spatial fluid parcel*", exceeds light speed by c/2+ΔV, during the acceleration.

A

$\vec{v}$   $\vec{V}(r)$   c/2   $\vec{V}(r)$   $L_1$   $\vec{V}(r)$   $\vec{v}$

$r$   $\theta$
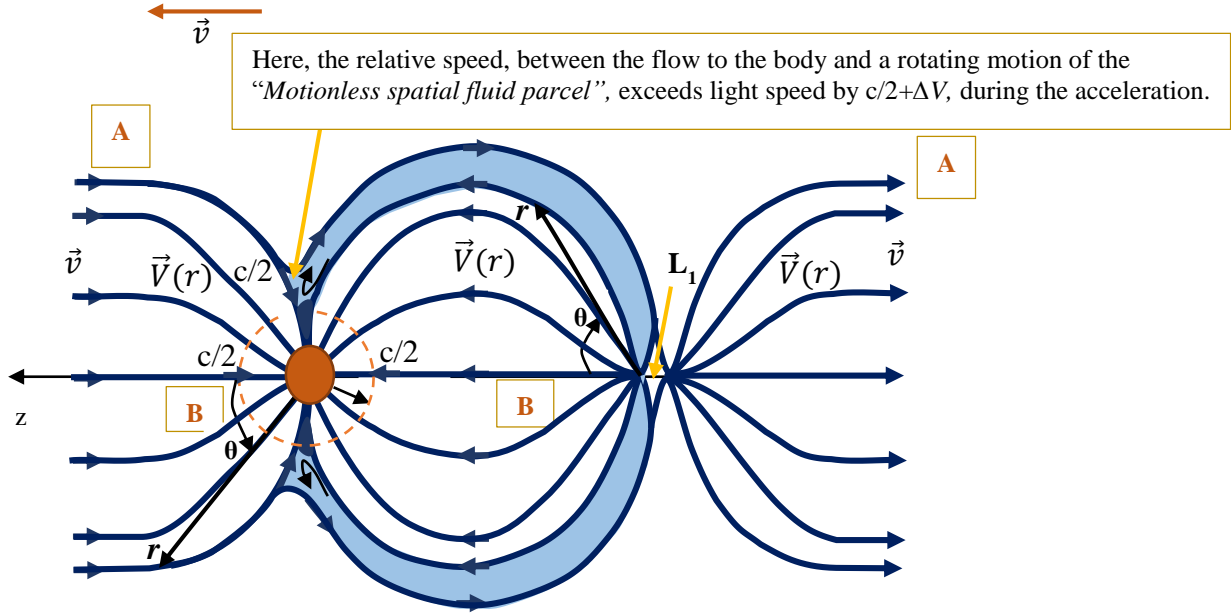
c/2   c/2

B   B

z

$\theta$

$r$

FIG. 2. (Color) A body uniformly accelerating through static or unmoving spatial fluid. This resulting flow field is axially symmetric, which is depicted as its cross sectional image, in which letter **A** indicates uniform flow part and letter **B** indicates potential flow part. The orange dashed circle indicates an equipotential surface through which flow speed is c/2. $L_1$ is a liberation point referred to as Lagrange point where hyperbolic equilibrium point is generated and streamline separation (a bifurcation) occurred at the point $L_1$. $\vec{v}(t)$ is an instantaneous velocity of the accelerating body. The light blue parcel in the flow field is the "*motionless parcel* of spatial fluid". c/2+ΔV is speed of circular motion of "*motionless parcel* of spatial fluid", which is in the opposite direction to the relative flow speed of c/2 toward the body, during an acceleration of the body. The bold red arrow indicates the direction of motion of the body at velocity of $\vec{v}$.

Let us consider a body being at absolute rest, shown Fig. 1 and then without regard to a cause of its acceleration in an abstract scenario, once the rest body started to accelerate from its initial position while transforming its flow structure into the topologically different flow structure depicted in Fig.2. There is a hyperbolic equilibrium point, $L_1$ at which flow speed reaches the *critical flow speed*, $c$ due to a pressure gradient to the singular point of hyperbolic equilibrium point, $L_1$ (i.e. it is a saddle-node bifurcation in continuous dynamical system where nullcline occurs). Here, two potential flows are produced from the point, $L_1$ (i.e. there are two unstable manifolds of the fixed point and two stable nullclines), which are directed into opposite directions, and their flow speed can be equally treated as $V(r) = Q/r^2$ where $Q$ is a volume metric flow rate for a solid angle of a cone as $\theta$ and $r$ is a radial distance from the point, $L_1$. When the body undergoes a rectilinear motion at a constant velocity $\vec{v}$, its spatial fluid flow structure remains unchanged while keeping balance of the dynamic pressures upon the body from all directions. This balanced flow toward the body keeps its motion at a constant velocity relative to its ambient spatial fluid without any friction. However, during an acceleration or deceleration, the dynamic pressure in front of the body (i.e. a sink of spatial fluid) may be initially increased or decreased, respectively, due to a change in pattern of its flow field of spatial fluid caused by a change in its translational velocity $\vec{v}$. Consequentially, a change in flow velocity toward the rear of the body may lag behind the change in flow velocity in front of the moving body during an acceleration or deceleration only. This retardation of the change in flow velocity toward the rear of the body may occur in each unit of time while generating imbalance of the dynamic pressures on the accelerating or decelerating body for separated inviscid flows from the same separation point at the "*motionless spatial fluid parcel*", shown in Fig.2. **This generated imbalance (a difference in) of the dynamic pressures from all directions toward the accelerated body causes either inertial force or gravitational force due to the locally arisen friction produced by a spatial fluid flowing at a superluminal speed relative to the "*motionless spatial fluid parcel*" within its flow field, which takes place during a material object's acceleration only (i.e. If the singular point $L_1$ moves at a speed equal to $\Delta v$ toward the accelerating body in order to keep the fixed point $L_1$ in equilibrium, a friction will locally arise due to the spatial fluid speed passing by very closely at the fixed point $L_1$, relative to the "*motionless spatial fluid parcel*", exceeds light speed, $c$.).** More explicitly, taking into account the *critical flow condition*, during the acceleration only, when

the singular point, **L₁** approaches at speed, approximately equal to $\Delta v$ toward the accelerated body, the "*motionless spatial fluid parcel*" starts to rotate within the flow field, while contracting with a change in its volume, due to the spatial flow speed of ( $c + \Delta v$ ) passing by very closely at the fixed point **L₁**, relative to the "*motionless spatial fluid parcel*", in the vicinity of the fixed point, **L₁**. As a result, a superluminal motion is generated by a relative speed between the opposite flows, equal to ( $c + \Delta v$ ) in the vicinity of an equipotential surface enclosed the body, through which flow speed is $c/2$ equally along its streamlines, as shown in Fig.2. Consequently, there infinitesimally small bubble sinks of spatial fluid (e.g. it can be treated as virtual particles) are produced under an increased static pressure within the rotating "*motionless spatial fluid parcel*", while generating a friction to prevent the motion accelerating and causing an increase in the spatial fluid sink rate of the accelerated body. The friction caused by the superluminal flow speed relatively between the flow to the body and a rotating motion of the "*motionless spatial fluid parcel*", which locally occurred in the vicinity of the equipotential surface of speed of $c/2$, while it may also give rise to produce the imbalance (a difference in) of dynamic pressures from all directions toward the accelerated body to generate inertial force and the retardation of the separated flows from the same separation point at the same time to get to the opposite sides of the body. During a deceleration, however any superluminal flow of spatial fluid does not occur, there the infinitesimally small bubble sinks of spatial fluid are broken down due to a decreased static pressure within the "*motionless spatial fluid parcel*", expanding its volume, within the spatial fluid flow field generated by the decelerated body, while generating a friction to prevent its motion decelerating and causing a decrease in the spatial fluid sink rate of the decelerated body.

As assuming that the mechanism in the same way to generate inertial force and gravitational force can be given by the following equation of dynamic pressure:

$$F_{inert} = \frac{m_o}{D_{inert}\frac{2\Delta r}{r}}\left(\left(\frac{c}{2}+\Delta V(r)\right)^2 - \left(\frac{c}{2}\right)^2\right) = m_o\left(1+\frac{V(r)}{c}\frac{2\Delta r}{r}\right)\frac{cV(r)}{D_{inert}} \tag{3}$$

where $V(r) = Q/r^2$ and $Q$ is a volume metric flow rate for a solid angle of a cone as $\theta$ and $r$ is a radial distance from the point, **L₁** and the change in flow velocity, caused by the acceleration or deceleration, can be taken as $\Delta V(r) \approx V(r)2\Delta r/r$, $D_{inert}$ is a drag coefficient for the difference in the dynamic pressures pertaining inertial force, $m_o$ is a rest mass of the body and $\Delta r$ is a displacement of the singular point, **L₁** for a time interval $\Delta t$ within the potential flow field of spatial fluid produced by the body. Then the Eq. 3 can be treated as

$$F_{inert} = m_o \frac{\Delta v}{\Delta t} \tag{4}$$

where $\Delta t = D_{inert}/c$, consider the accelerated motion started from the body's initial position at rest, $V(r) \approx v = \Delta v$ on intersection between the uniform flow field and potential flow field shown in Fig.2, $\Delta v/\Delta t = cV(r)/D_{inert}$, $V(r)/c \prec\prec 1$, $2\Delta r/r \prec\prec 1$ and as considering that a length of the longitudinal "*motionless spatial fluid parcel*" is approximately equal to $4r$ where the spatial fluid flows at speed of $c/2$ along its outside boundary due to the pressure gradient toward the "*motionless spatial fluid parcel*".

**For gravitational force**, we consider the same mechanism for inertial force and gravitational force, the gravitational force is conceived as a sink flow of spatial fluid, being in a spatial fluid bulk flow directed radially inward toward a massive body, (i.e. a superposition of two sink flow fields, having incomparable net flow rates). Let us now discuss the topological structure of the resulting spatial fluid flow field produced by a system of two sinks having incomparable net flow rates in free space. We predict that the resulting flow field generated by the system, in which a global bifurcation occurs, takes a shape of a horseshoe orbit about the massive body, where the positions of hyperbolic equilibrium points are denoted by the bold letters **L₁**, **L₂**, **L₃**, **L₄**, and **L₅** as shown in Fig.3 [1]. The hyperbolic equilibrium points are referred to as the Lagrangian points as **L₁**, **L₂**, **L₃**, **L₄**, and **L₅**. All the equilibrium points in the horseshoe-shaped flow pattern are connected by null homotopic heteroclinic orbits (i.e., streamlines) [1]. There a nullcline also arises between two disjoint adjacent null homotopic heteroclinic orbits along which the spatial fluid

flows in opposite directions. Consequently, pressure gradients at the maximum magnitude are produced in opposite directions normal to the nullcline. At the *critical flow condition*, the flow speeds along the heteroclinic orbits uniformly reach the *critical flow speed* c, so that all the heteroclinic orbits are null homotopic. Fig.3 shows a secondary body situated in a sphere bounded by the null homotopic heteroclinic orbits that pass by the equilibrium points $\mathbf{L_1}$ and $\mathbf{L_2}$, respectively. This sphere is called here as the Hill sphere. The spatial fluid outside the Hill sphere, which is supposed to sink into the secondary body, initially flows inward along the stable manifold of the point $\mathbf{L_2}$. The spatial fluid is continuously delivered to the point $\mathbf{L_1}$ from the point $\mathbf{L_2}$ through the null homotopic heteroclinic orbits, after which the spatial fluid flows toward the secondary body as usual within the Hill sphere. There a spatial fluid flow with a net flow rate equal to half of the net flow rate of spatial fluid sink into the secondary body also sinks into the massive body through another null homotopic heteroclinic orbit that is from the point $\mathbf{L_1}$ to the barycenter $\mathbf{L}$ as being directly delivered to the massive body. Within the Lagrangian representation, a spatial fluid passing by the point $\mathbf{L_2}$ at the instantaneous Lagrangian time $t_L$ spends a time interval, $\Delta t_L$ to travel to the point $\mathbf{L_4}$ (or to the point $\mathbf{L_5}$) from the point $\mathbf{L_2}$. Thus, the spatial fluid at the equilibrium point $\mathbf{L_2}$ travels along the null homotopic heteroclinic orbit connecting the points $\mathbf{L_2}$, $\mathbf{L_4}$ (or $\mathbf{L_5}$) and back to the point $\mathbf{L_2}$ for a time interval of $2\Delta t_L$, to return to the point $\mathbf{L_2}$. However, as Fig.3 shows, if the spatial fluid travels along another null homotopic heteroclinic orbit connecting the points $\mathbf{L_2}$, $\mathbf{L_4}$ (or $\mathbf{L_5}$), $\mathbf{L_3}$, $\mathbf{L}$, and $\mathbf{L_1}$, it takes a time interval of $10\Delta t_L$ to reach the point $\mathbf{L_1}$ from the point $\mathbf{L_2}$. Therefore, for the two specified flows of spatial fluid from the point $\mathbf{L_2}$ at the same instantaneous time $t_L$, one spatial fluid flow arrives at the point $\mathbf{L_1}$ later than other spatial fluid flow that returns to the point $\mathbf{L_2}$. Therefore, a time delay of $8\Delta t_L$ occurs between the two specified spatial fluid flows that arrive at the unstable manifolds of the points $\mathbf{L_2}$ and $\mathbf{L_1}$ within the Hill sphere, as shown in Fig.3. Consequently, this time delay of $8\Delta t_L$ between the spatial fluid flow from the point $\mathbf{L_2}$ toward the secondary body and another spatial fluid flow from the point $\mathbf{L_1}$ toward the secondary body within the Hill sphere may occur in each unit of time while generating imbalance of the dynamic pressures on the secondary body.

In the same way of the mechanism to generate inertial force, there this generated imbalance of the dynamic pressures and a friction caused by the superluminal flow of spatial fluid locally occurred in the vicinity of the equipotential surface through which flow speed is $c/2$ along its streamlines within the Hill sphere may result in generating gravitational force.
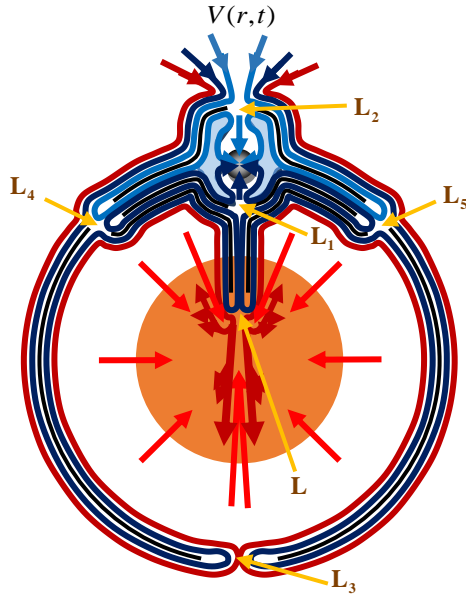


FIG.3. (Color online) Cross sectional topological structure of the resulting flow field generated by two bodies with incomparable masses. The dark red bold curves indicate the null homotopic heteroclinic orbits through which the spatial fluid is directly delivered into the mass center $\mathbf{L}$. The dark blue bold curves indicate the null homotopic heteroclinic orbits through which the spatial fluid is delivered to the equilibrium point $\mathbf{L_1}$. The blue bold curves indicate the null homotopic heteroclinic orbits through which the spatial fluid is delivered to the equilibrium point $\mathbf{L_2}$. The black curves indicate where zero resultant flow speed for oppositely directed flows (nullcline). A small secondary body is located in a sphere bounded by null homotopic heteroclinic orbits, which pass by the equilibrium points $\mathbf{L_1}$ and $\mathbf{L_2}$. The sphere is referred to as the Hill sphere. The white blue parcel within the Hill sphere illustrates the "*motionless spatial fluid parcel*".

As assuming that the same mechanism of inertial force and gravitational force, the gravitational force exerted upon unit mass of a secondary body by a massive body can be given by the following equation of dynamic pressure:

$$F_{grav} = \frac{1}{D_{grav}\frac{2\Delta r}{r}}\left(\left(\frac{c}{2}+v+\Delta V(r)\right)^2 - \left(\frac{c}{2}+v\right)^2\right) = \left(1+\frac{2v}{c}+\frac{V(r)}{c}\frac{2\Delta r}{r}\right)\frac{cV(r)}{D_{grav}} \tag{5}$$

where $V(r) = Q/r^2$ and $Q$ is a volume metric flow rate and $r$ is a radial distance from the barycenter, **L** shown in Fig.3 and the change in flow velocity, caused by the generated imbalance of the dynamic pressures and a friction caused by the superluminal flow of spatial fluid locally occurred in the vicinity of the equipotential surface through which flow speed is $c/2$ along its streamlines within the Hill sphere, can be taken as $\Delta V(r) \approx V(r) 2\Delta r/r$, $D_{grav}$ is a drag coefficient of the dynamic pressure for gravitational force, $\Delta r$ is a displacement of the singular point, **L₂** for a time interval $8\Delta t_L$. Then the Eq.5 can be treated as

$$F_{grav} = \left(1 + \frac{2v}{c}\right)\left(\frac{1}{4\pi\rho_\infty T_\infty}\frac{c}{D_{grav}}\right)\frac{4\pi\rho_\infty T_\infty V(r)r^2}{r^2} = \left(1 + \frac{2v}{c}\right)G\frac{M}{r^2} \tag{6}$$

where $G$ is gravitational constant that is expressed as $G = c/\left(4\pi\rho_\infty T_\infty D_{grav}\right)$, $M = 4\pi\rho_\infty T_\infty V(r)r^2 = 4\pi\rho_\infty T_\infty c r_0^2$ from Eq.1, $v$ is radial speed of an uniform motion of one unit mass of secondary body relative to the massive body, $V(r)/c \prec\prec 1$, $2\Delta r/r \prec\prec 1$ and $r$ is a radial distance from the barycenter, **L**, $V(r)$ is speed of spatial fluid flow toward the massive body. The second term in Eq.6 corresponds Pioneer Anomaly. Gravitational constant can be written as

$$G = \frac{r_s c^2}{2M} = \frac{c}{4\pi\rho_\infty T_\infty D_{grav}}, \quad D_{grav} = \frac{2M}{4\pi\rho_\infty T_\infty r_s c} = 2\frac{4\pi\rho_\infty T_\infty c r_0^2}{4\pi\rho_\infty T_\infty r_s c} = 2\frac{r_0^2}{r_s} \text{ and } G = \frac{1}{4\pi\rho_\infty T_\infty}\frac{r_s c}{2r_0^2} \tag{7}$$

here $M$ is mass of the massive body, $r_s$ is Schwarzschild radius, $r_0$ an imaginary equipotential closed surface (the *horizon surface $S_c$*) through which flow speed is the *critical flow speed, c* for the massive body in Eq.1.

## 4. RELATIVISTIC MASS INCREASE

A change in mass occurs due to a change in spatial fluid sink rate of the body that undergoes an accelerated or decelerated motion relative to its ambient spatial fluid, caused by the oppositely directed flows whose relative velocity exceeds the light velocity, near to its center of mass as mentioned above, while transforming its streamline pattern at speed $c$ where its displacement is $c\Delta t$, as mentioned in Section 3 and shown in Fig.2. For a body that undergoes uniformly accelerated translational motion from its initial position at rest, relative to its unmoving spatial fluid being far away from it, the relativistic mass equation can be obtained by using the Reynolds Transport Theorem:

$$\frac{D}{Dt_L}m(t_L) = \frac{D}{Dt_L}\int_{\Omega(t_L)}\bar{\rho}(\vec{r}(t_L),t_L)d\Omega = \int_{\Omega(\vec{r})}\frac{\partial\bar{\rho}(\vec{r},t)}{\partial t}d\Omega - \oint_{\partial\Omega(\vec{r})}(\vec{V}(\vec{r},t)\cdot\hat{n})\bar{\rho}(\vec{r},t)ds$$

$$= \int_{\Omega(t)}\left(\frac{\partial\bar{\rho}(\vec{r},t)}{\partial t} - \frac{\partial(\vec{V}(\vec{r},t)\bar{\rho}(\vec{r},t))}{\partial\vec{r}}\right)d\Omega = 0 \tag{8}$$

where $\hat{n}(\vec{r},t)$ is a unit normal vector to the surface element $ds$ and spatial superfluid flow velocity is defined as $\vec{V}(\vec{r}) = -d\vec{r}(t_L)/dt_L$ in Lagrangian representation. $\partial\Omega(t_L)$ is taken as a material surface that is coincident with an equipotential surface through which spatial superfluid flow speed $\vec{V}(\vec{r})$, $t_L$ is a time in Lagrangian representation, $\bar{\rho}(\vec{r},t)$ is average mass density function over the volume $\Omega(\vec{r})$, $\vec{v}(\vec{t})$ is an instantaneous velocity of the accelerated body. The element of radial vector $d\vec{r}$ in Eq.8 is conceived as an infinitesimally small change in flow field pattern and so it can be written as $d\vec{r} \approx \hat{n}_z cdt$ where $\hat{n}_z$ is a unit vector of displacement for the change of its spatial fluid flow pattern parallel to the acceleration in z-axial direction in the center-of-mass frame as shown in Fig.2. Thus, from Eq.8, we obtain the following equation:

$$\frac{\partial \bar{\rho}(\vec{r},t)}{\partial t} - \frac{1}{c}\frac{\partial((\vec{V}(\vec{r},t)\cdot\hat{n}_z)\bar{\rho}(\vec{r},t))}{\partial t} = 0 \tag{9}$$

In Eulerian description, as assuming that the body started to accelerate from the *absolute rest position* at its initial time $t = 0$, after taking the definite integral over a time interval $[0, t]$, from Eq.9 the following equations are obtained as

$$\bar{\rho}(\vec{r},t) - \bar{\rho}(\vec{r},0) = \frac{1}{c}(\vec{V}(\vec{r},t)\cdot\hat{n}_z)\bar{\rho}(\vec{r},t) \text{ and } \bar{\rho}(\vec{r},t) = \frac{\bar{\rho}(\vec{r},0)}{1 - \frac{1}{c}(\vec{V}(\vec{r},t)\cdot\hat{n}_z)} \tag{10}$$

then mass of the body is given by

$$m = \int_{\Omega(\vec{r})} \frac{\bar{\rho}(\vec{r},0)}{1 - \frac{1}{c}(\vec{V}(\vec{r},t)\cdot\hat{n}_z)}d\Omega \tag{11}$$

The average mass density function in Eq.11 is axially symmetric in the center-of-mass frame and on the intersection between the uniform flow field and the potential flow field, magnitude of the flow velocities are $V(\vec{r},t) \approx v$ as mentioned in Section 3 and shown in Fig.2; By using First Mean Value Theorem for definite integrals, the volume integral is taken as

$$m = \int_0^R \int_0^\pi \int_0^{2\pi} \frac{\bar{\rho}(r,\theta,\varphi)}{1 - \frac{v}{c}\cos(\theta)}r^2 dr\sin(\theta)d\theta d\varphi = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \text{ and } \frac{4\pi\rho_\infty T_\infty V(r)r^2}{\sqrt{1 - \frac{v^2}{c^2}}} = \frac{m_0}{\sqrt{1 - \frac{v^2}{c^2}}} \tag{12}$$

Taking into consideration the change in flow field pattern caused by a slight increase in its sink rate takes place in z-axial direction in the center-of-mass frame, the slight change in the flow pattern occurs, while keeping the flow speed as $v \approx V(x,y,z,t) = |\vec{V}'(x,y,z+dz,t)| = |d\vec{r}'/dt'|$ that can be treated as a 4-dimensional Space-Time, and Lorentz contraction is obtained as $z = (z+dz)\sqrt{1 - v^2/c^2}$.

## 5. CONCLUSION

We presume that dynamically curved space-time, time dilation and length contraction in Special and General Theory of Relativity can be characterized by a change in sink flow field pattern of spatial fluid caused by a change in the spatial fluid sink rate of material objects. Also it is conceived that light propagates through a vacuum at light speed, $c$ constantly relative to its ambient spatial fluid only. Consequently, a resulting spatial fluid sink flow field produced by system of celestial stars and galaxies, as imagining them as sinks of spatial fluid, may have much complex streamline pattern. Since consider that Lagrange points are hyperbolic equilibrium points in spatial fluid flow field, it is presumed that if a spacecraft flies directly through Lagrangian point $L_2$ or $L_1$ in a certain direction for the earth-moon system, the spacecraft may pick up much kinetic energy without burning its fuel.

The *superluminal relative flow condition* of spatial fluid may be manifested in Heisenberg's uncertainty principle.

Furthermore, spatial fluid may be composed of "positive" spatial fluid and "negative" spatial fluid (i.e. anti-spatial fluid). For charged particles, during sinking into a charged elementary particle, sink strengths of the "positive" and "negative" spatial fluid are unbalanced (i.e. slightly different in sink rate for them) while releasing the "positive" or "negative" spatial fluid on charged particles and the inflowing spatial fluid behaves like conically spiral infinitesimally narrow pipe shaped flow. Consequently, the released anti-spatial fluid from a charged particle results in locally creating quantum space and it also results giving rise to negative or positive electric charge. Moreover, magnetic field is caused by infinitesimally narrow conically spiral shaped spatial fluid flow with speed equal to the *critical flow speed*, $c$ toward a charged elementary particle, which behaves like lines of magnetic flux.

The *superluminal relative flow condition* of spatial fluid, mentioned in this paper and shown in Fig.2, may give rise to either the strong nuclear interaction or weak interaction, which is the key condition to produce a friction in the perfect spatial fluid.

As assuming the mass involved in its spatial fluid sink rate, we envisioned that in the beginning the Universe was created, just after the Big Bang, all material objects in the Universe existed in exactly the same way as now day's supermassive black holes that are located at the center of many galaxies. In other words, spatial fluid sink strength of those primordial "subatomic particles" in the primordial "supermassive black holes" that were once created during the Big Bang were much stronger than infinitesimally small spatial fluid sink rates of now day's ordinary subatomic particles. Since the beginning of the Universe, the spatial fluid strengths of the primordial "subatomic particles" within the primordial "supermassive black holes", have been being exponentially reduced and then when the strong sink strength of the primordial "subatomic particles" subsequently reached a certain threshold magnitude, the ordinary subatomic particles, which each has the same mass and charge, were released from the primordial "supermassive black holes" in some way, while creating galaxies that have residual parts of the gradually vanishing "primordial supermassive black hole" at their center, and also it resulting in the accelerating expansion of the Universe.

Furthermore, the exponentially reducing infinitesimally small spatial fluid sink strengths of subatomic particles that we have known as electron, positron and etc. will subsequently reach a certain threshold magnitude in an "infinite time" again, the Big Rip will occur and immediately after it, the Big Bang will take place to create A New Universe again.

## References

[1] Bayarsaikhan Choisuren and Itgel Bayarsaikhan, "New Aether Sink Model for Gravity", *Physics Essays Vol 26, No 2*, pages 205‑206, June 2013.