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Particularization of the Sequence of Spacetime/Intrinsic Spacetime Geometries and Associated Sequence of Theories in Metric Force Fields in the Four-world Picture to the Gravitational Field I

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Author's contribution

The sole author designed, analysed, interpreted and prepared the manuscript.

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ABSTRACT

The two stages of evolutions of metric spacetime and intrinsic metric spacetime and the associated spacetime/intrinsic spacetime geometries in long range metric force fields, derived in the four-world picture in previous articles, are particularized to the gravitational field. The theory of relativity on flat four-dimensional gravitational-relativistic metric spacetime $(\mathrm{IE}^3, c_s t)$ and the theory of intrinsic relativity on the underlying flat two-dimensional gravitational-relativistic intrinsic metric spacetime $(\varnothing\rho, \varnothing c_s \varnothing t)$, due to the presence of a long range metric force field in spacetime, as well as the absolute intrinsic metric theory (of the metric force field) on the curved 'two-dimensional' absolute intrinsic metric spacetime $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ with absolute intrinsic metric tensor $\varnothing\hat{g}_{ik}$, all of which evolve at two stages of evolutions of metric spacetimes and intrinsic metric spacetimes in long range metric force fields in general, developed in the previous articles, are adapted to the gravitational field.

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They become the theory of gravitational relativity (TGR) on the flat four-dimensional relativistic metric spacetime, the theory of intrinsic gravitational relativity (T∅GR) on the underlying flat two-dimensional relativistic intrinsic metric spacetime and the metric theory of absolute intrinsic gravity (MA∅G) on the curved 'two-dimensional' absolute intrinsic metric spacetime, which evolve at two stages of evolutions of metric spacetime and intrinsic metric spacetime in a gravitational field of arbitrary strength. The basic aspects of these coexisting theories in the gravitational field are developed.

Keywords: Simultaneous two stages of evolutions of spacetime/intrinsic spacetime; associated space-time/intrinsic spacetime geometries; particularization to the gravitational field; flat four-dimensional spacetime; curved 'two-dimensional' absolute intrinsic spacetime; absolute intrinsic metric tensor; metric theory of absolute intrinsic gravity; theory of gravitational relativity; gravitational length contrac-tion/time dilation.

1 INTRODUCTION

The special theory of relativity (SR) on flat four-dimensional proper spacetime and a newly added intrinsic special theory of relativity (∅SR) on a formally derived flat two-dimensional proper intrinsic spacetime, which underlies the flat four-dimensional proper spacetime, in assumed Newtonian gravitational field, are reformulated on a four-world background in a series of articles [1–4]. A new set of affine spacetime and intrinsic affine spacetime diagrams in the four-world picture are drawn, from which Lorentz transformation and intrinsic Lorentz transformation and the inverse are derived.

The new development in SR/∅SR in the four-world picture is extended to a general long-range metric force field of arbitrary strength in spacetime and its underlying long-range intrinsic metric force field in intrinsic spacetime in a series of articles [5–8]. Two stages of evolutions of metric spacetime and intrinsic metric spacetime in a general long-range metric force field and the underlying long-range intrinsic metric force field are isolated and the associated sequence of metric spacetime and intrinsic metric spacetime diagrams are developed progressively in those articles.

The two stages of evolutions of metric spacetime/intrinsic metric spacetime and the associated sequence of spacetime/intrinsic spacetime diagrams in long range metric force fields and long-range intrinsic metric force fields in general in the previous articles [5–8], are particularized to gravitational field of arbitrary strength in spacetime and a newly added intrinsic gravitational field in intrinsic spacetime in section 2 of this article. Gravitational and non-gravitational parameters, such as gravitational potential and field, mass, energy, electric and magnetic fields, etc, and their intrinsic counterparts, undergo two stages of evolutions along with spacetime and intrinsic spacetime in the gravitational field. The basic aspects of the theories of gravity and theories of intrinsic gravity encompassed by the sequence of diagrams are formulated in sections 3 and 4.

The two stages of evolutions of spacetime/intrinsic spacetime and the associated sequence of spacetime/intrinsic spacetime geometries developed in long-range metric force fields in general in the previous articles [5–8] and their particularization to the gravitational field in this article, are pure novel effort of the author. No related work in physics or mathematics exists in the open literature, as far as can be found. This thereby limits the references in this paper to the previous papers of the author cited above, upon which this paper is based essentially. It is to be remarked however that the progression made in the present work from SR/∅SR flat spacetime/flat intrinsic spacetime in a four-world picture in [1–4] to the theories of gravity and theories of intrinsic gravity on flat spacetime and curved intrinsic spacetimes in the four-world picture in [5–8] and this article, follows the same trend as Einstein's progression from the special relativity on flat spacetime [9] to the general theory of relativity on curved spacetime in the gravitational field [10].

2 METRIC SPACETIME/ INTRINSIC METRIC SPACE-TIME GEOMETRIES AT THE FIRST AND SECOND STAGES OF EVOLUTIONS OF SPACETIME/ INTRINSIC SPACETIME IN THE GRAVITATIONAL FIELD IN THE FOUR-WORLD PICTURE

2.1 The First Stage of Evolutions of Spacetime/Intrinsic Spacetime and Parameters/ Intrinsic Parameters in the Gravitational Field

Let us start by reproducing the geometry of Fig. 7 of [7], reproduced as Fig. 2 of [8], which existed with the assumed absence of long-range metric force field (or prior to the first stage of evolution of spacetime and intrinsic spacetime in long-range metric force fields) in our universe, as Fig. 1 of this article. The absence of absolute intrinsic Riemannian metric spacetime geometry implies the absence of curved 'two-dimensional' absolute intrinsic metric spacetime $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ and its projective flat (or non-curved) 'two-dimensional' absolute proper intrinsic metric spacetime $(\varnothing\rho'_{ab}, \varnothing c_{sab}\varnothing t'_{ab})$ and the outward manifestation of the latter namely, the flat (or non-curved) 'two-dimensional' absolute proper metric spacetime $(\rho'_{ab}, c_{sab}t'_{ab})$ in that figure. There is also the absence of the flat (or non-curved) two-dimensional relative proper intrinsic metric spacetime $(\varnothing\rho', \varnothing c_s\varnothing t')$ and its outward manifestation namely, the flat (or non-curved) four-dimensional relative proper metric spacetime $(\mathbb{E}'^3, c_st')$, which appear automatically in absolute intrinsic Riemannian spacetime geometry, as is the case in Fig. 1 of this article.

On the other hand, Fig. 7 of [7], reproduced as Fig. 1 of this article, evolves into Fig. 11 of that article, reproduced as Fig. 2 of this article, at the first stage of evolutions of metric spacetime and intrinsic metric spacetime in all finite neighbourhood of a long-range meric force field in our universe. The metric spacetimes and intrinsic metric spacetimes, which are absent in Fig. 1 of this article, due to the absence of long-range metric force field (or absence of absolute intrinsic Riemannian metric spacetime geometry), mentioned in the preceding paragraph, are contained in Fig. 2 of this article.

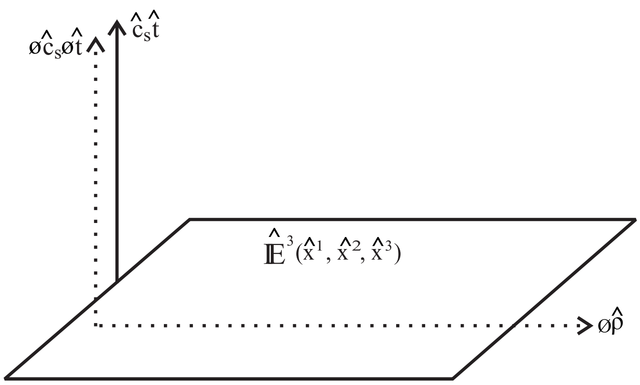

Fig. 1. Flat 'four-dimensional' absolute metric spacetime and its underlying flat 'two-dimensional' absolute intrinsic metric spacetime with the assumed absence of a long-range metric force field (or absence of absolute intrinsic Riemannian spacetime geometry) in our universe; (Fig. 7 of [7])

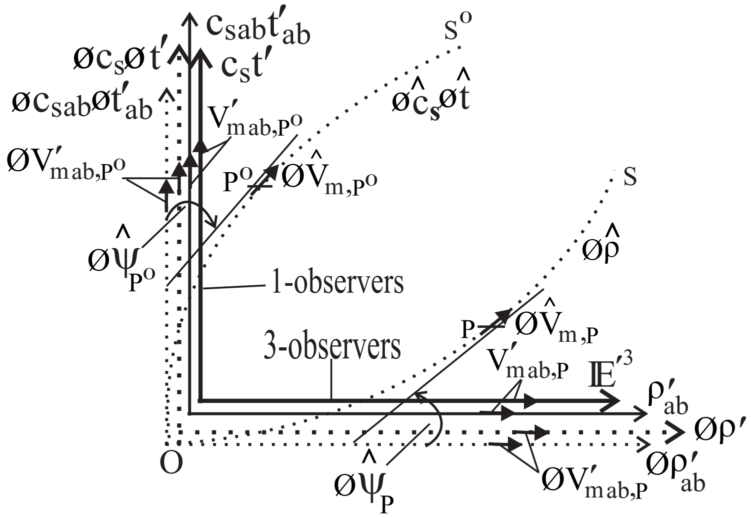

Fig. 2. The flat four-dimensional relative proper metric spacetime/flat 'two-dimensional' absolute proper metric spacetime and hierarchy of two-dimensional intrinsic metric spacetimes that evolve at the first stage of evolutions of metric spacetimes and hierarchy intrinsic spacetimes in long-range metric force fields in our universe; (Fig. 11 of [7]).

Let us consider the reference metric spacetime and intrinsic metric spacetime geometry of Fig. 1 of this article in our universe assumed to be devoid of a long-range metric force field, now being considered to be the absence of gravitational field in this article. There is the absence of absolute intrinsic Riemannian metric spacetime geometry in the universe by this assumption.

On the other hand, let us introduce the absolute rest mass, to be denoted by $\hat{M}_0$, of a gravitational field source at a point $\hat{S}$ on the flat 'three-dimensional' absolute space $\hat{\mathbb{E}}^3$ in our universe in Fig. 1. The absolute rest masses, $\hat{M}_0^0, -\hat{M}_0^*$ and $-\hat{M}_0^{0*}$, of the identical symmetry-partner gravitational field sources will be automatically introduced at the symmetry-partner points, $\hat{S}^0, \hat{S}^*$ and $\hat{S}^{0*}$, in the assumed initially empty flat absolute metric 3-spaces, $\hat{\mathbb{E}}^{03}, -\hat{\mathbb{E}}^{3*}$ and $-\hat{\mathbb{E}}^{03*}$, of the positive time-universe, negative universe and negative time-universe respectively, simultaneously with the introduction of $\hat{M}_0$ at point $\hat{S}$ in $\hat{\mathbb{E}}^3$ in the positive (or our) universe. This follows from the perfect symmetry of state among the four universes established in section 2 of [4]. The fact that $\hat{M}_0$, $\hat{M}_0^0$, $-\hat{M}_0^*$ and $-\hat{M}_0^{0*}$ are identical in magnitude, size and shape is also established in sub-sections 2.1 and 2.2 of [4].

As explained in sub-section 3.1 of [3], the appearance of $\hat{M}_0$ at point $\hat{S}$ in $\hat{\mathbb{E}}^3$; of $\hat{M}_0^0$ at point $\hat{S}^0$ in $\hat{\mathbb{E}}^{03}$; of $-\hat{M}_0^*$ at point $\hat{S}^*$ in $-\hat{\mathbb{E}}^{3*}$ and of $-\hat{M}_0^{0*}$ at point $\hat{S}^{0*}$ in $-\hat{\mathbb{E}}^{03*}$, where $\hat{S}, \hat{S}^0, \hat{S}^*$ and $\hat{S}^{0*}$, are symmetry-partner points, will lead to the appearance of identical symmetry-partner 'one-dimensional' absolute intrinsic rest masses, $\varnothing\hat{M}_0$ in 'one-dimensional' absolute intrinsic metric space $\varnothing\hat{\rho}$ directly underneath $\hat{M}_0$ in $\hat{\mathbb{E}}^3$ in the positive (or our) universe; $\varnothing\hat{M}_0^0$ in $\varnothing\hat{\rho}^0$ directly underneath $\hat{M}_0^0$ in $\hat{\mathbb{E}}^{03}$ in the positive time-universe; $-\varnothing\hat{M}_0^*$ in $-\varnothing\hat{\rho}^*$ directly underneath $-\hat{M}_0^*$ in $-\hat{\mathbb{E}}^{3*}$ in the negative universe and $-\varnothing\hat{M}_0^{0*}$ in $-\varnothing\hat{\rho}^{0*}$ directly underneath $-\hat{M}_0^{0*}$ in $-\hat{\mathbb{E}}^{03*}$ in the negative time-universe, as illustrated in Fig. 3.

Let us recall the explanation of the transformation of Fig. 1 into Fig. 4a of [3], with respect to 3-observers in the relative proper Euclidean 3-space $\mathbb{E}'^3$ (denoted by Σ' in those figures), of the positive (or our) universe in section 2 of that article. Figures 1 and 4a of [3] are reproduced as Figs. 4a and 4b respectively of this article, for convenience of reading. It follows from the transformation of Fig. 4a into Fig. 4b of this article, as explained in section 2 of [3] that, the geometry of Fig. 3 of this article will naturally transform into that of Fig. 5 of this article, with respect to '3-observers' in the absolute metric spaces, $\hat{\mathbb{E}}^3$ and $-\hat{\mathbb{E}}^{3*}$, of our universe and the negative universe.

The geometry of Fig. 5 will emerge automatically in the positive (or our) universe and the negative universe as the absolute rest mass $\hat{M}_0$ of a gravitational field source is introduced at a point $\hat{S}$ in the empty flat absolute space $\hat{\mathbb{E}}^3$ in our universe, which is being hypothetically considered to be otherwise devoid of gravitational field source. This happens by virtue of the prefect symmetry of state among the four universes, established in section 2 of [4].

The empty exterior neighborhood of one external gravitational field source in our universe and its symmetry-partner in the negative universe, as illustrated in Fig. 5, shall be considered in order to make this first article on the particularization to the gravitational field of the two stages of evolutions of metric spacetime and intrinsic metric spacetime and parameters/intrinsic parameters and the associated new metric spacetime/intrinsic metric spacetime geometries in the four-world picture in long-range metric force fields, developed in the previous papers [1–4] and [6–8] concise, revealing only the essential features, while extension to the neighbourhood of two and larger number of external gravitational field sources in each universe shall be considered elsewhere.

2.2 Introducing Absolute Intrinsic Static Gravitational Flow Speed and Absolute Static Gravitational Flow Speed

Now the absolute intrinsic rest mass $\varnothing\hat{M}_0$ will establish non-uniform absolute intrinsic 'static flow' speed $\varnothing\hat{V}_m$ (isolated geometrically in section 2 of [7]), which has its largest magnitude at point $\hat{L}$ at the edge of $\varnothing\hat{M}_0$ (point $\hat{S}$ being at the base of $\varnothing\hat{M}_0$), and decreases continuously to zero magnitude virtually at point O that is far removed from point $\hat{S}$. The absolute intrinsic rest mass $\varnothing\hat{E}/\varnothing\hat{c}_s^2\,(=\ \varnothing\hat{M}_0)$ in the absolute intrinsic metric time 'dimension' $\varnothing\hat{c}_s\varnothing\hat{t}$ (which has identical absolute inertial and absolute gravitational attributes as $\varnothing\hat{M}_0$ in $\hat{\mathbb{E}}^3$), will likewise establish non-uniform absolute intrinsic 'static flow' speed $\varnothing\hat{V}_m$ that has its largest magnitude at point $\hat{L}^0$ at the edge of $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ (point $\hat{S}^0$ being at the base of $\varnothing\hat{E}/\varnothing\hat{c}_s^2$), and decreases continuously to zero magnitude virtually at point O that is far removed from point $\hat{\mathrm{S}}^0$. (Recall from discussion in sub-section 3.1 of [3] that, $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ in $\varnothing\hat{c}_s\varnothing\hat{t}$ possesses absolute intrinsic gravitational or absolute intrinsic inertial attributes like absolute intrinsic rest mass $\varnothing\hat{M}_0^0$ in $\varnothing\hat{\rho}^0$ in Fig. 3).

The absolute rest mass $\hat{M}_0$ (assumed spherical), will establish non-uniform absolute 'static flow' speed $\hat{V}_m$, which has maximum magnitude at the surface of $\hat{M}_0$ and decreases continuously to zero magnitude virtually at point O, along every radial direction from its centre in $\hat{\mathbb{E}}^{03}$ in Fig. 6. The 'one-dimensional' absolute rest mass $\hat{E}/\hat{c}_s^2\,(=\ \hat{M}_0)$ in the absolute metric time 'dimension' $\hat{c}_s\hat{t}$ (that possesses absolute gravitational and absolute inertial attributes like $\hat{M}_0^0$ in $\hat{\mathbb{E}}^{03}$ in Fig. 6), will likewise establish non-uniform absolute 'static flow' speed $\hat{V}_m$ along $\hat{c}_s\hat{t}$, which has the largest magnitude at point $\hat{L}^0$ and decreases continuously to zero magnitude virtually at point O in Fig. 5.

The discussions in the preceding two paragraphs for $(\hat{M}_0, \hat{E}/\hat{c}_s^2)$ in $(\hat{\mathbb{E}}^3, \hat{c}_s\hat{t})$ and its underlying $(\varnothing\hat{M}_0, \varnothing\hat{E}/\varnothing\hat{c}_s^2)$ in $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ in the positive (or our) universe, obtain for $(-\hat{M}_0^*, -\hat{E}^*/\hat{c}_s^2)$ in $(-\hat{\mathbb{E}}^{3*}, -\hat{c}_s\hat{t}^*)$ and its underlying $(-\varnothing\hat{M}_0^*, -\varnothing\hat{E}^*/\varnothing\hat{c}_s^2)$ in $(-\varnothing\hat{\rho}^*, -\varnothing\hat{c}_s\varnothing\hat{t}^*)$ in the negative universe as well. It is important to note that the two-world diagram of Fig. 5 has arisen from the four-world diagram of Fig. 3.

Let us for convenience replace the representation of the 'three-dimensional' absolute spaces, $\hat{\mathbb{E}}^3$ and $-\hat{\mathbb{E}}^{3*}$, by horizontal plane surfaces in Fig. 5 by lines along the horizontal. Let us also revert back to the notations, Σ and $-\Sigma^*$, respectively for Euclidean 3-spaces adopted in [1–4]. That is, let us replace $\hat{\mathbb{E}}^3$ and $-\hat{\mathbb{E}}^{3*}$ that appear in Fig. 5 and in the diagrams in [6–8] by $\hat{\Sigma}$ and $-\hat{\Sigma}^*$

respectively henceforth. The assumed spherical absolute rest masses, $\hat{M}_0$ and $-\hat{M}_0^*$, represented by circles on $\hat{\mathbb{E}}^3$ and $-\hat{\mathbb{E}}^{3*}$ in Fig. 5, shall be represented by short line segments in $\hat{\Sigma}$ and $-\hat{\Sigma}^*$ respectively. These representations are dummy with no consequence on the geometry and theory being developed.

Further more, since we are now particularizing to the gravitational field, the absolute intrinsic 'static flow' speed $\varnothing\hat{V}_m(\varnothing\hat{r})$ at 'distance' $\varnothing\hat{r}$ from the base $\hat{S}$ of $\varnothing\hat{M}_0$ in Fig. 5, shall be re-denoted by $\varnothing\hat{V}_g(\varnothing\hat{r})$ and referred to as absolute intrinsic static gravitational flow speed. The absolute 'static flow' speed $\hat{V}_m(\hat{r})$ at radial distance $\hat{r}$ from the centre of $\hat{M}_0$ shall likewise be re-denoted by $\hat{V}_g(\hat{r})$ and referred to as absolute static gravitational flow speed.

The absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ and absolute static gravitational flow speed $\hat{V}_g(\hat{r})$, are static like $\varnothing\hat{V}_m$ and $\hat{V}_m$ in [7, 8] which they replace. This means that $\varnothing\hat{V}_g(\varnothing\hat{r})$ is not made manifested in actual absolute intrinsic flow of the absolute intrinsic metric spacetime dimensions, $\varnothing\hat{\rho}$ and $\varnothing\hat{c}_s\varnothing\hat{t}$, along which it is established and $\hat{V}_g(\hat{r})$ is not made manifested in actual absolute flow of the absolute metric 3-space $\hat{\Sigma}$ in which it is established and of the absolute metric time dimension $\hat{c}_s\hat{t}$ along which it is established.

As follows from the discussions to this point in this sub-section, Fig. 5 shall be replaced with Fig. 6, where only absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ at an arbitrary 'distance' $\varnothing\hat{r}$ along $\varnothing\hat{\rho}$ from the base $\hat{S}$ of $\varnothing\hat{M}_0$ in $\varnothing\hat{\rho}$ and at equal 'distance' $\varnothing\hat{r}$ along $\varnothing\hat{c}_s\varnothing\hat{t}$ from the base $\hat{S}^0$ of $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ in $\varnothing\hat{c}_s\varnothing\hat{t}$, corresponding to absolute static gravitational flow speed $\hat{V}_g(\hat{r})$ at an arbitrary absolute radial distance $\hat{r}$ in the absolute 3-space $\hat{\Sigma}$ from the centre of $\hat{M}_0$ in $\hat{\Sigma}$ are shown.

The line of absolute rest mass $\hat{M}_0$ of length $\hat{\text{S}}\hat{L}$ in Fig. 6 is actually a spherical absolute rest mass (as being assumed) of radius, $\hat{R}_0 = \hat{S}\hat{L}$, and the segment $\hat{S}$O of the line of universal absolute space $\hat{\Sigma}$ is actually a spherical region of absolute 3-space of large radius $\hat{S}$O with $\hat{M}_0$ at its centre. The 'one-dimensional' absolute intrinsic metric space $\varnothing\hat{\rho}$ is an isotropic intrinsic metric dimension with respect to '3-observers' in the absolute metric space $\hat{\Sigma}$. It can be considered to lie along any of the radial directions from the centre of the spherical region of absolute space of radius $\hat{S}$O.

The spherical region of the universal absolute space $\hat{\Sigma}$ within the gravitational field of $\hat{M}_0$ (assuming the gravitational field of $\hat{M}_0$ can be considered to vanish outside this sphere), is just a portion of the vast 'three-dimensional' flat universal absolute space, which is being assumed to be devoid of the absolute rest mass of any other gravitational field source at present.

The reference geometry of Fig. 5 or 6 above, in which symmetry-partner absolute gravitational field sources are present in absolute metric spacetimes and symmetry-partner absolute intrinsic gravitational field sources are present in absolute intrinsic metric spacetimes in our universe and negative universe, will endure for no moment before transforming into the geometry of Fig. 7, at the first stage of evolutions of spacetimes and intrinsic spacetimes within the symmetry-partner gravitational fields in our universe and negative universe.

Again the line of rest mass M_0 of length S′L′ in Fig. 7 is actually a spherical rest mass M_0 (as being assumed) of radius R_0 (=S′L′) and the line of relative proper metric Euclidean 3-space Σ' in that figure, is actually a spherical relative proper metric Euclidean 3-space of large radius S′O with M_0 at its centre. The one-dimensional relative proper intrinsic metric space $\varnothing\rho'$ is an isotropic intrinsic dimension with respect to 3-observers in Σ' in Fig. 7. It can be considered to lie along any of the radial directions of the spherical Σ' from the centre of M_0.

The spherical relative proper metric Euclidean 3-space Σ' of large radius S′O evolves around the rest mass M_0 of the gravitational field source at its centre in Fig. 7, such that the gravitational field of M_0 can be considered to vanish outside the Σ'. The region of the universal 3-space outside Σ' (or outside the gravitational field of M_0), remains the flat absolute space $\hat{\Sigma}$, since this gravitational field source is the only one in our universe as being assumed.

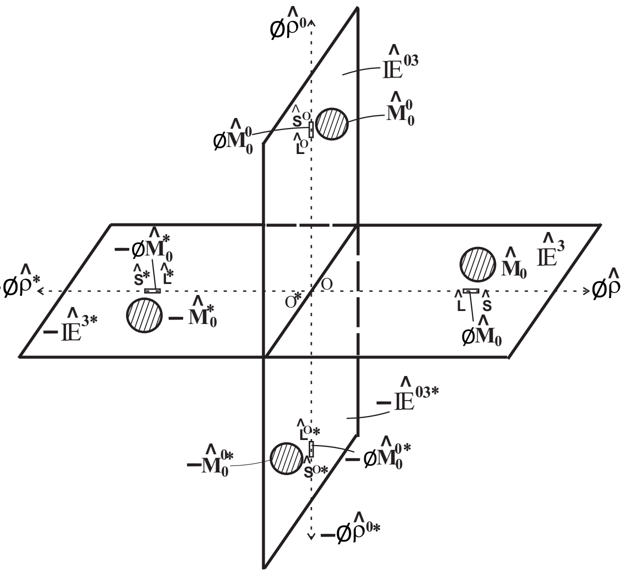

Fig. 3. The mutually orthogonal flat 'three-dimensional' absolute metric spaces (as flat hyper-surfaces) and their underlying straight line 'one-dimensional' absolute intrinsic metric spaces of four symmetrical universes namely, the positive (or our) universe, the negative universe, the positive time-universe and the negative time-universe, containing identical assumed spherical absolute rest masses in the absolute metric 3-spaces and lines of absolute intrinsic rest masses in the 'one-dimensional' absolute intrinsic metric spaces directly underneath the absolute rest masses in the absolute spaces, of symmetry-partner gravitational field sources at symmetry-partner points in the absolute spaces within the assumed otherwise empty universes.

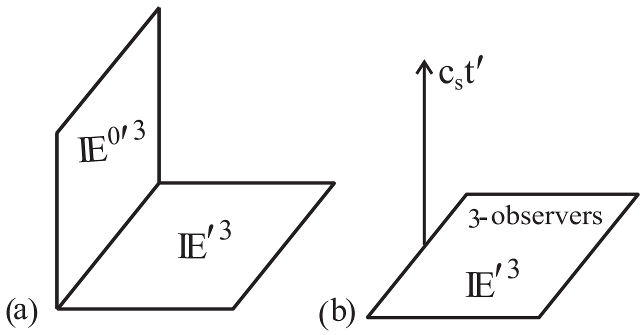

Fig. 4. Figure 4a naturally transforms into Fig. 4b with respect to 3-observers in the proper Euclidean 3-space $\mathbb{E}'^3$; (Figs. 1 and 4a of [3])

The segment $\hat{S}$O of the straight line universal absolute intrinsic metric space $\varnothing\hat{\rho}$ along the horizontal, containing the absolute intrinsic rest mass $\varnothing\hat{M}_0$ of the gravitational field source within interval $\hat{S}\hat{L}$ of segment $\hat{S}$O of $\varnothing\hat{\rho}$ in Fig. 6, becomes curved toward the vertical as a plane curve on the vertical $(\varnothing\rho'\text{-}\varnothing c_s\varnothing t')-$intrinsic spacetime hyperplane, by virtue of the non-uniform absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ established along the segment $\hat{S}$O of $\varnothing\hat{\rho}$ by $\varnothing\hat{M}_0$ in that figure.

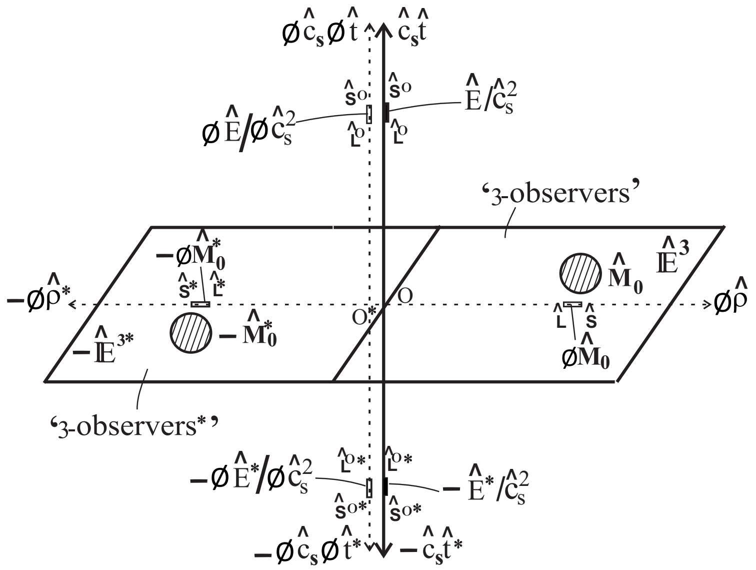

Fig. 5. The diagram of Fig. 3 of four symmetrical universes in the four-world picture naturally transforms into flat 'four-dimensional' absolute metric spacetimes and the underlying flat 'two-dimensional' absolute intrinsic metric spacetimes of the positive (or our) universe and the negative universe, with respect to '3-observers' in the absolute metric spaces in our universe and the negative universe.

The curved $\varnothing\hat{\rho}$ in Fig. 7 projects a straight line isotropic absolute proper intrinsic metric space $\varnothing\rho'_{ab}$ that is imperceptibly embedded in the straight line relative proper intrinsic metric space $\varnothing\rho'$, which appears automatically along with the projection of $\varnothing\rho'_{ab}$ along the horizontal. The projective $\varnothing\rho'_{ab}$ is made manifested outwardly in 'one-dimensional' absolute proper metric space ρ'_{ab} that is imperceptibly embedded in the relative proper metric Euclidean 3-space Σ', as the outward manifestation of $\varnothing\rho'$, which appears automatically with the projection of $\varnothing\rho'_{ab}$ within the gravitational field in Fig. 7.

The line of absolute intrinsic rest mass $\varnothing\hat{M}_0$ of the gravitational field source located at the origin (or base) of the curved segment $\hat{\text{S}}$O of $\varnothing\hat{\rho}$, likewise forms (or 'projects') absolute proper intrinsic mass $\varnothing M_{0ab}$ at the origin (or base) of the projective absolute proper intrinsic metric space $\varnothing\rho'_{ab}$, which is imperceptibly embedded in the relative intrinsic rest rest mass $\varnothing M_0$ of the gravitational field source that appears automatically with the relative proper intrinsic metric space $\varnothing\rho'$ along the horizontal. The $\varnothing M_{0ab}$ is made manifested in 'one-dimensional' absolute proper mass M_{0ab} in ρ'_{ab} and it is imperceptibly embedded in the three-dimensional relative rest mass M_0 of the gravitational field source in relative proper physical Euclidean 3-space Σ'.

The segment $\hat{S}^0$O of the straight line universal absolute intrinsic metric time 'dimension' $\varnothing\hat{c}_s\varnothing\hat{t}$ along the vertical, containing the line of absolute intrinsic rest mass $\varnothing\hat{E}/\varnothing\hat{c}_s^2\,(=\ \varnothing\hat{M}_0)$ of the gravitational field source within interval $\hat{\text{S}}^0\hat{L}^0$ at the origin (or base) of the segment $\hat{S}^0$O of $\varnothing\hat{c}_s\varnothing\hat{t}$ in Fig. 6, becomes curved toward $\varnothing\rho'$ along the horizontal, by virtue of the non-uniform absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ established along the segment $\hat{S}^0$O of $\varnothing\hat{c}_s\varnothing\hat{t}$ by $\varnothing\hat{E}/\varnothing\hat{c}_s^2\,(=\varnothing\hat{M}_0)$ in Fig. 5 or Fig. 6.

The curved $\varnothing\hat{c}_s\varnothing\hat{t}$ projects a straight line absolute proper intrinsic metric time dimension $\varnothing c_{sab}\varnothing t'_{ab}$ that is imperceptibly embedded in the relative proper intrinsic metric time dimension $\varnothing c_s\varnothing t'$, which appears automatically with the projection of $\varnothing c_{sab}\varnothing t'_{ab}$ along the vertical within the gravitational field. It is made manifested outwardly in absolute proper metric time dimension $c_{sab}t'_{ab}$ that is imperceptibly embedded in the relative proper metric time dimension $c_s t'$, which appears automatically with the projection of $\varnothing c_{sab}\varnothing t'_{ab}$ along the vertical within the gravitational field in Fig. 7.

The line of absolute intrinsic rest mass $\varnothing\hat{E}/\varnothing\hat{c}_s^2\,(=\varnothing\hat{M}_0)$ of the gravitational field source at the origin (or base) of the curved segment $\hat{S}^0$O of $\varnothing\hat{c}_s\varnothing\hat{t}$, likewise forms (or 'projects') a line of absolute proper intrinsic mass $\varnothing E'_{ab}/\varnothing c_{sab}^2\,(=\varnothing M_{0ab})$ that is imperceptibly embedded in the line of relative rest mass $E'/c_s^2\,(\equiv\ M_0)$, which appears automatically at the origin (or base) of the relative proper intrinsic metric time dimension $\varnothing c_s\varnothing t'$ that appears automatically along the vertical. The $\varnothing E'_{ab}/\varnothing c_{sab}^2\,(=\ \varnothing M_{0ab})$ is made manifested outwardly in absolute proper mass $E'_{ab}/c_{sab}^2\,(=\ \ M_{0ab})$, which is imperceptibly embedded in the line of relative rest mass $E'/c_s^2\,(=\ \ M_0)$ at the origin (or base) of the relative proper metric time dimension $c_s t'$ in Fig. 7.

Only the relative proper intrinsic metric spacetimes, $(\varnothing\rho', \varnothing c_s\varnothing t')$ and $(-\varnothing\rho'^*, -\varnothing c_s\varnothing t^*)$, and the relative proper metric spacetimes, $(\Sigma', c_s t')$ and $(-\Sigma'^*, -c_s t'^*)$, which appear automatically and the relative intrinsic rest masses, $(\varnothing M_0, \varnothing E'/\varnothing c_s^2)$ and $(-\varnothing M_0^*, -\varnothing E'^*/\varnothing c_s^2)$, and the relative rest masses, $(M_0, E'/c_s^2)$ and $(-M_0^*, -E'^*/c_s^2)$, in them shall be shown, as done in Fig. 7 already, while their embedding projective absolute proper intrinsic metric spacetimes, $(\varnothing\rho'_{ab}, \varnothing c_{sab}\varnothing t'_{ab})$ and $(-\varnothing\rho'^*_{ab}, -\varnothing c_{sab}\varnothing t'^*_{ab})$, containing 'projective' absolute proper intrinsic masses, $(\varnothing M_{0ab}, \varnothing E'_{ab}/\varnothing c_{sab}^2)$ and $(-\varnothing M_{0ab}^*, -\varnothing E'^*_{ab}/\varnothing c_{sab}^2)$, and the absolute proper metric spacetimes, $(\rho'_{ab}, c_{sab}t'_{ab})$ and $(-\rho'^*_{ab}, -c_{sab}t'^*_{ab})$, containing 'projective' absolute proper (or classical) masses, $(M_{0ab}, E'_{ab}/c_{sab}^2)$ and $(-M_{0ab}^*, -E'^*_{ab}/c_{sab}^2)$, which are imperceptibly embedded in the relative intrinsic rest masses and relative rest masses, shall be hidden in the diagrams in this article. On the other hand, $(\varnothing\rho'_{ab}, \varnothing c_{sab}\varnothing t'_{ab})$ and $(\rho'_{ab}, c_{sab}t'_{ab})$, are shown along with $(\varnothing\rho', \varnothing c_s\varnothing t')$ and $(\Sigma', c_s t')$ in the one-world diagram of Fig. 2 of this article in a general long-range metric force field.

The 'one-dimensional' absolute intrinsic rest mass $\varnothing\hat{M}_0$ in the straight line absolute intrinsic metric space $\varnothing\hat{\rho}$ along the horizontal and $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ in the straight line absolute intrinsic metric time 'dimension' $\varnothing\hat{c}_s\varnothing\hat{t}$ along the vertical, of the gravitational field source, in the reference geometry of Fig. 6, are indeed curved along with $\varnothing\hat{\rho}$ and $\varnothing\hat{c}_s\varnothing\hat{t}$, at the first stage of evolutions of metric spacetimes and intrinsic metric spacetimes in the gravitational field, as illustrated in Fig. 7. However, the curvatures of $\varnothing\hat{M}_0$ within segment $\hat{S}\hat{L}$ of the curved $\varnothing\hat{\rho}$ and the curvature of $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ within segment $\hat{S}^0\hat{L}^0$ of the curved $\varnothing\hat{c}_s\varnothing\hat{t}$, shown in Fig. 7, are temporary. The final forms of the segment $\hat{S}\hat{L}$ of the curved $\varnothing\hat{\rho}$ containing $\varnothing\hat{M}_0$ and segment $\hat{S}^0\hat{L}^0$ of the curved $\varnothing\hat{c}_s\varnothing\hat{t}$ containing $\varnothing\hat{E}/\varnothing\hat{c}_s^2$ in Fig. 7, shall be derived elsewhere when the need for the spacetime and intrinsic spacetime geometry at the interior of a gravitational field source arises. On the other hand, the segments $\hat{L}$O of the curved $\varnothing\hat{\rho}$ and and $\hat{L}^0$O of the curved $\varnothing\hat{c}_s\varnothing\hat{t}$ at assumed empty space at the exterior of a gravitational field source in Fig. 7 are valid.

It is being assumed that the absolute gravitational field source $(\hat{M}_0, \hat{E}/\hat{c}_s^2)$, introduced at point $(\hat{\mathrm{S}}\,, \hat{S}^0)$ on $(\hat{\Sigma}\,,\,\hat{c}_s\hat{t}\,)$ in our universe and its symmetry-partner $(-\hat{M}_0^*, -\hat{E}^*/\hat{c}_s^2)$, introduced simultaneously at the symmetry-partner point $(\hat{\mathrm{S}}^*, \hat{S}^{0*})$ on $(-\hat{\Sigma}^*, -\hat{c}_s\hat{t}^*)$ in the negative universe in Fig. 5 or 6, are the only gravitational field sources in our universe and the negative universe. Consequently only the segment $\hat{S}$O of the curved absolute intrinsic metric space $\varnothing\hat{\rho}$, the straight line relative proper intrinsic metric space $\varnothing\rho'$ between points S$'$ and O along the horizontal, and the outward manifestation of $\varnothing\rho'$ namely, the large spherical proper metric Euclidean 3-space Σ', represented by a line segment in Fig. 7, exist within our universe, while the regions of the flat universal absolute metric spacetime $(\hat{\Sigma}, \hat{c}_s\hat{t}\,)$ underlay by flat universal absolute intrinsic metric spacetime $(\varnothing\hat{\rho}\,,\,\varnothing\hat{c}_s\varnothing\hat{t}\,)$, outside the gravitational field of the introduced lone absolute gravitational field source in our universe, remain unchanged. Likewise for the assumed lone symmetry-partner absolute gravitational field source $(-\hat{M}_0^*, -\hat{E}^*/\hat{c}_s^2)$ introduced simultaneously at the symmetry-partner point $(\hat{S}^*, \hat{S}^{0*})$ in $(-\hat{\Sigma}^*, -\hat{c}_s\hat{t}^*)$ in Fig. 5 or 6 in the negative universe.

The absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ at arbitrary 'distance' $\varnothing\hat{r}$ from the base $\hat{S}$ of $\varnothing\hat{M}_0$ along the straight line absolute intrinsic metric space $\varnothing\hat{\rho}$ in Fig. 6, is now at an arbitrary 'distance' $\varnothing\hat{r}$ from the base $\hat{S}$ of $\varnothing\hat{M}_0$ along the curved $\varnothing\hat{\rho}$ in Fig. 7. It invariantly projects absolute proper intrinsic static gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing\hat{V}_g(\varnothing\hat{r}))$ into the projective straight line absolute proper intrinsic metric space $\varnothing\rho'_{ab}$ embedded in the relative proper intrinsic metric space $\varnothing\rho'$ along the horizontal. The projective $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing\hat{V}_g(\varnothing\hat{r}))$ is consequently established in the relative proper intrinsic metric space $\varnothing\rho'_{ab}$ at the corresponding 'distance' $\varnothing r'$ from the base of the relative intrinsic rest mass $\varnothing M_0$ in $\varnothing\rho'$, which is made manifested outwardly in absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ at radial distance r' from the centre of the relative rest mass M_0 in Σ', with respect to 3-observers in Σ'.

The absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ at 'distance' $\varnothing\hat{r}$ from the base of $\hat{S}^0$ of $\varnothing\hat{E}/\varnothing\hat{c}^2$ along the curved absolute intrinsic metric time 'dimension' $\varnothing\hat{c}_s\varnothing\hat{t}$, also invariantly projects absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})$ into the projective straight line absolute proper intrinsic metric time dimension $\varnothing c_{sab}\varnothing t'_{ab}$ embedded in the relative proper intrinsic metric time dimensions $\varnothing c_s\varnothing t'$. Thus the projective $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing\hat{V}_g(\varnothing\hat{r}))$ is established in $\varnothing c_s\varnothing t'$, which is made manifested outwardly in absolute proper static gravitational flow speed $V_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ at 'distance' r' from the base of E'/c_s^2 in c_st', with respect to 1-observers in c_st' in Fig. 7. The discussions on the first quadrant (or in the positive universe) in Fig. 7 in the preceding two paragraphs and this paragraph, equally obtain for the third quadrant (or in the negative universe).

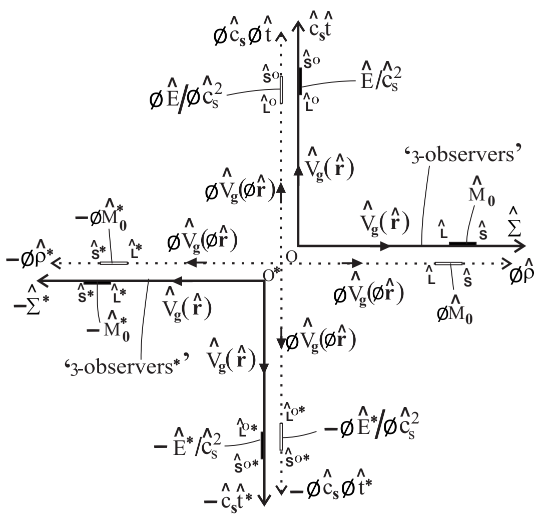

Fig. 6. The absolute rest masses of symmetry-partner gravitational field sources on flat absolute metric spacetimes establish non-uniform absolute static gravitational flow speed in all their finite neighborhoods in absolute metric spacetimes and their absolute intrinsic rest masses in the underlying absolute intrinsic metric spactimes establish non-uniform absolute intrinsic static gravitational flow speed in all their finite neighborhoods in absolute intrinsic metric spacetimes in the positive and negative universes.

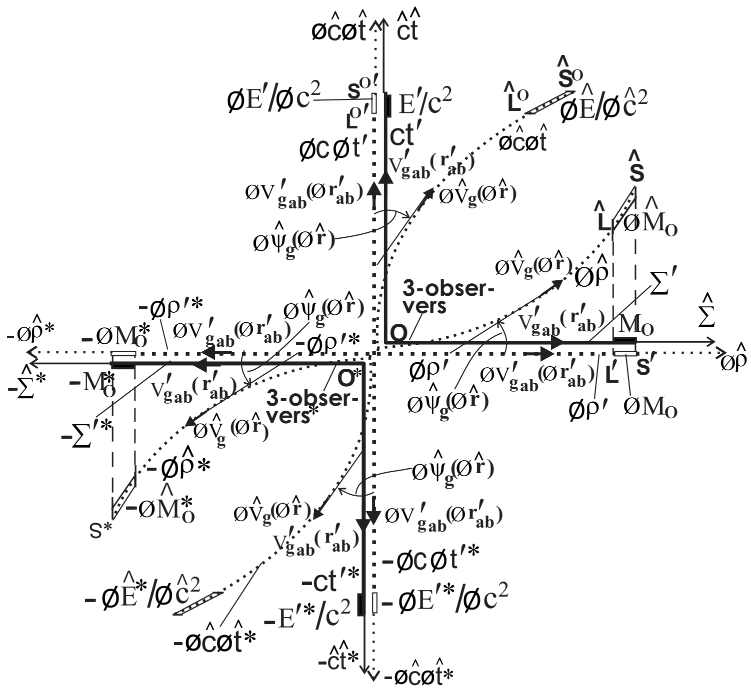

Fig. 7. The metric spacetime/intrinsic metric spacetime geometry that evolves from the reference geometry of Fig. 5 at the first stage of evolutions of spacetimes/intrinsic spacetimes in all finite neighbourhoods of symmetry-partner gravitational field sources within the assumed otherwise empty positive and negative universes.

There are the invariance of absolute intrinsic static gravitational flow speed and absolute static gravitational flow speed in the contexts of the theory of absolute intrinsic gravity and theory of absolute gravity (A∅G/AG) (which are the theories associated with the geometry of Fig. 7 to be discussed at the end of this article). The $\varnothing\hat{V}_g(\varnothing\hat{r})$ along the curved absolute intrinsic metric spacetime 'dimensions', $\varnothing\hat{\rho}$ and $\varnothing\hat{c}_s\varnothing\hat{t}$, are invariantly projected as absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing\hat{V}_g(\varnothing\hat{r}))$ into the projective straight line absolute proper intrinsic metric spacetime dimensions, $\varnothing\rho'_{ab}$ and $\varnothing c_{sab}\varnothing t'_{ab}$, which are imperceptibly embedded in the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$, respectively that appear automatically in the contexts of A∅G in Fig. 7. These are then made manifested outwardly in absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ along the 'one-dimensional' absolute proper metric space ρ'_{ab} and absolute proper metric time 'dimension' $c_{sab}t'_{ab}$ (the outward manifestations of $\varnothing\rho'_{ab}$ and $\varnothing c_{sab}\varnothing t'_{ab}$ respectively), where ρ'_{ab} and $c_{sab}t'_{ab}$ are imperceptibly embedded in the relative proper metric 3-space and time dimension, Σ' and c_st'.

The invariance of absolute intrinsic static gravitational flow speed and absolute static gravitational flow speed have been stated as the invariance of absolute intrinsic 'static flow' speed and absolute 'static flow' speed by Eqs. (79a) and (79b) in [7], in the context of the absolute intrinsic metric phenomenon and absolute metric phenomenon that give rise to the geometry of Fig. 11 of that article, reproduced as Fig. 2 of this article in the one-world picture. It corresponds to Fig. 7 of this article in the contexts of AG and A∅G in the two-world picture. They shall be re-stated as the invariance of absolute intrinsic static gravitational flow speed and absolute static gravitational flow speed in the contexts of the theory of absolute intrinsic gravity and theory of absolute gravity (∅AG/AG) in the geometry of Fig. 7 as

$$\varnothing V'_{gab}(\varnothing r'_{ab}) = \varnothing \hat{V}_g(\varnothing \hat{r}) \quad (1a)$$

and

$$V'_{gab}(r'_{ab}) = \hat{V}_g(\hat{r}) \quad (1b)$$

Equation (1a) states that the absolute proper intrinsic static gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})$ projected along the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$ and $\varnothing c_s \varnothing t'$, by the absolute intrinsic static gravitational flow speed $\varnothing \hat{V}_g(\varnothing \hat{r})$ along the curved absolute intrinsic metric spacetime 'dimensions', $\varnothing\hat{\rho}$ and $\varnothing\hat{c}_s\varnothing\hat{t}$, is the same as the absolute intrinsic static gravitational flow speed $\varnothing \hat{V}_g(\varnothing \hat{r})$. Equation (1b) says that the absolute proper gravitational flow speed $V'_{gab}(r'_{ab})$ established in Σ' and along $c_s t'$ in Fig. 7, is the same as the absolute static gravitational flow speed $\hat{V}_g(\hat{r})$.

It is crucial to note that the line of relative intrinsic rest mass $\varnothing M_0$ of the gravitational field source in $\varnothing\rho'$ is not the source of the non-uniform absolute proper intrinsic static gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along $\varnothing\rho'$ and that the assumed spherical relative rest mass M_0 of the field source is not the source of the non-uniform absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})\,(\equiv \hat{V}_g(\hat{r}))$ along every radial direction from its centre in Σ', with respect to 3-observers in Σ' in Fig. 7. Rather the non-uniform absolute proper intrinsic static gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along $\varnothing\rho'$ are the projections of the non-uniform absolute intrinsic static gravitational flow speed that $\varnothing \hat{M}_0$ at the origin of the curved $\varnothing\hat{\rho}$ establishes along the curved $\varnothing\hat{\rho}$ and the non-uniform absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})(= \hat{V}_g(\hat{r}))$ in Σ' are the outward manifestations of the projective non-uniform $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along $\varnothing\rho'$.

Likewise the non-uniform absolute proper intrinsic static gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})$ along the relative proper intrinsic metric time dimension $\varnothing c_s \varnothing t'$ along the vertical has not been established by the relative intrinsic rest mass $\varnothing E'/\varnothing c_s^2$ in $\varnothing c_s \varnothing t'$ and the non-uniform absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})(= \hat{V}_g(\hat{r}))$ along the relative proper metric time dimension $c_s t'$ has not been established by the relative rest mass $E'/c_s^2\,(= M_0)$ of the gravitational field source in $c_s t'$ in Fig. 7. Rather the non-uniform $\varnothing V'_{gab}(\varnothing r'_{ab})(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along $\varnothing c_s \varnothing t'$ is the invariant projection along the vertical of the non-uniform $\varnothing \hat{V}_g(\varnothing \hat{r})$ established along the curved $\varnothing\hat{c}_s\varnothing\hat{t}$ by $\varnothing\hat{E}/\varnothing\hat{c}^2\,(= \varnothing \hat{M}_0)$ at the origin of the curved $\varnothing\hat{c}_s\varnothing\hat{t}$ and $V'_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ along $c_s t'$ are the outward manifestations of the projective $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along $\varnothing c_s \varnothing t'$.

It is to be remembered however that $\varnothing \hat{V}_g(\varnothing \hat{r})$ along the curved $\varnothing\hat{\rho}$ and $\varnothing\hat{c}_s\varnothing\hat{t}$ actually projects $\varnothing V'_{gab}(\varnothing r'_{ab})$ into the projective $\varnothing\rho'_{ab}$ along the horizontal and the projective $\varnothing c_{sab}\varnothing t'_{ab}$ along the vertical. It is because $\varnothing\rho'_{ab}$ is embedded in $\varnothing\rho'$ and $\varnothing c_{sab}\varnothing t'_{ab}$ is embedded in $\varnothing c_s \varnothing t'$ that $\varnothing V'_{gab}(\varnothing r'_{ab})$ appear along $\varnothing\rho'$ and $\varnothing c_s \varnothing t'$ in Fig. 7. Having now known that $\varnothing \hat{V}_g(\varnothing \hat{r})$ and $\varnothing V'_{gab}(\varnothing r'_{ab})$ are absolute intrinsic static flow speeds and that $\hat{V}_g(\hat{r})$ and $V'_{gab}(r'_{ab})$ are absolute static flow speeds, the qualification "static" in absolute intrinsic static gravitational flow speed and absolute static gravitational flow speed shall be suppressed largely henceforth.

2.3 The Second Stage of Evolutions of Spacetime/Intrinsic Spacetime and Parameters/Intrinsic Parameters in the Gravitational Field

The geometry of Fig. 7 evolves from the reference geometry of Fig. 5 or Fig. 6 at the first stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters in the gravitational field. There is a second stage, which shall be presented in this section.

As discussed in section 2 of [7], the projective non-uniform absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(\equiv \varnothing \hat{V}_g(\varnothing \hat{r}))$ along the relative proper intrinsic metric space $\varnothing\rho'$ and along the relative proper intrinsic metric time dimension $\varnothing c_s \varnothing t'$ in Fig. 7, cannot give rise to the curvature of these relative proper intrinsic metric dimensions, or produce any other effect on them. The non-uniform absolute proper gravitational flow speed $V'_{gab}(r'_{ab})$ in the relative proper metric Euclidean 3-space Σ' and along the relative proper metric time dimension $c_s t'$, can likewise produce no detectable effect on the flat relative proper metric spacetime $(\Sigma', c_s t')$.

Thus if the projective static absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing \hat{V}_g(\varnothing \hat{r}))$ along the straight line relative proper intrinsic metric spaces, $\varnothing\rho'$ and $-\varnothing\rho'^{*}$, and straight line relative proper intrinsic metric time dimensions, $\varnothing c_s \varnothing t'$ and $-\varnothing c_s \varnothing t'^{*}$, are all that is possible and, consequently, only their outward manifestations namely, the non-uniform absolute proper gravitational flow speed $V'_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ in the relative proper metric Euclidean 3-spaces, Σ' and $-\Sigma'^{*}$, and along the relative proper metric time dimensions, $c_s t'$ and $-c_s t'^{*}$, are all that are possible in Fig. 7, then the geometry of Fig. 7 will endure and evolutions of spacetimes and intrinsic spacetimes will terminate at the first stage within the gravitational field.

However the second stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters within the gravitational field is immutable. This is so because, apart from the non-uniform absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})\,(= \varnothing \hat{V}_g(\varnothing \hat{r}))$, projected along the straight line relative proper intrinsic dimensions, $\varnothing\rho'$, $\varnothing c_s \varnothing t'$, $-\varnothing\rho'^{*}$ and $-\varnothing c_s \varnothing t'^{*}$, the relative intrinsic rest mass $\varnothing M_0$ that automatically appears in $\varnothing\rho'$ along with the automatic appearance of $\varnothing\rho'$ (as the absolute proper intrinsic mass $\varnothing M_{0ab}$ is 'projected' into $\varnothing\rho'_{ab}$ by $\varnothing \hat{M}_0$ in the curved $\varnothing\hat{\rho}$), serving as a relative proper intrinsic gravitational field source, establishes relative proper intrinsic static gravitational flow speed $\varnothing V'_g(\varnothing r')$ along $\varnothing\rho'$, whose magnitude is largest at the edge L′ of $\varnothing M_0$ and decreases continuously to zero virtually at point O that is far removed from the base S′ of $\varnothing M_0$ in Fig. 7.

The relative intrinsic rest mass $\varnothing E'/\varnothing c_s^2\,(= \varnothing M_0)$ in $\varnothing c_s \varnothing t'$ also establishes non-uniform relative proper intrinsic gravitational flow speed $\varnothing V'_g(\varnothing r')$ along $\varnothing c_s \varnothing t'$, whose magnitude is largest at the edge L$^{0\prime}$ of $\varnothing E'/\varnothing c_s^2$ and decreases continuously to zero virtually at point O. The intrinsic rest mass $-\varnothing M_0^{*}$ in $-\varnothing\rho'^{*}$ likewise establishes non-uniform relative proper intrinsic static gravitational flow speed $\varnothing V'_g(\varnothing r')$ along $-\varnothing\rho'^{*}$ and $-\varnothing E'^{*}/\varnothing c^2$ in $-\varnothing c_s \varnothing t'^{*}$ establishes non-uniform relative proper intrinsic static gravitational flow speed $\varnothing V'_g(\varnothing r')$ along $-\varnothing c_s \varnothing t'$ in Fig. 7.

Quite apart from the non-uniform absolute proper static gravitational flow speed $V'_{gab}(r'_{ab})\,(= \hat{V}_g(\hat{r}))$ in Σ' and along $c_s t'$ in Fig. 7, the rest mass M_0 in Σ', as a relative gravitational field source, establishes non-uniform relative proper static gravitational flow speed $V'_g(r')$ along every radial direction from its centre in Σ' and the rest mass $E'/c_s^2\,(= M_0)$ in $c_s t'$, establishes non-uniform relative proper static gravitational flow speed $V'_g(r')$ along $c_s t'$. Likewise $-M_0^{*}$ in $-\Sigma'^{*}$ and $-E'^{*}/c_s^2$ in $-c_s t'^{*}$ in the third quadrant in Fig. 7.

The relative proper intrinsic gravitational flow speed $\varnothing V_g(\varnothing r')$ has not been shown along with the absolute proper intrinsic gravitational flow speed $\varnothing V'_{gab}(\varnothing r'_{ab})$ along the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$, $\varnothing c_s \varnothing t'$, $-\varnothing\rho'^{*}$, $-\varnothing c_s \varnothing t'^{*}$, and $V_g(r')$ has not been shown along with $V_{gab}(r'_{ab})$ in Σ', $-\Sigma'^{*}$ and along $c_s t'$ and $-c_s t'^{*}$ in Fig. 7, in order to artificially freeze the evolutions of metric spacetimes and intrinsic metric spacetimes to the first stage that has the geometry of Fig. 7. However they actually exist and cause the second stage of evolutions of metric spacetimes and intrinsic metric spacetimes in the gravitational field as described below.

The non-uniform relative proper intrinsic static gravitational flow speed $\varnothing V'_g(\varnothing r')$ established along the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho', \varnothing c_s \varnothing t'$, $-\varnothing\rho'^{*}$ and $-\varnothing c \varnothing t'^{*}$, by the relative proper intrinsic rest mass of the gravitational field sources, $\varnothing M_0$, $\varnothing E'/\varnothing c_s^2$, $-\varnothing M_0^{*}$ and $-\varnothing E'^{*}/\varnothing c_s^2$, respectively, in these relative proper intrinsic metric spacetime dimensions, as described above, being relative intrinsic gravitational flow speed (i.e. with magnitude that varies along the lengths of $\varnothing\rho'$ and $\varnothing c_s \varnothing t'$), will cause the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$, to be simultaneously curved anticlockwise into the first quadrant and second quadrant respectively to form pseudo-orthogonal curvilinear intrinsic metric spacetime dimensions. This is so, because $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$ are simultaneously relative intrinsic dimensions at equal footing with respect to 3-observers in Σ', in the context of the intrinsic theory of relativity in intrinsic metric spacetime associated with the presence of non-uniform relative proper intrinsic gravitational flow speed $\varnothing V_g'(\varnothing r')$ along $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$.

The curved $\varnothing\rho'$ in the first quadrant will then project a straight line isotropic relativistic intrinsic metric space $\varnothing\rho$ along the horizontal, which will be made manifested in a spherical region of relativistic metric Euclidean 3-space Σ in the first quadrant. The curved $\varnothing c_s\varnothing t'$ in the second quadrant will likewise project straight line relativistic intrinsic metric time dimension $\varnothing c_s\varnothing t$ along the vertical, which will be made manifested outwardly in the relativistic metric time dimension $c_s t$ along the vertical in the first quadrant.

As discussed in the process of transforming Fig. 11 of [7], reproduced as Fig. 2 of this article, into Fig. 5 of [8] (reproduced as Fig. 16 on page 106 of this article), Fig. 7 above at the first stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters in the gravitational field, will endure for no moment before transforming into Fig. 8 at the second stage in the gravitational field. Figure 5 of [8], drawn within an attractive long-range metric force field in general, has simply been adapted to the gravitational field as Fig. 8 of this article. Consequently the symmetry-partner gravitational field sources in the metric spacetimes and the underlying symmetry-partner intrinsic gravitational field sources in the intrinsic metric spacetimes in the positive (or our) universe and the negative universe, have been integrated into the diagram in Fig. 8. The non-uniform relative proper intrinsic static flow speed and relative proper static flow speed, denoted by $\varnothing V_{m,P}'$ and $V_{m,P}'$, in Fig. 5 of [8] (reproduced as Fig. 16 on page 106 of this article), have also been re-denoted by $\varnothing V_g'(\varnothing r')$ and $V_g'(r')$ and referred to as relative proper intrinsic gravitational flow speeds and relative proper gravitational flow speed in Fig. 8, as the appropriate names in the present case of metric gravitational field.

The gravitational-relativistic[1] mass M represented by a line segment of length SL in Fig. 8 is actually a spherical gravitational-relativistic mass M (as being assumed), of radius, $\mathrm{R} = \mathrm{SL}$, and the relativistic metric Euclidean 3-space Σ represented by a line of length SO, is actually a spherical relativistic metric Euclidean 3-space of large radius SO with M at its centre. The relativistic intrinsic metric space $\varnothing\rho$ is an isotropic intrinsic metric dimension with respect to 3-observers in the relativistic Euclidean 3-space Σ. It can be considered to lie along any of the radial direction from the center of M in Σ, with respect to 3-observers in Σ.

As illustrated in Fig. 8, the relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ along the curved relative proper intrinsic metric space $\varnothing\rho'$ is projected invariantly as non-uniform relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ along the projective straight line relativistic intrinsic metric space $\varnothing\rho$ along the horizontal, which is made manifested in non-uniform relative proper gravitational velocities $\vec{V}_g'(r')$ along every radial direction from the centre of the relativistic mass M of the gravitational field source in Σ. The non-uniform relative proper intrinsic gravitational flow speed $\varnothing V_g'(\varnothing r')$ along the curved relative proper intrinsic metric time dimension $\varnothing c_s\varnothing t'$, is likewise invariantly projected as non-uniform relative proper intrinsic gravitational flow speed along the projective relativistic intrinsic metric time dimension $\varnothing c_s\varnothing t$ along the vertical, which is made manifested in non-uniform relative proper gravitational flow speed $V_g'(r')$ along the relativistic metric time dimension ct.

[1] *The term 'relativistic' in the gravitational field (in the absence of SR) in this article is 'gravitational-relativistic' in the context of the theory of relativity associated with the presence of gravitational field in spacetime, to be identified shortly in this article.*

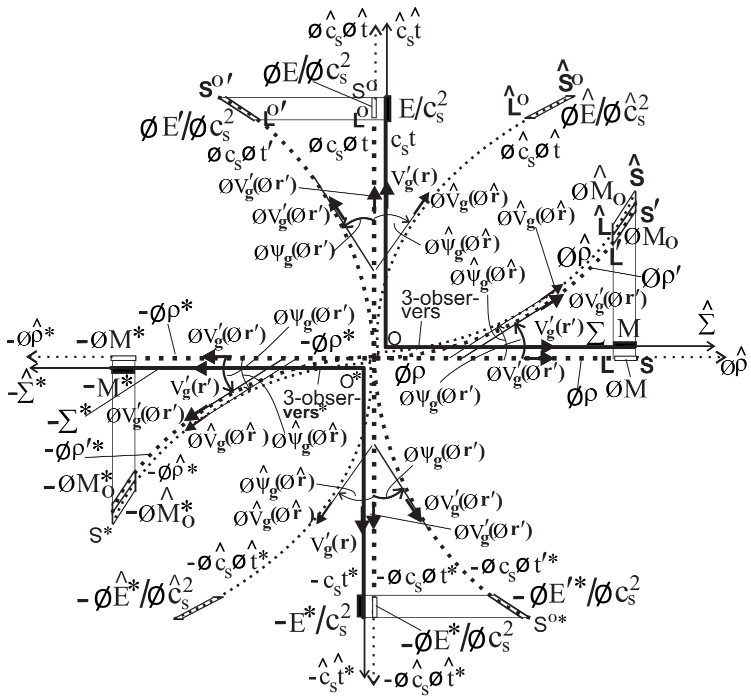

Fig. 8. The global metric spacetime/intrinsic metric spacetime geometry of combined first and second stages of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters within the identical gravitational fields of a pair of symmetry-partner sources in the positive and negative universes, with respect to 3-observers in the Euclidean 3-spaces in the two universes, which evolves upon the geometry of Fig. 7 at the first stage.

The foregoing paragraph describes the graphical representation of the invariance of relative intrinsic gravitational flow speed and relative gravitational flow speed in the context of the theory of relative intrinsic gravity and theory of relativive gravity that transform Fig. 7 into Fig. 8, at the second stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters in the gravitational field, expressed as follows

$$\varnothing V_g(\varnothing r) = \varnothing V_g'(\varnothing r') \qquad (2a)$$

and

$$V_g(r) = V_g'(r') \qquad (2b)$$

Equation (2a) states that the non-uniform gravitational-relativistic intrinsic static gravitational flow speed $\varnothing V_g(\varnothing r)$ that is expected to be projected into the relativistic intrinsic metric space $\varnothing\rho$ by the non-uniform relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ along the curved relative proper intrinsic metric space $\varnothing\rho'$, are the same as the non-uniform relative proper intrinsic gravitational flow speed along the curved $\varnothing\rho'$, and Eq. (2b) states that the non-uniform gravitational-relativistic gravitational flow speed $V_g(r)$ that is expected to be established along every radial direction from the centre of the relativistic mass M of the gravitational field source in the relativistic metric Euclidean 3-space Σ in Fig. 8, is non-uniform relative proper static gravitational flow speed $V_g'(r')$. Formal explanations of the invariance (2a) and (2b) along with those of Eqs. (1a) and (1b) shall be given elsewhere.

The geometry of Fig. 8 will endure for as long as the 'projective' relativistic intrinsic mass $\varnothing M$ does not establish a new non-uniform relativistic intrinsic gravitational flow speed $\varnothing V_g(\varnothing r) \neq$

$\varnothing V'_g(\varnothing r')$ along the relativistic intrinsic space $\varnothing\rho$, which could cause the curvature of $\varnothing\rho$, and as long as the 'projective' relativistic intrinsic mass $\varnothing E/\varnothing c_s^2\,(\equiv \varnothing M)$ does not establish a new non-uniform relativistic intrinsic gravitational flow speed $\varnothing V_g(\varnothing r) \neq \varnothing V'_g(\varnothing r')$ along the relativistic intrinsic time dimension $\varnothing c_s \varnothing t$ along the vertical, which could cause the curvature of $\varnothing c_s \varnothing t$.

Now the gravitational-relativistic mass M in the gravitational-relativistic Euclidean 3-space Σ shall be identified as the inertial mass and passive gravitational mass, which is non-trivially related to the rest mass M_0 according to a relation that shall be established elsewhere. The relativistic mass (i.e. the inertial mass or passive gravitational mass) is not a gravitational field source; the active gravitational mass, denoted by M_0a in the present theory, being the source of the Newtonian gravitational field [11, 12]. Consequently M is not a source of gravitational flow speed. This means that M cannot establish a new non-uniform relativistic gravitational flow velocity $\vec{V}_g(r) \neq \vec{V}'_g(r')$ radially from its centre in Σ and, consequently, $\varnothing M$ cannot establish a new non-uniform relativistic static intrinsic gravitational flow speed $\varnothing V_g(\varnothing r) \neq \varnothing V_g(\varnothing r')$ along the relativistic intrinsic space $\varnothing\rho$. The relativistic mass $E/c_s^2\,(\equiv M)$ in the relativistic time dimension $c_s t$ cannot establish a new non-uniform relativistic gravitational flow speed $V_g(r) \neq V'_g(r')$ along $c_s t$ and $\varnothing E/\varnothing c_s^2$ cannot establish non-uniform relativistic static intrinsic gravitational flow speed $\varnothing V_g(\varnothing r) \neq \varnothing V'_g(\varnothing r')$ along $\varnothing c_s \varnothing t$.

The non-existence of non-uniform relativistic intrinsic gravitational flow speed $\varnothing V_g(\varnothing r) \neq \varnothing V'_g(\varnothing r')$ along the relativistic intrinsic metric spacetime dimensions, $\varnothing\rho$, $\varnothing c_s\varnothing t$, $-\varnothing\rho^*$ and $-\varnothing c_s\varnothing t^*$, either by projections from the curved relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$, $\varnothing c_s\varnothing t'$, $-\varnothing\rho'^*$ and $-\varnothing c_s\varnothing t'^*$, or by establishments by $\varnothing M, \varnothing E/\varnothing c_s^2$, $-\varnothing M^*$, $-\varnothing E^*/\varnothing c_s^2$ respectively as sources, as discussed in the preceding paragraph, implies that the relativistic intrinsic metric spaces, $\varnothing\rho$ and $-\varnothing\rho^*$, and relativistic intrinsic metric time dimensions, $\varnothing c_s\varnothing t$ and $-\varnothing c_s\varnothing t^*$, in Fig. 8 cannot be curved. This makes the geometry of Fig. 8 to endure for as long as the symmetry-partner gravitational field sources in the positive and negative universes exist. A consequence of this is that the evolutions of spacetime/intrinisic spacetime and parameters/intrinsic parameters in the gravitational field terminates at the second stage naturally. This immutable fact shall become solidly established upon this initial introduction to it elsewhere.

The geometry of Fig. 8 is valid with respect to 3-observers in the relativistic Euclidean 3-spaces, Σ and $-\Sigma^*$, in the positive and negative universes as indicated. It corresponds to Fig. 5 of [8] (reproduced as Fig. 16 on page 106 of this article). There is a complimentary diagram to Fig. 8 of this article, which corresponds to Fig. 7 of [8] (reproduced as Fig. 17 on page 106 of this article). It is depicted in Fig. 9 of this article. Figure 9 is valid with respect to 1-observers in the relativistic time dimensions, $c_s t$ and $-c_s t^*$, as indicated. While Fig. 8 has evolved from Fig. 7 with respect to 3-observers in Σ' and $-\Sigma'^*$, Fig. 9 has evolved from Fig. 7 with respect to 1-observers in $c_s t'$ and $-c_s t'^*$.

The global metric spacetime/intrinsic metric spacetime diagram of Fig. 8 and its complimentary diagram of Fig. 9, evolve at the second stage of evolutions of spacetime/intrinsic spacetime in the gravitational field. The remarkable feature of the diagrams, as discussed for Figs. 5 and 7 of [8] (reproduced as Fig. 16 and Fig. 17 on page 106 of this article), in a long-range metric force field in general is that, the four-dimensional relativistic metric spacetime $(\Sigma, c_s t)$ in which the observers are located and its underlying two-dimensional relativistic intrinsic metric spacetime $(\varnothing\rho\,,\, \varnothing c_s\varnothing t)$, are everywhere flat in an arbitrary gravitational field. This fact has been solidly established by demonstrating local Lorentz invariance[2] in a long-range metric force field in general in [8]. Gravitational local Lorentz invariance (GLLI) shall be established within a gravitational field of arbitrary strength shortly in this article.

[2] *Local Lorentz invariance in a long-range metric force field is associated with the theory of relativity within the field due to the non-uniform 'static flow' speed V'_m established within the field by the source.*

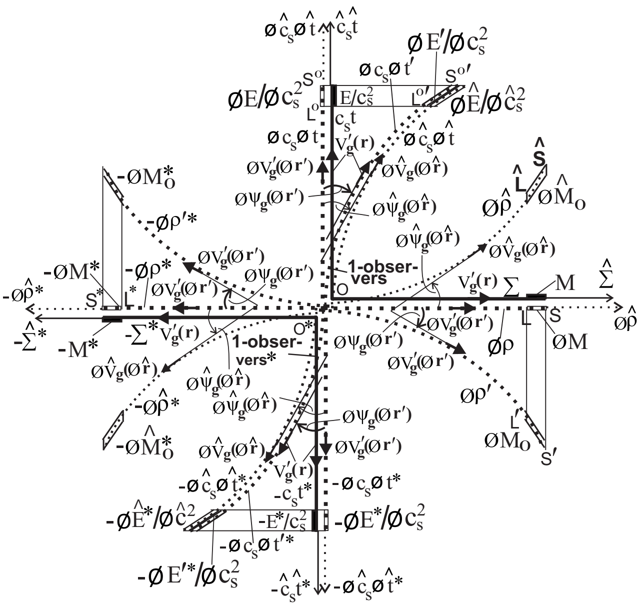

Fig. 9. The complementary geometry to the global geometry of Fig. 8 is valid with respect to 1-observers in the relativistic metric time dimensions in the positive and negative universes.

Although the extended two-dimensional relative proper intrinsic metric spacetimes, $(\varnothing\rho', \varnothing c_s \varnothing t')$ and $(-\varnothing\rho'^*, -\varnothing c_s \varnothing t'^*)$, are curved in the gravitational field in Figs. 8 and 9, they possess pseudo-orthogonal curvilinear intrinsic metric dimensions. This means that they possess the Lorentzian metric tensor at every point of them with respect to 3-observers in the relativistic metric Euclidean metric 3-spaces, Σ and $-\Sigma^*$, and 1-observers in the relativistic metric time dimensions, $c_s t$ and $-c_s t^*$, as has been demonstrated in long-range metric force fields in general in [8].

The only curved spacetime with a Riemannian metric tensor, so to speak, in Figs. 8 and 9, at the second stage of evolutions of spacetime/intrinsic spacetime in the gravitational field in our universe, is the 'two-dimensional' absolute intrinsic metric spacetime $(\varnothing\hat{\rho}\,, \varnothing\hat{c}_s\varnothing\hat{t})$ with absolute intrinsic sub-Riemannian metric tensor $\varnothing\hat{g}_{ik}$, with respect to 3-observers in the relativistic metric Euclidean 3-space Σ in the positive (or our) universe (Fig. 8) and 1-observers in the relativistic metric time dimension $c_s t$ (Fig. 9), as has been established within long-range metric force fields in general in [8]. The curved $(\varnothing\hat{\rho}\,, \varnothing\hat{c}_s\varnothing\hat{t})$ in Figs. 8 and 9, at the second stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters in the gravitational field, has been brought forward from the geometry of Fig. 7 at the first stage.

For completeness and in order to be able to derive the inverse intrinsic gravitational local Lorentz transformation (inverse ∅GLLT) and inverse gravitational local Lorentz transformation (inverse GLLT), the inverses of the global diagrams of Figs. 8 and 9 must also drawn as Fig. 10 and Fig. 11 respectively. The explanations of how Figs. 10 and 11 of this article are the inverses of Figs. 8 and 9 of this article respectively, with respect to the indicated observers, are the same as the explanations of how Figs. 8 and 9 of [8] (reproduced as Fig. 18 and Fig. 19 on page 107 of this article) are the inverses of Figs. 5 and 7 of [8] (reproduced as Fig. 16 and Fig. 17 on page 106 of this article), in a long-range metric force field in general, done in [8].

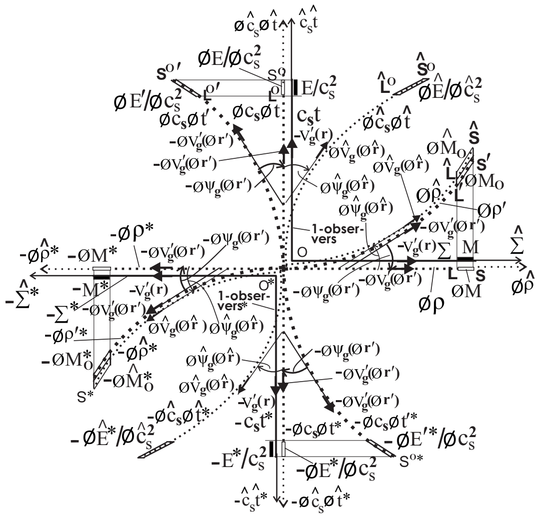

Fig. 10. The inverse of the global metric spacetime/intrinsic metric spacetime geometry of Fig. 8 of combined first and second stages of evolutions of spacetimes/intrinsic spactimes and parameters/intrinsic parameters within symmetry-partner gravitational fields in our universe and negative universe is valid with respect to 1-observers in the relativistic metric time dimensions c_st and $-c_st^*$ in the two universes.

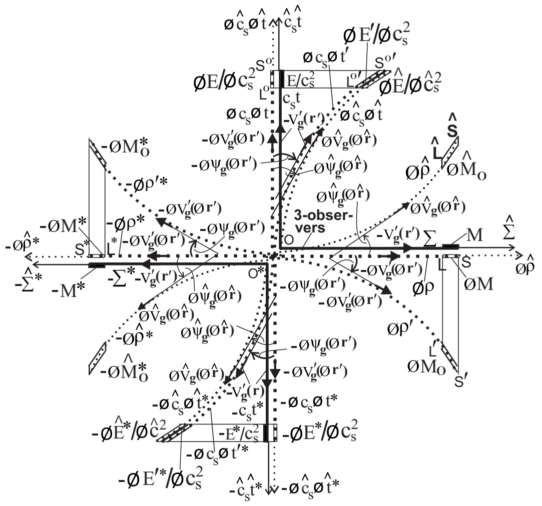

Fig. 11. The inverse of the global metric spacetime/intrinsic metric spacetime geometry to Fig. 9 of combined first and second stages of evolutions of spacetimes/intrinsic spactimes and parameters/intrinsic parameters within symmetry-partner gravitational fields in the positive and negative universe is valid with respect to 3-observers in the relativistic Euclidean 3-spaces in the two universes.

The next step in this article is to adapt the new results derived in section 2 of [8] from the local spacetime/intrinsic spacetime geometries of that article, at the second stage of evolution of metric spacetime/intrinsic metric spacetime in a long-range metric force field in general, to the gravitational field. This is the subject ot the next section.

3 THE THEORY OF GRAVITATIONAL RELATIVITY AND THEORY OF INTRINSIC GRAVITATIONAL RELATIVITY ASSOCIATED WITH THE PRESENCE OF GRAVITATIONAL FIELD AND INTRINSIC GRAVITATIONAL FIELD AT THE SECOND STAGE OF EVOLUTIONS OF SPACE-TIME/INTRINSIC SPACETIME AND PARAMETERS/INTRINSIC PARAMETERS IN THE GRAVITATIONAL FIELD

As stated above, the programme of this section is to adapt the results of section 2 of [8] in a long-range metric force field in general to the gravitational field. Those results are the intrinsic local Lorentz transformation (∅LLT) in terms of relative proper intrinsic 'static flow' speed $\varnothing V_m'$; local Lorentz transformation (LLT) in terms of relative proper 'static flow' speed V_m'; intrinsic local Lorentz invariance (∅LLI) and local Lorentz invariance (LLI) implied by ∅LLT and LLT respectively; intrinsic metric time dilation and intrinsic metric length contraction formulae in terms of relative proper intrinsic 'static flow' speed $\varnothing V_m'$ and metric time dilation and metric length contraction formulae in terms of relative proper 'static flow' speed V_m'.

The relative proper intrinsic 'static flow' speed $\varnothing V_{m,P}'$ and relative proper 'static flow' speed $V_{m,P}'$ that appear in those results must simply be replaced by the relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ and relative proper static gravitational flow speed $V_g'(r')$ respectively, where $\varnothing V_g'(\varnothing r')$ must be related to the relative proper intrinsic gravitational parameters and $V_g'(r')$ must be related to the relative proper gravitational parameters of the source of the external gravitational field.

It thus follows that the place to start this section from is the derivation of expressions for $\varnothing V_g'(\varnothing r')$ and $V_g'(r')$ that will appear in the theory of relativity and theory of intrinsic relativity associated with the presence of relative gravitational field in spacetime and relative intrinsic gravitational field in intrinsic spacetime, as well as absolute intrinsic static gravitational flow speed $\varnothing \hat{V}_g(\varnothing \hat{r})$ that will appear in the absolute intrinsic metric tensor $\varnothing \hat{g}_{ij}$, absolute intrinsic Ricci tensor $\varnothing \hat{R}_{ij}$ and absolute intrinsic line element of the metric theory of absolute intrinsic gravity (M∅AG) on the curved 'two-dimensional' absolute intrinsic metric spacetime $(\varnothing \hat{\rho}, \varnothing \hat{c}_s \varnothing \hat{t})$, with respect to 3-observers in the relativistic metric Euclidean 3-space Σ in Fig. 8.

3.1 Relating static gravitational flow speed and intrinsic static grav- itational flow speed to gravitational parameters and intrinsic gravitational parameters

Figure 7 that is valid partially with respect to 3-observers in the Σ' and $-\Sigma'^*$ and partially with respect to 1-observers in $c_s t'$ and $-c_s t'^*$, is a valid geometry at the first stage of evolutions of spacetime/intrinsic spacetime and parameters/intrinsic parameters in the gravitational field. It does not exist however, because there was no time for it to be formed, since the second stage of evolutions commences at the same moment that the geometry of Fig. 7 at the first stage begins to evolve, as shall be shown in the second part ov this article. It thereby yields the geometry of Figs. 8 of combined first and second stages of evolutions of spacetime/intrinsic spacetime and and parameters/intrinsic parameters in the gravitational field, as the geometry that exists with respect to 3-observers in the relativistic metric Euclidean 3-spaces, Σ and $-\Sigma^*$, and Fig. 9 as the geometry that exists with respect to 1-observers in the relativistic metric time dimensions, $c_s t$ and $-c_s t^*$, in a gravitational field of arbitrary strength.

Now let the 'one-dimensional' absolute intrinsic rest mass $\varnothing\hat{m}_0$ of a test particle be in absolute intrinsic gravitational fall (at increasing absolute intrinsic dynamical speed $\varnothing\hat{V}_d$) along the curved absolute intrinsic space $\varnothing\hat{\rho}$, toward the absolute intrinsic rest mass $\varnothing\hat{M}_0$ of the gravitational field source at the origin of the curved $\varnothing\hat{\rho}$ in the first quadrant (or our universe) in Fig. 8. In perfect symmetry, the symmetry-partner test particle of negative absolute intrinsic rest mass $-\varnothing\hat{m}_0^*$ is in absolute intrinsic gravitational fall (at identical increasing absolute intrinsic dynamical speed $\varnothing\hat{V}_d$), along the curved absolute intrinsic space $-\varnothing\hat{\rho}^*$, toward the negative absolute intrinsic rest mass $-\varnothing\hat{M}_0^*$ of the symmetry-partner gravitational field source at the origin of the curved $-\varnothing\hat{\rho}^*$ in the third quadrant (or the negative universe) in Fig. 8.

Let the absolute intrinsic rest mass $\varnothing\hat{m}_0$ of the test particle in our universe possess absolute intrinsic dynamical speed $\varnothing\hat{V}_d$ upon falling along the curved $\varnothing\hat{\rho}$ to a position P of 'distance' $\varnothing\hat{r}$ from the base $\hat{S}$ of $\varnothing\hat{M}_0$ at the origin of the curved $\varnothing\hat{\rho}$. It will acquire the absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ at position P, of the non-uniform absolute intrinsic static gravitational flow speed established along the curved $\varnothing\hat{\rho}$ by $\varnothing\hat{M}_0$. Thus the absolute intrinsic rest mass $\varnothing\hat{m}_0$ of the test particle will possess absolute intrinsic dynamical speed $\varnothing\hat{V}_d$ and absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ it acquires at position P, upon falling to this position along the curved $\varnothing\hat{\rho}$.

On the other hand, the curved relative proper intrinsic metric space $\varnothing\rho'$ possesses relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ at the corresponding point P′ along $\varnothing\rho'$, which the relative intrinsic rest mass $\varnothing M_0$ of the gravitational field source at the origin of the curved $\varnothing\rho'$ establishes along $\varnothing\rho'$, as well as absolute proper intrinsic static gravitational flow speed $\varnothing V_{gab}'(\varnothing r_{ab}')\,(=\varnothing\hat{V}_g(\varnothing\hat{r}))$ invariantly projected into the curved $\varnothing\rho'$ by $\varnothing\hat{V}_g(\varnothing\hat{r})$ at point $\hat{\mathrm{P}}$ along the curved $\varnothing\hat{\rho}$. Recall that the absolute proper intrinsic metric space $\varnothing\rho_{ab}'$ into which $\varnothing V_{\mathrm{gab}}'(\varnothing r_{ab}')$ is projected is embedded in the straight line $\varnothing\rho'$ in Fig. 7 and the curved $\varnothing\rho'$ in Fig. 8. The relative intrinsic rest mass $\varnothing m_0$ of the test particle in absolute intrinsic fall at absolute proper intrinsic dynamical speed $\varnothing V_{dab}'$ through point P′ on the curved $\varnothing\rho'$, therefore acquires relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ and absolute proper intrinsic static gravitational flow speed $\varnothing V_{gab}'(\varnothing r_{ab}')\,(=\varnothing\hat{V}_g(\varnothing\hat{r}))$, in addition to its absolute proper intrinsic dynamical speed $\varnothing V_{dab}'\,(=\varnothing\hat{V}_d)$.

Now the curved two-dimensional relative proper intrinsic metric spacetime $(\varnothing\rho', \varnothing c_s\varnothing t')$ with pseudo-orthogonal curvilinear intrinsic dimensions, $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$, possesses the Lorentzian metric tensor at every point with respect to the 3-observers in Σ. Consequently the 3-observers in Σ will formulate the theory of combined intrinsic gravity and intrinsic motion with the relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ and its absolute proper intrinsic dynamical speed $\varnothing V_{dab}'$ along the curved $\varnothing\rho'$ and write the proper intrinsic total energy of the intrinsic rest mass of the test particle as

$$\varnothing U' = \frac{1}{2}\varnothing m_0 \varnothing V_{dab}'^2 - \frac{1}{2}\varnothing m_0 \varnothing V_g'(\varnothing r')^2 \ . \quad (3)$$

The fact that the proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ is an absolute intrinsic speed in the context of intrinsic dynamical relativity (since it is the same relative to all observers), makes the combination of absolute proper intrinsic kinetic energy and relative proper intrinsic gravitational energy possible in Eq. (3).

On the other hand, Eq. (3) takes on the Newtonian form in terms of the relative proper (or classical) intrinsic gravitational potential function as

$$\varnothing U' = \frac{1}{2}\varnothing m_0 \varnothing V_{dab}'^2 - \frac{G\varnothing M_0 \varnothing m_0}{\varnothing r'} \ . \tag{4a}$$

Equation (4a) is correct numerically, but the intrinsic rest mass $\varnothing M_0$ of the gravitational field source, as source of the intrinsic Newtonian gravitational field in that equation, must be replaced by the intrinsic active gravitational mass of the field source, to be denoted by $\varnothing M_{0\text{a}}$. The fact that the active gravitational mass is the source of the Newtonian gravitational potential and field is known [12–14]. This fact shall be abundantly justified elsewhere in the present theory.

It is also known that the rest mass and the active gravitational mass are equivalent, which means that M_0 and $M_{0\text{a}}$ have equal magnitude but are distinct masses [12]. The fact that the active gravitational mass $M_{0\text{a}}$ is an immaterial entity with the same shape and size and equal magnitude as the rest mass M_0 and that $M_{0\text{a}}$ is imperceptibly contained in M_0, shall also be fully justified elsewhere in the present theory. Thus the immaterial $M_{0\text{a}}$ that imperceptibly wholly occupies M_0 is the source of the massless gravitational potential and field, which appear to originate from M_0 in Σ', in the present theory.

Equation (4a) must be replaced with the following equivalent form

$$\varnothing U' = \frac{1}{2}\varnothing m_0 \varnothing V_{dab}'^2 - \frac{G\varnothing M_{0\text{a}} \varnothing m_0}{\varnothing r'} \ . \tag{4b}$$

Equation (4b) along the curved relative proper intrinsic metric space $\varnothing \rho'$ is valid for all magnitudes of the classical intrinsic gravitational potential and absolute proper intrinsic dynamical speed, with respect to the intrinsic 1-observers on the curved $\varnothing \rho'$ at the location of the intrinsic rest mass $\varnothing m_0$ of the test particle and 3-observers at any position in Σ.

A comparison of Eqs. (4b) and (3) yields the following expressions for relative proper intrinsic gravitational flow speed, $\varnothing V_g'(\varnothing r')^2 = 2G\varnothing M_{0\text{a}}/\varnothing r'$;
$\varnothing V_g'(\varnothing r') = -\sqrt{2G\varnothing M_{0\text{a}}/\varnothing r'}$. The negative root of $2G\varnothing M_{0\text{a}}/\varnothing r'$ is chosen in the definition of $\varnothing V_g'(\varnothing r')$, because of the attractive nature of the intrinsic gravitational field $\varnothing g'$ and the fact that $\varnothing g'$ and $\varnothing V_g'(\varnothing r')$ are collinear and co-directional. This fact shall be fully entrenched with further development elsewhere.

The relative proper intrinsic gravitational potential is dependent on the relative proper intrinsic static gravitational flow speed as

$$\varnothing \Phi'(\varnothing r') = -\frac{1}{2}\varnothing V_g'(\varnothing r')^2 = -\frac{G\varnothing M_{0\text{a}}}{\varnothing r'} \ . \tag{5}$$

Also because of the local Lorentzian metric tensor on the curved $(\varnothing \rho', \varnothing c_s \varnothing t')$ with respect to 3-observers in Σ, the relative proper intrinsic gravitational acceleration (or relative proper intrinsic gravitational field) at the point P along the curved $\varnothing \rho'$, is given from definition like in Euclidean geometry, with respect to the 3-observer in Σ as

$$\varnothing g'(\varnothing r') = \frac{1}{2}\frac{\varnothing V_g'(\varnothing r')^2}{\varnothing r'} \quad = \quad -\frac{\varnothing \Phi'(\varnothing r')}{\varnothing r'} = -\frac{G\varnothing M_{0\text{a}}}{\varnothing r'^2} \ . \tag{6}$$

Removing the symbol $\varnothing$ from Eqs. (5a-b) – Eq. (7) gives the expressions for relative proper gravitational flow speed (or velocity), relative proper gravitational potential and relative proper gravitational acceleration respectively as $\mathrm{V}_g'(r')^2 = \frac{2GM_0\mathrm{a}}{r'}$;
$\vec{V}_g'(r') = -\sqrt{\frac{2GM_0\mathrm{a}}{r'}}\frac{\vec{r}'}{r'}$;

$$\Phi'(r') = -\frac{1}{2}V_g'(r')^2 = -\frac{GM_0\mathrm{a}}{r'} \tag{7}$$

and

$$\vec{g}'(r') = \frac{1}{2}\frac{V_g'(r')^2}{r'} = -\frac{\Phi'(r')}{r'} = -\frac{GM_0\mathrm{a}\vec{r}'}{r'^3}\ . \tag{8}$$

The $\vec{V}_g'(r')$ and $\vec{g}'(r')$ are collinear and parallel vectors from Eqs. (8b) and (10).

In order to derive expressions for the absolute intrinsic gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$, absolute intrinsic gravitational potential $\varnothing\hat{\Phi}(\varnothing\hat{r})$ and absolute intrinsic gravitational acceleration (or field) $\varnothing\hat{g}(\varnothing\hat{r})$, along the curved absolute intrinsic metric space $\varnothing\hat{\rho}$, which correspond to Eqs. (5b), (6) and (7) for the respective relative proper intrinsic parameters along the curved relative proper intrinsic metric space $\varnothing\rho'$, we shall employ the natural covariance of absolute intrinsic natural laws on the curved absolute intrinsic metric spacetime $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$, with respect to 3-observers in Σ' in Fig. 7 and 3-observers in Σ in Fig. 8. The covariance of absolute intrinsic natural laws implies that the absolute intrinsic natural laws remain the same at every point on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ with respect to the 3-observers in Σ, including at the point O at 'infinity' where the curved $(\varnothing\hat{\rho}\,,\ \varnothing\hat{c}_s\varnothing\hat{t})$ is flat.

The natural covariance of absolute intrinsic natural laws on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ with respect to all 3-observers in Σ in Fig. 8 follows from the invariance of absolute intrinsic spacetime coordinate interval projections, $d\varnothing\rho'_{ab} = d\varnothing\hat{\rho}$ and $d\varnothing t'_{ab} = d\varnothing\hat{t}$ and of all absolute intrinsic parameters $\hat{q}$ in physics as, $\varnothing q'_{ab} = \varnothing\hat{q}$, at every point of the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$ and its invariantly projected flat absolute proper intrinsic metric spacetime $(\varnothing\rho'_{ab}, \varnothing c_{sab}\varnothing t'_{ab})$, with respect to 3-observers in Σ. The invariance, $d\varnothing\rho'_{ab} = d\varnothing\hat{\rho}$ and $\varnothing c_{sab}d\varnothing t'_{ab} = \varnothing\hat{c}_s d\varnothing\hat{t}$, have been introduced and applied to establish absolute intrinsic local Lorentz invariance (A$\varnothing$LLI) on the curved absolute intrinsic metric spacetime $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$, which also possesses absolute intrinsic sub-Riemannian metric tensor $\varnothing\hat{g}_{ik}$, with respect to 3-observers in Σ in [7].

The invariance, $d\varnothing\rho'_{ab} = d\varnothing\hat{\rho}$ and $\varnothing c_{sab}d\varnothing t'_{ab} = \varnothing\hat{c}_s d\varnothing\hat{t}$, at every point of the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$ with respect to 3-observers in Σ, implies that local absolute intrinsic coordinate at every point of the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$ is the same as the local 'coordinate' $(\varnothing\hat{r}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$ of any given point on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$, including points at infinity where $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$ is flat, with respect to 3-observers in Σ. This, along with the invariance, $\varnothing q'_{ab} = \varnothing\hat{q}$, of all absolute intrinsic parameters $\varnothing\hat{q}$ in physics, guarantees the covariance of all absolute intrinsic natural laws on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$, with respect to 3-observers in the relativistic Euclidean 3-space Σ. A more formal proof of covariance of all absolute intrinsic natural laws on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t}\,)$, with respect to 3-observers in Σ shall be supported quantitatively by derivation elsewhere.

An absolute intrinsic natural law formulated at an arbitrary point P on the curved $\varnothing\hat{\rho}$ will remain the same at the point O at infinity where $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\hat{t})$ is flat, according to the natural covariance of absolute intrinsic natural laws on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ with respect to 3-observers in Σ in Fig. 7. It follows from this that the absolute intrinsic natural laws take on their absolute intrinsic Newtonian forms on flat $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$ at every point on the curved $(\varnothing\hat{\rho}, \varnothing\hat{c}_s\varnothing\hat{t})$, with respect to all 3-observers in Σ in the gravitational field in Fig. 8.

As follows from the preceding paragraph, the absolute intrinsic total energy $\varnothing\hat{U}$ of the absolute intrinsic rest mass $\varnothing\hat{m}_0$ of the test particle at the position $\hat{\mathrm{P}}$ of 'distance' $\varnothing\hat{r}$ from the base of the absolute intrinsic rest mass $\varnothing\hat{M}_0$ of the gravitational field source along the curved $\varnothing\hat{\rho}$ in Fig. 8, is given in terms of the absolute intrinsic speeds $\varnothing\hat{V}_d$ and $\varnothing\hat{V}_g(\varnothing\hat{r})$ in the following absolute intrinsic Newtonian form

$$\varnothing\hat{U} = \frac{1}{2}\varnothing\hat{m}_0\varnothing\hat{V}_d^2 - \frac{1}{2}\varnothing\hat{m}_0\varnothing\hat{V}_g(\varnothing\hat{r})^2 \,. \quad (9)$$

This is the same as the following absolute intrinsic Newtonian expression for absolute intrinsic total energy

$$\varnothing\hat{U} = \frac{1}{2}\varnothing\hat{m}_0\varnothing\hat{V}_d^2 - \frac{G\varnothing\hat{M}_{0\mathsf{a}}\varnothing\hat{m}_0}{\varnothing\hat{r}} \,. \quad (10)$$

The expression for the absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ that follows from Eqs. (11) and (12) is the following $\varnothing\hat{V}_g(\varnothing\hat{r})^2 = 2G\varnothing\hat{M}_{0\mathsf{a}}/\varnothing\hat{r}$;
$\varnothing\hat{V}_g(\varnothing\hat{r}) = -\sqrt{2G\varnothing\hat{M}_{0\mathsf{a}}/\varnothing\hat{r}}$.
The dependence of the absolute intrinsic gravitational potential and absolute intrinsic gravitational acceleration on the absolute intrinsic gravitational flow speed, obtained by writing Eqs. (6) and (7) in terms of absolute intrinsic gravitational parameters are the following

$$\varnothing\hat{\Phi}(\varnothing\hat{r}) = -\frac{1}{2}\varnothing\hat{V}_g(\varnothing\hat{r})^2 = -\frac{G\varnothing\hat{M}_{0\mathsf{a}}}{\varnothing\hat{r}} \,. \quad (11)$$

and

$$\varnothing\hat{g}(\varnothing\hat{r}) = \frac{1}{2}\frac{\varnothing\hat{V}_g(\varnothing\hat{r})^2}{\varnothing\hat{r}} = -\frac{\varnothing\hat{\Phi}(\varnothing\hat{r})}{\varnothing\hat{r}} = -\frac{G\varnothing\hat{M}_{0\mathsf{a}}}{\varnothing\hat{r}^2} \,. \quad (12)$$

The absolute intrinsic static gravitational flow speed $\varnothing\hat{V}_g(\varnothing\hat{r})$ is taken to be the negative root of $2G\varnothing\hat{M}_0/\varnothing\hat{r}$ in Eq. (13b), because of the attractive nature of the gravitational field.

Removing the symbol $\varnothing$ from Eqs. (13a-b) – Eq. (15), gives expressions for absolute gravitational flow speed, absolute gravitational potential and absolute gravitational acceleration respectively as
${}_g(\hat{r})^2 = 2G\hat{M}_{0\mathsf{a}}/\hat{r}$;
$\hat{V}_g(\hat{r}) = -\sqrt{2G\hat{M}_{0\mathsf{a}}/\hat{r}}$;

$$\hat{\Phi}(\hat{r}) = -\frac{1}{2}\hat{V}_g(\hat{r})^2 = -\frac{G\hat{M}_{0\mathsf{a}}}{\hat{r}} \,; \quad (13)$$

$$\hat{g}(\hat{r}) = \frac{1}{2}\frac{\hat{V}_g(\hat{r})^2}{\hat{r}} = -\frac{\hat{\Phi}(\hat{r})}{\hat{r}} = -\frac{G\hat{M}_{0\mathsf{a}}}{\hat{r}^2} \,. \quad (14)$$

3.2 Deriving intrinsic gravitational local Lorentz transformation and gravitational local Lorentz transformation and establishing intrinsic gravitational local Lorentz invariance and gravitational local Lorentz invariance in the gravitational field

The intrinsic local Lorentz transformation and its inverse in terms of relative proper intrinsic 'static flow' speed $\varnothing V_m'$, as well as intrinsic local Lorentz invariance, intrinsic metric time dilation and intrinsic metric length contraction formulae they imply, derived with the aid of the local metric spacetime/intrinsic metric spacetime diagrams of Figs. 10 and 11 and their inverses, Figs. 12 and 13 of [8] (reproduced as Figs. 20 and 21 and their inverses as Figs. 22 and 23 on pages 108 – 109 of this article), within an arbitrary long-range metric force field, in sub-section 2.2 of [8] and the outward manifestations of those results namely, local Lorentz transformation and its inverse in terms of relative proper 'static flow' speed V_m', as well as local Lorentz invariance, metric time dilation and metric length contraction formulae they imply, on the flat four-dimensional relativistic metric spacetime, in a long-range metric force field, shall be adapted to the gravitational field in this sub-section.

The counterparts in the gravitational field of the local metric spacetime/intrinsic metric spacetime geometries of Fig. 10 – Fig. 13 of [8] in long-range metric force fields in general (reproduced as Fig. 20 – Fig. 23 on pages 108 – 109 of this article), must be drawn from the global geometries of Fig. 8 – Fig. 11 of this article in the gravitational field. This will be an easy task, since the counterpart local geometries to be derived from Figs. 8 – Fig. 11 of this article are exactly the same as Fig. 10 – Fig 13 of [8], except that the relative proper intrinsic static 'flow speed' $\varnothing V_m'$, which appears in those diagrams in [8] in long-range metric force fields in general, must be replaced by relative proper intrinsic static gravitational flow speed $\varnothing V_g'(\varnothing r')$ in the gravitational field. For completeness of this article, the counterpart in the gravitational field of Fig. 10 of [8] (reproduced as Fig. 20 on page 108 of this article) in long-range metric force fields in general is presented as Fig. 12 of this article.

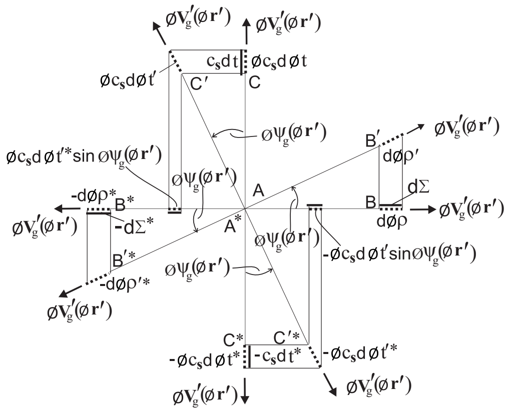

Fig. 12. Local metric spacetime/intrinsic metric spacetime diagram derived from the global diagram of Fig. 8 is valid respect to 3-observers in the relativistic Euclidean 3-spaces in the positive and negative universes.

The local geometry of Fig. 12 derived from the global geometry of Fig. 8 of this article is valid with respect to 3-observers in the relativistic Euclidean 3-spaces, Σ and $-\Sigma^*$, as is the case with Fig. 8. This is so because, the anti-clockwise rotation by a positive relative intrinsic angle $\varnothing\psi_g(\varnothing r')$ of the relative proper intrinsic metric spacetime intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, relative to their projective relativistic intrinsic metric spacetime intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, in Fig. 12 is valid with respect to these 3-observers. The partial intrinsic metric spacetime interval transformation that can be derived with respect to 3-observers in Σ in the first quadrant in Fig. 12, which follows from the derivation of Eq. (5) from Fig. 10 in [8] (reproduced as Fig. 20 on page 108 of this article), is the following

$$\begin{aligned} d\varnothing\rho' &= d\varnothing\rho \sec\varnothing\psi_g(\varnothing r') - \varnothing c_s d\varnothing t \tan\varnothing\psi_g(\varnothing r') \; ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \; . \end{aligned} \tag{15}$$

The counterpart in the gravitational field of Fig. 11 of [8] (reproduced as Fig. 21 on page 108 of this article), in a long-range metric force field in general, is depicted as Fig. 13 of this article. The local diagram of Fig. 13, drawn from the global diagram of Fig. 9, is valid with respect to 1-observers in the relativistic metric time dimensions, $c_s t$ and $-c_s t^*$, as is the case with Fig. 9. This is so, because the clockwise rotation by a positive relative intrinsic angle $\varnothing\psi_g(\varnothing r')$ of the relative proper intrinsic metric spacetime intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, relative to their projective relativistic intrinsic metric spacetime intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, in Fig. 13 is valid with respect to these 1-observers in $c_s t$ and $-c_s t^*$.

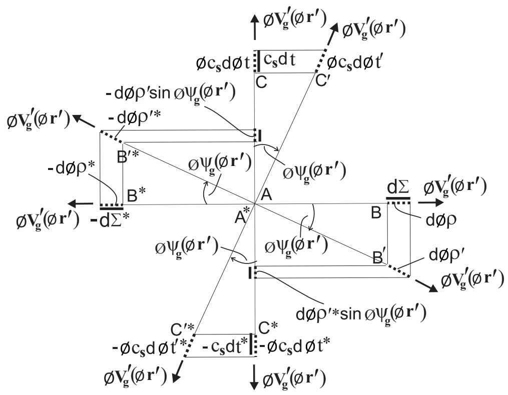

Fig. 13. Local metric spacetime/intrinsic metric spacetime diagram derived from the global diagram of Fig. 9 is valid with respect to 1-observers in the relativistic metric time dimensions in the positive and negative universes; the complementary diagram to Fig. 12.

The partial intrinsic metric spacetime interval transformation that can be derived with respect to 1-observers in c_st in the first quadrant from Fig. 13, which follows from the derivation of Eq. (6) from Fig. 11 in [8] (reproduced as Fig. 21 on page 108 of this article), is the following

$$\begin{aligned} \varnothing c_s d\varnothing t' &= \varnothing c_s d\varnothing t \sec\varnothing\psi_g(\varnothing r') - d\varnothing\rho\tan\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_st)\ . \end{aligned} \tag{16}$$

Collecting Eqs. (19) and (20) gives the full inverse intrinsic metric spacetime interval transformation with respect to 3-observers in Σ and 1-observers in c_st, at 'distance' $\varnothing r'$ along the curved relative proper intrinsic metric space $\varnothing\rho'$ from the base S$'$ of the intrinsic rest mass $\varnothing M_0$ of the gravitational field source at the origin of the curved $\varnothing\rho'$ in Figs. 12 and 13 as

$$\begin{aligned} \varnothing c_s d\varnothing t' &= \varnothing c_s d\varnothing t \sec\varnothing\psi_g(\varnothing r') - d\varnothing\rho\tan\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_st)\ ; \\ d\varnothing\rho' &= d\varnothing\rho\sec\varnothing\psi_g(\varnothing r') - \varnothing c_s d\varnothing t\tan\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma)\ . \end{aligned} \tag{17}$$

There is an inverse of system (21), which must be derived from the inverses of Figs. 12 and 13 of this article. The inverse of Fig. 12 is the counterpart in the gravitational field of Fig. 12 of [8] (reproduced as Fig. 22 on page 109 of this article) in long range metric force fields in general. It is depicted in Fig. 14 of this article. Figure 14 derived from the inverse global geometry Fig. 10 of this article, is valid with respect to 1-observers in the relativistic metric time dimensions, c_st and $-c_st^*$, as is the case with Figs. 10 and 12 of this article. This, as explained for Fig. 12 of [8] of this article), is so, because the clockwise rotation of the relativistic intrinsic metric spacetime intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, relative to the inclined relative proper intrinsic metric spacetime intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, by a negative relative intrinsic angle $-\varnothing\psi_g(\varnothing r')$ in Fig. 14, is equivalent to clockwise rotation of the inclined relative proper intrinsic metric spacetime coordinate intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, relative to their projective relativistic intrinsic metric spacetime coordinate intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, by a positive relative intrinsic angle $\varnothing\psi_g(\varnothing r')$ in Fig. 13. Consequently Fig. 14, like Fig. 13, is valid with respect to 1-observers in the relativistic metric time dimensions, c_st and $-c_st^*$, as is the case for Figs. 9 and 10, from which Figs. 13 and 14 have been drawn respectively.

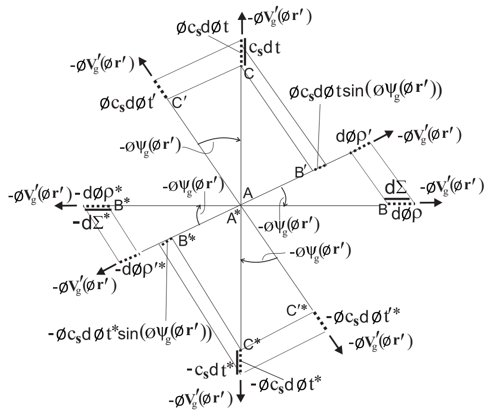

Fig. 14. The inverse of Fig. 12 is valid with respect to 1-observers in the relativistic metric time dimensions in the positive and negative universes.

The partial intrinsic metric spacetime interval transformation that can be derived with respect to 1-observers in $c_s t$ in the first quadrant (or in the positive universe) from Fig. 14, which follows from the derivation of Eq. (8) from Fig. 12 of [8] (reproduced as Fig. 22 on page 109 of this article), is the following

$$d\varnothing\rho \;=\; d\varnothing\rho' \sec\varnothing\psi_g(\varnothing r') + \varnothing c_s d\varnothing t' \tan\varnothing\psi_g(\varnothing r')\ ; \quad (\text{w.r.t. } 1-\text{observers in } c_s t)\ . \tag{18}$$

Finally the inverse of Fig. 13 is the counterpart in the gravitational field of Fig. 13 of [8] (reproduced as Fig. 23 on page 109 of this article) in long range metric force fields in general. It is depicted in Fig. 15 of this article. The inverse local geometry of Fig. 15, derived from the inverse global geometry Fig. 11, is valid with respect to 3-observers in the relativistic Euclidean 3-spaces, Σ and $-\Sigma^*$, of the positive and negative universes, as is the case with Fig. 11. This, as explained for Fig. 13 of [8] (reproduced as Fig. 23 on page 109 of this article), is so, because the anti-clockwise rotation of the relativistic intrinsic spacetime coordinate intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, relative to the inclined relative proper intrinsic metric spacetime coordinate intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, by a negative intrinsic angle $-\varnothing\psi_g(\varnothing r')$ in Fig. 15, is equivalent to anti-clockwise rotation of the inclined proper intrinsic metric spacetime coordinate intervals, $d\varnothing\rho'$ and $\varnothing c_s d\varnothing t'$, relative to relativistic intrinsic metric spacetime coordinate intervals, $d\varnothing\rho$ and $\varnothing c_s d\varnothing t$, by positive relative intrinsic angle $\varnothing\psi_g(\varnothing r')$ in Fig. 12. Consequently Fig. 15, like Fig. 12, is valid with respect to 3-observers in the relativistic Euclidean 3-spaces, Σ and $-\Sigma^*$.

The partial intrinsic metric spacetime coordinate interval transformation that can be derived with respect to 3-observers in Σ in the first quadrant (or in the positive universe) from Fig. 15, which follows from the derivation of Eq. (9) of [8] from Fig. 13 of that article (reproduced as Fig. 23 on page 109 of this article), is the following

$$\varnothing c_s d\varnothing t \;=\; \varnothing c_s d\varnothing t' \sec\varnothing\psi_g(\varnothing r') + d\varnothing\rho' \tan\varnothing\psi_g(\varnothing r')\ ; \quad (\text{w.r.t. } 3-\text{observers in } \Sigma)\ . \tag{19}$$

Collecting Eqs. (22) and (23) gives the full intrinsic metric spacetime coordinate interval transformations with respect to 3-observers in Σ and 1-observers in $c_s t$, derived with the aid of the inverse local diagrams of Figs. 14 and 15, at 'distance' $\varnothing r'$ along the curved relative proper intrinsic metric space $\varnothing\rho'$, from the base S$'$ of the relative intrinsic rest mass $\varnothing M_0$ of the gravitational field source at the

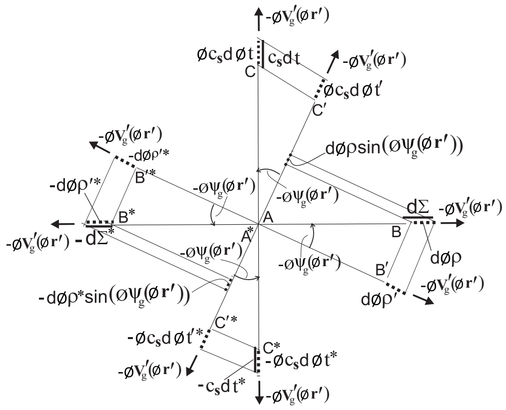

Fig. 15. The inverse of Fig. 13 is valid with respect to 3-observers in the relativistic metric Euclidean 3-spaces in the positive and negative universes.

origin of the curved $\varnothing\rho'$ in the global diagrams of Figs. 8 or 9 as

$$\begin{aligned}\varnothing c_s d\varnothing t &= \varnothing c d\varnothing t' \sec\varnothing\psi_g(\varnothing r') + d\varnothing\rho' \tan\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma)\ ; \\ d\varnothing\rho &= d\varnothing\rho' \sec\varnothing\psi_g(\varnothing r') + \varnothing c_s d\varnothing t' \tan\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t)\ , \end{aligned} \tag{20}$$

where, as follows from the derivation of relations (12) – (13a-b) of [8],

$$\frac{d\varnothing\rho}{\varnothing c_s d\varnothing t} = \frac{\varnothing V_g(\varnothing r')}{\varnothing c_s} = \sin\varnothing\psi_g(\varnothing r')\ , \tag{21}$$

and $d\varnothing\rho/d\varnothing t = \varnothing V_g'(\varnothing r')$, since only relative proper intrinsic static gravitational flow speed is present in the absence of of a test particle in intrinsic motion (or in the absence of SR) in the external gravitational field, as being inherently assumed in this article.

Now following the discussion that led to the replacement of Eqs. (79) and (80) by Eqs. (81) and (82) in [7], the divisor in $\varnothing V_g(\varnothing r')/\varnothing c_s$ in Eq. (25) cannot be the maximum intrinsic static geodesic flow speed $\varnothing c_s$ that appears in $\varnothing c_s\varnothing t$, but the maximum over all relative intrinsic static gravitational flow speeds, to be denoted by $\varnothing c_g$, with magnitude of $3\times 10^8\,\text{m}\,\text{s}^{-1}$. Indeed the presence of intrinsic static geodesic flow speed $\varnothing c_s$ at every point along $\varnothing c_s\varnothing t'$ does not give rise to intrinsic gravitational potential along $\varnothing c_s\varnothing t'$, unlike $\varnothing V_g'(\varnothing r')$ that is present along $\varnothing c_s\varnothing t'$ in the gravitational field and gives rise to intrinsic gravitational potential $\varnothing\Phi_g'(\varnothing r')$ along $\varnothing c_s\varnothing t'$, with respect to 1-observers in $c_s t'$. Hence c_s is equivalent to zero magnitude of static intrinsic gravitational potential $\varnothing V_g'(\varnothing r')$. This makes $\varnothing c_s$ inappropriate as divisor in $\varnothing V_g(\varnothing r')/\varnothing c_s$. Equation (25) must consequently be modified as $\sin\varnothing\psi_g(\varnothing r') = \frac{\varnothing V_g'(\varnothing r')}{\varnothing c_g} = \varnothing\beta_g(\varnothing r')$;
$\sec\varnothing\psi_g(\varnothing r') = (1 - \frac{\varnothing V_g'(\varnothing r')^2}{\varnothing c_g^2})^{-1/2} = \varnothing\gamma_g(\varnothing r')$.
Using Eqs. (26a) and (26b) in systems (21) and (24) gives the counterparts in the gravitational field

to systems (14) and (15) of [8] in general long-range metric force fields respectively as

$$\begin{aligned} d\varnothing t' &= \varnothing\gamma_g(\varnothing r')(d\varnothing t - \frac{\varnothing V_g'(\varnothing r')}{\varnothing c_g^2} d\varnothing\rho) \ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \ ; \\ d\varnothing\rho' &= \varnothing\gamma_g(\varnothing r')(d\varnothing\rho - \varnothing V_g'(\varnothing r') d\varnothing t) \ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \end{aligned} \tag{22}$$

and

$$\begin{aligned} d\varnothing t &= \varnothing\gamma_g(\varnothing r')(d\varnothing t' + \frac{\varnothing V_g'(\varnothing r')}{\varnothing c_g^2} d\varnothing\rho') \ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \ ; \\ d\varnothing\rho &= \varnothing\gamma_g(\varnothing r')(d\varnothing\rho' + \varnothing V_g'(\varnothing r') d\varnothing t') \ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \ . \end{aligned} \tag{23}$$

Finally, using the expression (5a) for the relative proper intrinsic gravitational flow speed in Eq. (26a) and (26b) gives the following relations for the relative intrinsic angle $\varnothing\psi_g(\varnothing r')$ $\sin\varnothing\psi_g(\varnothing r') = \frac{\varnothing V_g'(\varnothing r')}{\varnothing c_g} = \sqrt{\frac{2G\varnothing M_0\mathsf{a}}{\varnothing r'\varnothing c_g^2}} = \varnothing\beta_g(\varnothing r')$;
$\sec\varnothing\psi_g(\varnothing r') = (1 - \frac{\varnothing V_g'(\varnothing r')^2}{\varnothing c_g^2})^{-1/2} = (1 - \frac{2GM_0\mathsf{a}}{\varnothing r'\varnothing c_g^2})^{-1/2} = \varnothing\gamma_g(\varnothing r')$.
Systems (21) and (24) or systems (27) and (28) are then given in terms of the relative intrinsic gravitational parameter $2G\varnothing M_0\mathsf{a}/\varnothing r'\varnothing c^2$ respectively as

$$\begin{aligned} d\varnothing t' &= \varnothing\gamma_g(\varnothing r')(d\varnothing t - \sqrt{\frac{2G\varnothing M_0\mathsf{a}}{\varnothing r'\varnothing c_g^4}} d\varnothing\rho) \ ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \ ; \\ d\varnothing\rho' &= \varnothing\gamma_g(\varnothing r')(d\varnothing\rho - \sqrt{\frac{2G\varnothing M_0\mathsf{a}}{\varnothing r'}} d\varnothing t) \ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \end{aligned} \tag{24}$$

and

$$\begin{aligned} d\varnothing t &= \varnothing\gamma_g(\varnothing r')(d\varnothing t' + \sqrt{\frac{2G\varnothing M_0\mathsf{a}}{\varnothing r'\varnothing c_g^4}} d\varnothing\rho') \ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \ ; \\ d\varnothing\rho &= \varnothing\gamma_g(\varnothing r')(d\varnothing\rho' + \sqrt{\frac{2G\varnothing M_0\mathsf{a}}{\varnothing r'}} d\varnothing t') \ ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } c_s t) \ . \end{aligned} \tag{25}$$

Systems (21) and (24), systems (27) and (28) and systems (30) and (31), are alternative forms of intrinsic gravitational local Lorentz transformation (∅GLLT) and its inverse on the two-dimensional relative intrinsic metric spacetime in a gravitational field of arbitrary strength. The concept of relativity associated with relative static intrinsic gravitational flow speed shall be clarified shortly in this section.

Either system (21) or its inverse (24), or the more explicit form (27) or (28) in terms of relative proper intrinsic gravitational flow speed, or the most explicit form (30) or (31) in terms of relative proper intrinsic gravitational parameters $2G\varnothing M_0\mathsf{a}/\varnothing r'$, leads to intrinsic gravitational local Lorentz invariance (∅GLLI)

$$\varnothing c_s^2 d\varnothing t^2 - d\varnothing\rho^2 = \varnothing c_s^2 d\varnothing t'^2 - d\varnothing\rho'^2 \ . \tag{26}$$

It follows from the $\varnothing$GLLI that the two-dimensional relativistic intrinsic metric spacetime $(\varnothing\rho, \varnothing c_s\varnothing t)$ possesses intrinsic Lorentzian metric tensor at every point and it is consequently everywhere flat in a gravitational field of arbitrary strength, as illustrated by the extended straight line $\varnothing\rho$ and $\varnothing c_s\varnothing t$ in Fig. 8 – Fig. 13.

Let us collect the partial intrinsic gravitational local Lorentz transformations of elementary intrinsic metric spacetime coordinate intervals with respect to 3-observers in the relativistic Euclidean 3-space Σ in systems (21) and (24) to have

$$\begin{aligned} d\varnothing\rho' &= \sec\varnothing\psi_g(\varnothing r')(d\varnothing\rho - \sin\varnothing\psi_g(\varnothing r')\varnothing c_s d\varnothing t)\ ; \\ d\varnothing t &= \sec\varnothing\psi_g(\varnothing r')(d\varnothing t' + \frac{\sin\varnothing\psi_g(\varnothing r')}{\varnothing c_g}d\varnothing\rho')\ ; \\ &\quad (\text{w.r.t } 3-\text{observers in } \Sigma)\ . \end{aligned} \tag{27}$$

Now when a hypothetical intrinsic 1-observer in the relativistic intrinsic metric space $\varnothing\rho$ underlying Σ picks his intrinsic laboratory rod to measure the relativistic intrinsic metric space interval involved in an intrinsic event in the relativistic intrinsic metric spacetime, in the first equation of system (33), he will be able to measure the term $d\varnothing\rho\sec\varnothing\psi_g(\varnothing r')$ but not the term $-\varnothing c_s d\varnothing t\tan\varnothing\psi_g(\varnothing r')$ at the right-hand side of that equation, with his intrinsic laboratory rod. Likewise when the hypothetical intrinsic 1-observers in $\varnothing\rho$ picks his intrinsic laboratory clock to measure the intrinsic metric time interval involved in the same intrinsic event in the second equation of system (33), he will be able to measure the term $d\varnothing t'\sec\varnothing\psi_g(\varnothing r')$ but not the term $(d\varnothing\rho'/\varnothing c_s)\tan\varnothing\psi_g(\varnothing r')$, with his intrinsic laboratory clock. Removing the terms that cannot be measured with intrinsic laboratory rod and intrinsic laboratory clock from system (33) gives

$$\begin{aligned} d\varnothing\rho &= d\varnothing\rho'\cos\varnothing\psi_g(\varnothing r') \ \text{ and } \ d\varnothing t = d\varnothing t'\sec\varnothing\psi_g(\varnothing r')\ ; \\ &\quad (\text{w.r.t } 3-\text{observers in } \Sigma)\ . \end{aligned} \tag{28}$$

System (34) gives the intrinsic gravitational length contraction and intrinsic gravitational time dilation formulae in terms of the intrinsic angle $\varnothing\psi_g(\varnothing r')$, with respect to 3-observers in the gravitational-relativistic Euclidean 3-space Σ, in the context of the intrinsic theory of relativity associated with the presence of a relative intrinsic gravitational field in intrinsic metric spacetime (with the global geometry of Figs. 8 and 9).

System (34) is given in terms of the relative proper intrinsic static gravitational flow speed by virtue of relation (26b) as

$$\begin{aligned} d\varnothing\rho &= d\varnothing\rho'(1 - \frac{\varnothing V_g'(\varnothing r')^2}{\varnothing c_g^2})^{1/2} \ \text{ and } \ d\varnothing t = d\varnothing t'(1 - \frac{\varnothing V_g'(\varnothing r')^2}{\varnothing c_g^2})^{-1/2}\ ; \\ &\quad (\text{w.r.t } 3-\text{observers in } \Sigma)\ . \end{aligned} \tag{29}$$

And system (35) is given in terms of the relative proper intrinsic gravitational parameter $2G\varnothing M_0\text{a}/\varnothing r'$ by virtue of relation (29b) as

$$d\varnothing\rho = d\varnothing\rho'(1 - \frac{2G\varnothing M_0\text{a}}{\varnothing r'\varnothing c_g^2})^{1/2} \text{ and } d\varnothing t = d\varnothing t'(1 - \frac{2G\varnothing M_0\text{a}}{\varnothing r'\varnothing c_g^2})^{-1/2} ; \quad (\text{w.r.t } 3-\text{observers in } \Sigma) . \tag{30}$$

Now the intrinsic theory of relativity in intrinsic metric spacetime that is associated with the presence of relative intrinsic gravitational field, will be made manifested in the theory of relativity in metric spacetime that is associated with the presence of relative gravitational field in metric spacetime. Consequently the intrinsic gravitational local Lorentz transformation (∅GLLT) of system (21) and its inverse of system (24), within intrinsic gravitational local Lorentz frames on the flat two-dimensional intrinsic metric spacetime in the gravitational field, in terms of the intrinsic angle $\varnothing\psi_g(\varnothing r')$, will be made manifested outwardly in gravitational local Lorentz transformation (GLLT) and its inverse within the corresponding gravitational local Lorentz frames on the flat four-dimensional metric spacetime in the gravitational field. Essentially the symbol ∅ must simply be removed from systems (21) and (24) to have their outward manifestations in spacetime respectively as

$$\begin{aligned} c_s dt' &= c_s dt \sec\psi_g(r') - dr \tan\psi_g(r') ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) ; \\ dr' &= dr \sec\psi_g(r') - c_s dt \tan\psi_g(r') ; \ r'd\theta' = rd\theta ; \ r'\sin\theta' d\varphi' = r\sin\theta d\varphi ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \end{aligned} \tag{31}$$

and

$$\begin{aligned} c_s dt &= c_s dt' \sec\psi_g(r') + dr' \tan\psi_g(r') ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) ; \\ dr &= dr' \sec\psi_g(r') + c_s dt' \tan\psi_g(r') ; \ \ rd\theta = r'd\theta' ; \ r\sin\theta d\varphi = r'\sin\theta' d\varphi' ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) . \end{aligned} \tag{32}$$

Now the relative proper static gravitational flow speed $V_g'(r')$ is isotropic in the relative proper metric Euclidean 3-space Σ' and the relativistic Euclidean 3-space Σ. It consequently lies radially from the centre of the rest mass M_0 in Σ' and from the centre of the relativistic mass M in Σ of the gravitational field source, irrespective of the shape of M_0 and M. It is for this reason that the outward manifestation in spacetime of systems (21) and (24) take on the forms of systems (37) and (38) respectively always in all gravitational fields, where the unprimed (or relativistic) coordinates, $r\theta$ and $r\sin\theta\varphi$, of Σ, along which $V_g'(r')$ does not lie, which are hence non-relativistic coordinates, transform into the corresponding proper coordinates, $r', r'\theta'$ and $r'\sin\theta'\varphi'$, of Σ' trivially as, $r'\theta' = r\theta$ and $r'\sin\theta'\varphi' = r\sin\theta\varphi$. These facts shall be more rigorously established elsewhere.

The appearance of the angle $\psi_g(r')$ in system (37) and (38) conveys the impression that the proper metric coordinates intervals dr' and $c_s dt'$ are rotated at angle $\psi_g(r')$ relative to their projective relativistic metric coordinate intervals dr and $c_s dt$ and, consequently that, the extended dimensions, r' and $c_s t'$, of the relative proper metric spacetime $(\Sigma', c_s t') \equiv (r', r'\theta', r'\sin\theta'\varphi', c_s t')$ are curved with non-uniform curvature relative to their projective straight line dimensions, r and $c_s t$, respectively of the relativistic metric spacetime $(\Sigma, c_s t) \equiv (r, r\theta, r\sin\theta\varphi, c_s t)$, in the gravitational field. It is to be noted however that there is no curvature of the four-dimensional metric spacetime, or of the dimensions of the four-dimensional metric spacetime, in the new geometrical background to the theory of relativity and gravitation within a four-world picture, presented as Figs. 8 – Fig. 11 of this article.

Only the relative proper intrinsic metric spacetime dimensions, $\varnothing\rho'$ and $\varnothing c_s\varnothing t'$, are actually curved relative to their projective relativistic intrinsic metric spacetime dimensions, $\varnothing\rho$ and $\varnothing c_s\varnothing t$, respectively in Figs. 8 and 9 and their inverses, Figs. 10 and 11. The curvature of the dimensions of the metric spacetime apparently implied by systems (37) and (38) is an intrinsic and not observable (or actual) curvature. This is what the actual curvatures of intrinsic metric spacetime in Fig. 10 – Fig. 13 represent.

The outward manifestations on the four-dimensional metric spacetime of the intrinsic gravitational local Lorentz transformation of system (27) and its inverse (28) in terms of gravitational flow speed are likewise given respectively as

$$\begin{aligned} dt' &= \gamma_g(r')(dt - \frac{V_g'(r')}{c_g^2}dr) \; ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \; ; \\ dr' &= \gamma_g(r')(dr - V_g'(r')dt) \; ; \; r'd\theta' = rd\theta \; ; \; r'\sin\theta' d\varphi' = r\sin\theta d\varphi \; ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \end{aligned} \tag{33}$$

and

$$\begin{aligned} dt &= \gamma_g(r')(dt' + \frac{V_g'(r')}{c_g^2}dr') \; ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \; ; \\ dr &= \gamma_g(r')(dr' + V_g'(r')dt') \; ; \; rd\theta = r'd\theta' \; ; \; r\sin\theta d\varphi = r'\sin\theta' d\varphi' \; ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \; , \end{aligned} \tag{34}$$

where

$$\gamma_g(r') = \sec\psi_g(r') = (1 - V_g'(r')^2/c_g^2)^{-1/2} \; . \tag{35}$$

Systems (39) – (41) correspond to systems (22) – (24) of [8].

The outward manifestations in the four-dimensional spacetime of systems (30) and (31) are given respectively as

$$\begin{aligned} dt' &= \gamma_g(r')(dt - \sqrt{\frac{2GM_0\mathsf{a}}{r'c_g^4}}dr) \; ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \; ; \\ dr' &= \gamma_g(r')(dr - \sqrt{\frac{2GM_0\mathsf{a}}{r'}}dt) \; ; \; r'd\theta' = rd\theta \; ; \; r'\sin\theta' d\varphi' = r\sin\theta d\varphi \; ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \end{aligned} \tag{36}$$

and

$$\begin{aligned} dt &= \gamma_g(r')(dt' + \sqrt{\frac{2GM_0\mathsf{a}}{r'c_g^4}}dr') \; ; \\ &\quad (\text{w.r.t. } 3-\text{observers in } \Sigma) \; ; \\ dr &= \gamma_g(r')(dr' + \sqrt{\frac{2GM_0\mathsf{a}}{r'}}dt') \; ; \; rd\theta = r'd\theta' \; ; \; r\sin\theta d\varphi = r'\sin\theta' d\varphi' \; ; \\ &\quad (\text{w.r.t. } 1-\text{observers in } c_s t) \; , \end{aligned} \tag{37}$$

where

$$\gamma_g(r') = (1 - V_g'(r')^2/c_g^2)^{-1/2} = (1 - 2GM_0\mathsf{a}/r'c_g^2)^{-1/2} \; . \tag{38}$$

Systems (37) and (38), systems (39) and (40) and systems (42) and (43), are alternative forms of gravitational local Lorentz transformation (GLLT) and its inverse in the four-dimensional relativistic metric spacetime in the gravitational field. They are called gravitational local Lorentz transformation, because they are restricted within gravitational local Lorentz frames (within which gravitational potential is constant) in arbitrary gravitational field. They pertain to a theory of relativity to be named shortly, which is associated with the presence of relative gravitational field in metric spacetime.

Either the GLLT (37), (39) or (42) or its inverse (38), (40) or (43), leads to gravitational local Lorentz invariance (GLLI):

$$c_s^2dt^2 \;-\; dr^2 \;-\; r^2(d\theta^2 + sin^2 d\varphi^2) = c_s^2 dt'^2 - dr'^2 - r'^2(d\theta'^2 + \sin^2 d\varphi'^2)\;. \qquad (39)$$

The gravitational local Lorentz invariance (GLLI) (45) is valid at every point on the four-dimensional relativistic metric spacetime in a gravitational field of arbitrary strength, implying the flatness of the four-dimensional gravitational-relativistic metric spacetime $(\Sigma, c_s t)$ everywhere in a gravitational field of arbitrary strength, as deduced graphically and illustrated in Figs. 8 and 9 and their inverses, Figs. 10 and 11 earlier. The GLLI (45) is the outward manifestation on the flat four-dimensional metric spacetime of the intrinsic gravitational local Lorentz invariance ($\varnothing$GLLI) (32) on flat two-dimensional intrinsic metric spacetime.

Finally the intrinsic gravitational length contraction and intrinsic gravitational time dilation formulae in the context of the intrinsic theory of relativity associated with the presence of relative intrinsic gravitational field on the flat two-dimensional intrinsic metric spacetime, presented in the alternative forms of systems (34), (35) and (36), are made manifested outwardly on the flat four-dimensional metric spacetime, in the context of the theory of relativity associated with the presence of relative gravitational field in metric spacetime respectively as

$$\begin{aligned} dr &= dr'\cos\psi_g(r')\;;\; rd\theta = r'd\theta'\;;\; r\sin\theta d\varphi = r'\sin\theta' d\varphi'\;;\;\text{and} \\ dt &= dt'\sec\psi_g(r')\;. \end{aligned} \qquad (40)$$

$$\begin{aligned} dr &= (1-\frac{V_g'(r')^2}{c_g^2})^{1/2}dr'\;;\; rd\theta = r'd\theta'\;;\; r\sin\theta d\varphi = r'\sin\theta' d\varphi'\;;\;\text{and} \\ dt &= (1-\frac{V_g'(r')^2}{c_g^2})^{-1/2}dt' \end{aligned} \qquad (41)$$

and

$$\begin{aligned} dr &= (1-\frac{2GM_0\text{a}}{r'c_g^2})^{1/2}dr';\; rd\theta = r'd\theta'\;;\; r\sin\theta d\varphi = r'\sin\theta' d\varphi'\;;\;\text{and} \\ dt &= (1-\frac{2GM_0\text{a}}{r'c_g^2})^{-1/2}dt'\;. \end{aligned} \qquad (42)$$

The gravitational length contraction and gravitational time dilation formulae (46) – (48) at radial distance r from the center of the gravitational-relativistic mass M in Σ in Fig. 8, corresponding to radial distance r' from the centre of the rest mass M_0 in Σ' in Fig. 7, are valid with respect to 3-observers in the relativistic Euclidean 3-space Σ in Fig. 8.

The theory of relativity on the flat four-dimensional relativistic metric spacetime $(\Sigma, c_s t)$, which is associated with the presence of a relative gravitational field, within which the gravitational local Lorentz transformation (GLLT) and its inverse (37) and (38), or (39) and (40), or (42) and (43), have been derived; within which the gravitational local Lorentz invariance (45) on the flat four-dimensional metric spacetime in a gravitational field of arbitrary strength has been established, and within which the gravitational length contraction and gravitational time dilation formulas of system (46), (47) or (48) have been derived, shall be referred to as the theory of gravitational relativity and given the acronym (TGR).

The TGR is the gravitational counterpart (involving relative static gravitational flow speed $V_g'(r')$), of the special theory of relativity (SR) (involving uniform relative dynamical speed v). However, while the relative dynamical speed is constant in SR, thereby satisfying the special principle of relativity [9], the relative static gravitational flow speed $V_g'(r')$, which appears in TGR, is spatially uniform within a gravitational local Lorentz frame, but varies from one gravitational local Lorentz frame to another, thereby satisfying the general principle of relativity of Einstein [10] globally in the gravitational field. Thus the theory of gravitational relativity (TGR) may also be referred to as the general theory of relativity on flat spacetime, going by the Einsteinian nomenclature, but TGR shall be preferred.

If we could have our way, the special theory of relativity associated with relative dynamical velocity would be referred to as the theory of dynamical relativity (TDR), which can then take care of the relativity of both uniform and non-uniform relative dynamical velocities. The relativity of non-uniform relative velocity motions shall be investigated in the context of the present theory elsewhere.

The intrinsic theory of relativity on the flat two-dimensional relativistic intrinsic metric spacetime $(\varnothing\rho, \varnothing c_s \varnothing t)$ associated with the presence of relativistic intrinsic gravitational field on $(\varnothing\rho, \varnothing c_s \varnothing t)$, within which the intrinsic gravitational local Lorentz transformation (∅GLLT) and its inverse of systems (21) and (24) or systems (27) and (28) or systems (30) and (31), have been derived; within which the intrinsic gravitational local Lorentz invariance (∅GLLI) (32) has been established, and within which the intrinsic gravitational length contraction and intrinsic gravitational time dilation formulae of system (34), (35) or (36) have been derived, is the theory of intrinsic gravitational relativity (T∅GR). It is the gravitational counterpart of the intrinsic special theory of relativity (∅SR).

The theory of gravitational relativity (TGR) on the flat four-dimensional relativistic metric spacetime $(\Sigma, c_s t)$ in an arbitrary gravitational field in Figs.10 and 11 and their inverses, Figs. 12 and 13, is mere outward manifestation on the flat $(\Sigma, c_s t)$ of the theory of intrinsic gravitational relativity (T∅GR) on the flat two-dimensional relativistic intrinsic metric spacetime $(\varnothing\rho, \varnothing c_s \varnothing t)$ underlying $(\Sigma, c_s t)$ in those figures. Once a result of T∅GR has been derived on the flat intrinsic spacetime $(\varnothing\rho\,,\, \varnothing c_s \varnothing t)$, the corresponding result of TGR on the flat four-dimensional spacetime $(\Sigma, c_s t)$ can be written straight away, essentially by dropping the symbol ∅ from the result of T∅GR. This procedure, which has been demonstrated above, has also been demonstrated between ∅SR and SR in [1].

The “relativity” aspect of the commonly used terminology “relativity and gravitation”, when applied in the present context, refers to a theory of relativity on the flat spacetime associated with the presence of gravitational field, which is the theory of gravitational relativity (TGR), while the “gravitation” part of the “relativity and gravitation” terminology, refers to the theory (or law) of gravity (i.e. of gravitational interaction) on flat four-dimensional relativistic metric spacetime $(\Sigma, c_s t)$ in Fig. 10, obtained from the transformations with the aid of GLLT and its inverse (42) and (43) of the classical (or Newtonian) theory (or law) of gravity (or of classical gravitational interaction), as shall be investigated elsewhere. This is analogous to the special theory of relativity and relativistic mechanics, where relativistic mechanics is classical mechanics transformed with the aid of LT and its inverse in the context of SR.

This first part of this article shall be ended at this point. The second part shall be a direct continuation of this first part. Division into two parts is necessary in order to avoid to long paper. The summary, conclusion and direction for further investigation in full of the two parts of this article shall be presented at the end of the second part. One conclusion reached in this article that, the four-dimensional metric spacetime is everywhere flat in arbitrary gravitational field shall be mentioned at this point however.

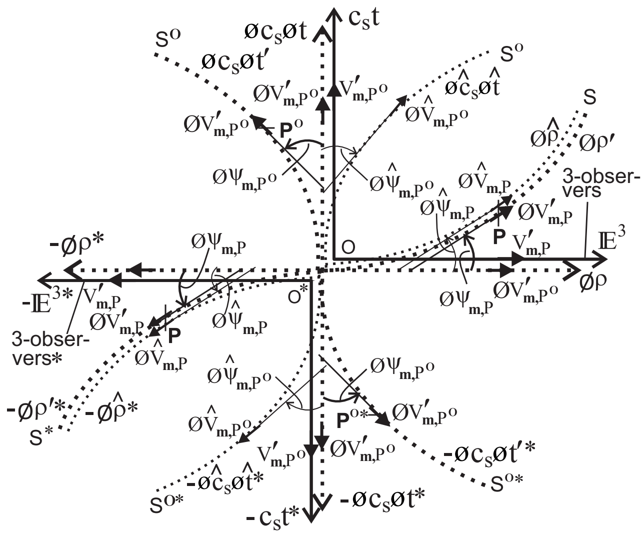

Fig. 16. The global metric spacetime/intrinsic metric spacetime diagram within symmetry-partner long-range relativistic metric force fields in our universe and negative universe, with respect to 3-observers in the relativistic metric Euclidean spaces in the two universes; (Fig. 1 of [8])

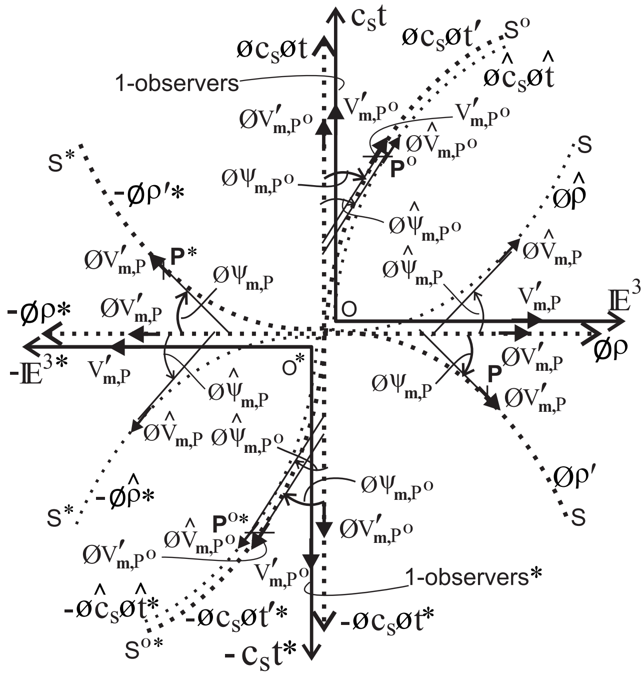

Fig. 17. The complementary global metric spacetime/intrinsic metric spacetime diagram to Fig. 18; is valid with respect to 1-observers in the relativistic metric time dimensions in our universe and the negative universe; (Fig. 3 of [8])

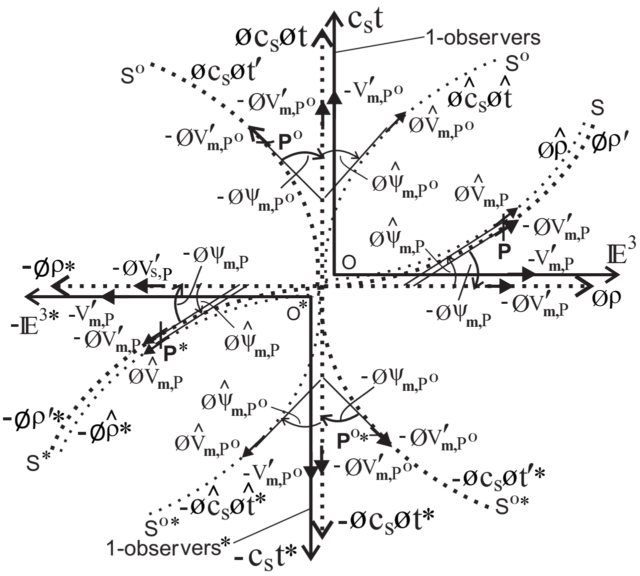

Fig. 18. The inverse of the global metric spacetime/intrinsic metric spacetime diagram of Fig. 18; is valid with respect to 1-observers in the relativistic time dimensions c_s and $-c_st^*$ in the positive and negative universes; (Fig. ... of [8])

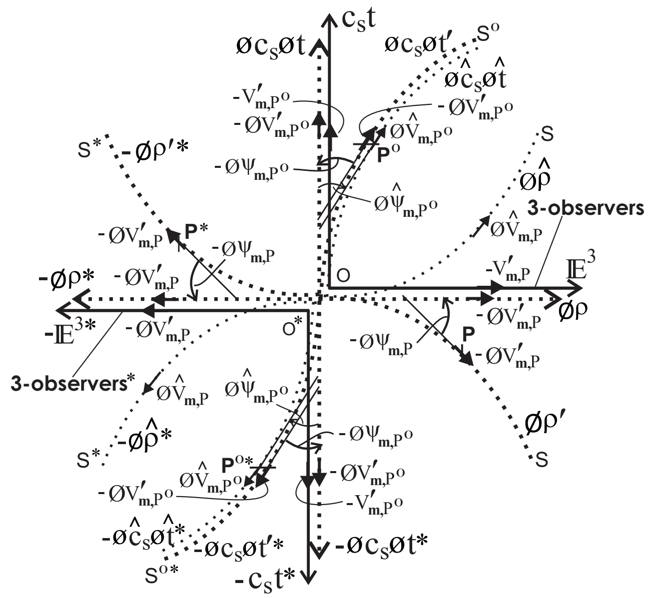

Fig. 19. The inverse of the global metric spacetime/intrinsic metric spacetime diagram of Fig. 19; is valid with respect to 3-observers in the relativistic metric Euclidean 3-spaces $\mathbb{E}^3$ and $-\mathbb{E}^{*3}$ of the positive and negative universes; (Fig. 12 of [8])

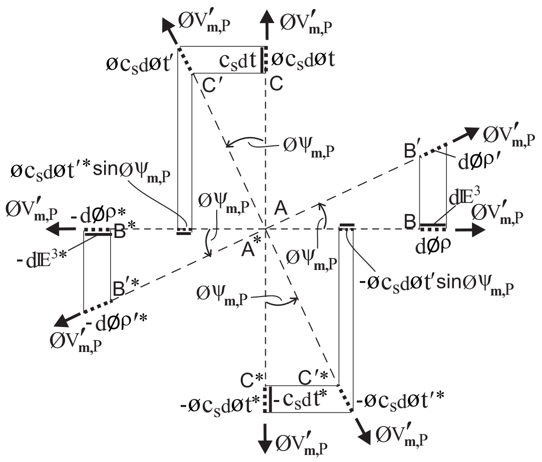

Fig. 20. The local metric spacetime/intrinsic metric spacetime diagram drawn at symmetry-partner points in spacetimes/intrinsic spacetimes in the positive (or our) universe and the negative universe from the global diagram of Fig. 18, for deriving partial transformation of elementary intrinsic metric spacetime coordinate intervals in terms of intrinsic static flow speed within symmetry-partner long-ranged metric force fields, with respect to 3-observers in the relativistic Euclidean 3-spaces in the positive and negative universes; (Fig. 12 of [8])

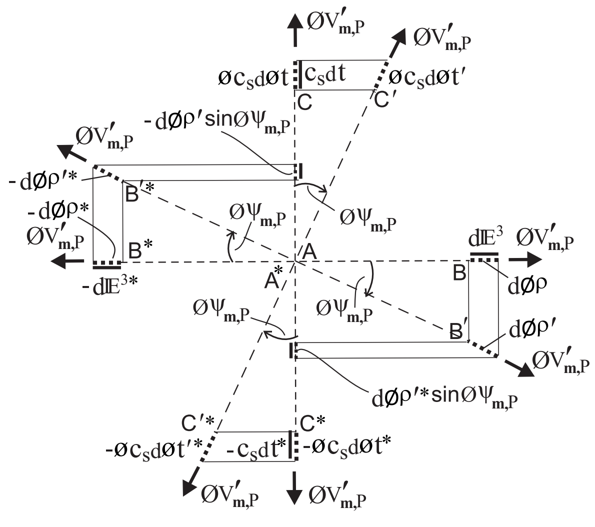

Fig. 21. The complementary diagram to Fig. 22 drawn at symmetry-partner points in spacetimes/intrinsic spacetimes from the global diagram of Fig. 19, for deriving partial transformation of elementary intrinsic metric spacetime coordinate intervals in terms of intrinsic static flow speed within symmetry-partner long-ranged metric force fields, with respect to 1-observers in the relativistic metric time dimensions in the positive and negative universes; (Fig. 13 of [8])

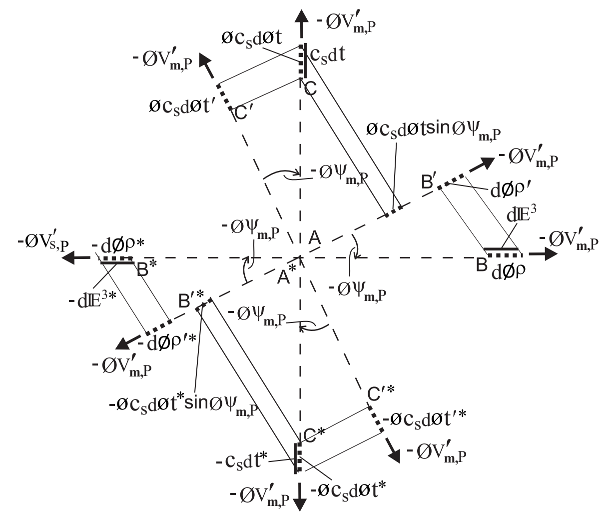

Fig. 22. The inverse of the local diagram of Fig. 22 drawn from the global diagram of Fig. 20, for deriving partial inverse transformations of elementary intrinsic metric coordinate intervals in terms of relative proper intrinsic static flow speed within symmetry-partner long-ranged metric force fields, with respect to 1-observers in the relativistic time dimensions $c_s t$ and $-c_s t^*$ in the positive and negative universes; (Fig. 14 of [8])

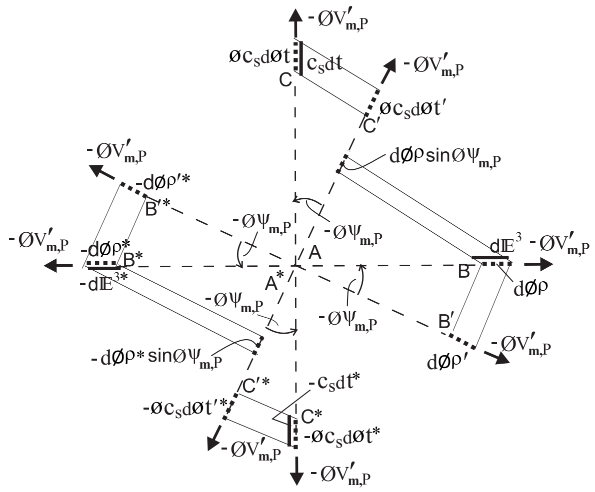

Fig. 23. The inverse of the local diagram of Fig. 23, drawn from the global diagram of Fig. 21, for deriving partial inverse transformations of elementary intrinsic metric spacetime coordinate intervals in terms of relative proper intrinsic static flow speed within symmetry-partner long-ranged metric force fields, with respect to 3-observers in the relativistic metric Euclidean 3-spaces in the positive and negative universes; (Fig. 15 of [8])

4 CONCLUSION

The summary of the progressive development of the two stages of evolution of metric spacetime and intrinsic metric spacetime and the associated sequence of metric spacetime/inrinsic metric spacetime geometries in long-range metric force fields in general, in the previous articles, which culminate in their adaptation to the gravitational field in this article and its upcoming second part, along with the developments in this article and its second part, as well as general conclusion and direction for further investigation, shall be presented at the end of the second part of this article. The specific conclusion reached in this article that, the four-dimensional gravitational-relativistic metric spacetime and its underlying two-dimensional gravitational-relativistic intrinsic metric spacetime are flat in arbitrary gravitational field, while the 'two-dimensional' absolute intrinsic metric spacetime is curved with absolute intrinsic sub-Riemannian metric tensor, shall be mentioned at this point. The derived set of metric spacetime/intrinsic metric spacetime geometries in the gravitational field in the four-world picture in this article, encompasses theories gravity and hierarchy of theories of intrinsic gravity and it is a more all-encompassing geometrical background for gravitation and relativity than a prescribed curved four-dimensional spacetime solely in a one-world picture in the general theory of relativity.

COMPETING INTERESTS

Author has declared that no competing interests exist.

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