FAN YONG

Motion of Matter and Space Time

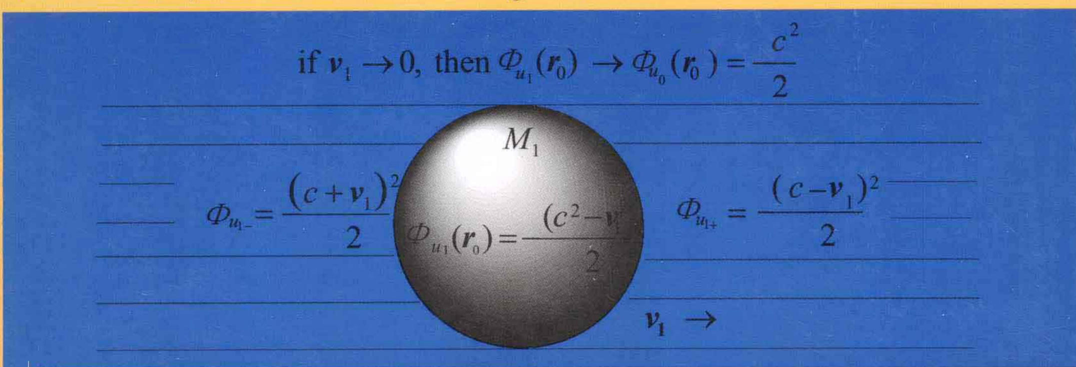
—— Inertial force, “dark matter”, “dark energy” …

物质运动与时空结构

——惯性力、“暗物质”、“暗能量”…

● 范勇 著

中英文对照（Issued in Chinese and English）



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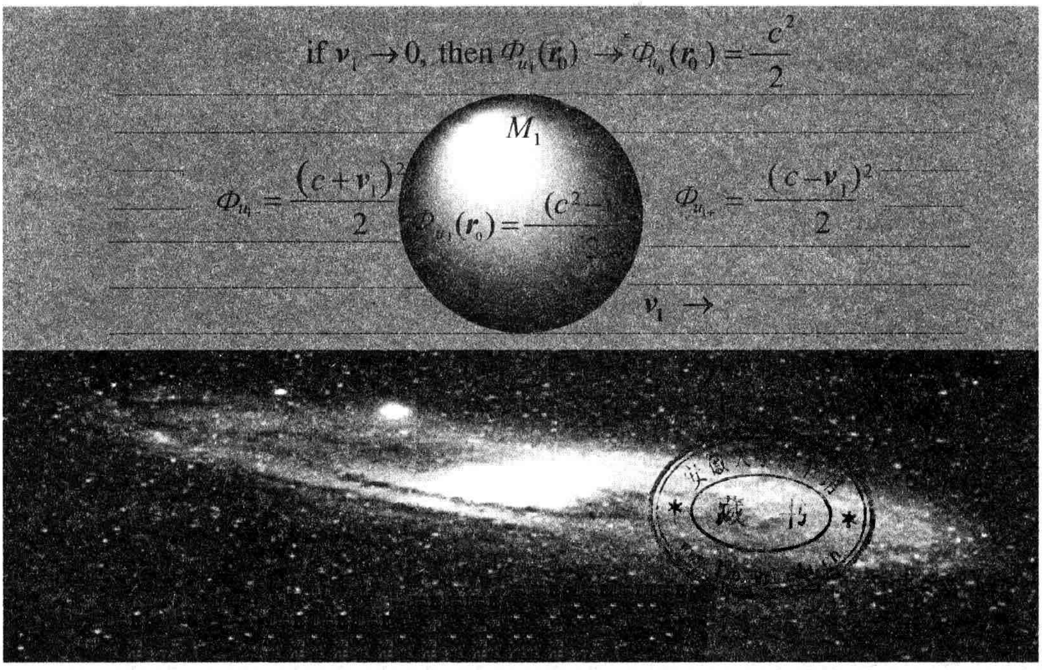

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内 容 提 要

本书的内容主要来自作者发表在哈尔滨理工大学学报上的论文《物质运动、引力势和时空结构的相对性 —— 惯性力、“暗物质”、“暗能量”等的本质》，原文是英文。书中对原论文中的推导过程作了详细的补充说明。

为了更容易理解，本书增加了一些补充说明和佐证。主要内容包括：基于当场测定的光速不变以及引力不是超距作用，引出两个基本原理。结合能量守恒定律，进一步验证了这两个基本原理，并由此澄清了惯性力的本质。据此，讨论了“暗物质”、“暗能量”与物质运动和时空结构之间的关系；在不同时空结构之间建立了确切的时间间隔以及空间间隔的时空变换关系；推导出了正确的相对固有速度的合成关系；推导了强相互作用、弱相互作用以及引力之间的基本关系；针对静态球对称引力场，由推出的时间间隔以及空间间隔的确切的时空变换关系直接得出爱因斯坦场方程的精确解；从函数关系及物理意义上确定了弱场近似的假设条件在 Schwarzschild 度规中所引入的误差，误差随着引力场强增大而增大，在极端的高场强情况下会导致误差非常大，这明确地证明 Schwarzschild 度规不合理。

本书适合具有理工科大学二年级数理知识的相关领域的爱好者阅读。

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Synopsis

The content of this book mainly comes from the author's paper titled Motion of Matter, Gravitational Potential and Relativity of Space-Time—Natures of Inertial Force, "Dark Matter", "Dark Energy", and so on published in English by Journal of Harbin University of Science and Technology. The author made further explanations to the original deduction in the paper.

In order to be easily understood, the author also add some explanation and evidences in this book. The main content is: Based on the premise that light speed measured on the spot always keeps constant and gravity is not an action at a distance, two principles are educed. Combined with conservation of energy, the basic energy transformation relations between different space-time structures are deduced, which further confirms the two principles. Therefore, the nature of inertial force is clarified. On these grounds, the relationship among the "dark matter", "dark energy", motion of matter and space-time structure is deduced; the precise transformation relations of time interval and space interval are established between different space-time structures; the correct composition of relative inherent speeds is figured out; the basic relationship among strong interaction, weak interaction and gravity is deduced. Accurate external solution of Einstein field equation aiming at a static spherically symmetric gravitational field is formulated. It has been confirmed from both function relation and physical significance that the treatment of weak field approximation introduced error into Schwarzschild metric and the error will increase with field intensity. Consequently, in the case of extremely strong field the error is very large, this definitely proves that Schwarzschild metric is unreasonable.

For a sophomore on science and engineering, there should be no too much difficulty to read.

序　言

1972 年春天，当时我是北大荒的兵团知青，我的一个荒友向我描述了光速不变原理和宇宙大爆炸。我当时的感觉是迷惑、震惊和不可思议。我那时的文化程度只能算是小学毕业，因为中学那三年正赶上"文革"中最乱的 1966 ~ 1969 年。所以对我来说听到这些是难以理解和难以接受的。越是想不明白却偏要去琢磨。我那时找不到对此感兴趣并且愿意和我讨论的人，更找不到有关资料（其实即使有资料我也看不懂），我只能自己思考。结果可想而知，越发想不出任何头绪，反倒平添了更多的疑惑。鬼使神差，渐渐地这竟成了我生活中的最大业余爱好。鲁迅先生曾说人生识字糊涂始，而对我来说则是人生思考疑惑始。记得在我读研期间的 1980 年，听物理老师讲狭义相对论，感觉他讲的非常精彩。不过，这并没有减少我的疑惑，反而由于我对狭义相对论的了解，使得我的疑惑变成了清晰的疑问。课余时间去问老师：既然标准尺和标准钟随着其运动状态在变化，那么，在运动坐标系中对光速的测量与在静止参考系中对光速的测量还会是完全等价的吗？既然粒子的能量随着其速度增大，在参照系和运动坐标系之间的变换怎么可能是任意相对的呢？这两个问题联系起来显然会令人难以理解。老师没有敷衍我，认为这个问题值得思考，不过他表示难以解答。时隔多年，随着时间的推移，我对这位老师的答复越来越心存感激，因为他没有不懂装懂（我个人认为这非常可贵）。

无端的指责对于任何理论都是不公道的。对于任何理论，要想理解它就需要去学习、研究，其中就包含对它的质疑。不去认真地质疑就不能很好地理解，不去认真地质疑也是对建立理论的人不尊重。真理是相对的，需要比较和鉴别。经过很多年的思考我终于发现，与狭义相对论的能量变换关系相比较，在保守场中广义相对论的能量变换关系无法严格满足能量守恒。问题很可能是出在那些支撑相对论的假设原理，而那些假设原理是建立在经验约定基础上的。然而，如果支撑相对论的假设原理有问题，在太阳系范围内针对广义相对论的四个经典检验又为什么会以非常小的实验或观测误差证明广义相对论是正确的呢？

物质运动与宇宙时空结构之间的关系一直是物理学需要面对的最基本的问题。从托勒密的地心说、哥白尼的日心说，到牛顿力学理论，再到爱因斯坦的相对论及其后来的发展，都在令人考问这样一个问题：物质的运动可以结合时

间和空间来描述,但时间和空间的本质是什么?对于时间和空间古往今来人们从物理学、心理学,甚至从哲学的角度给出了各种解释。牛顿创建了他的力学理论,其理论的基础是绝对时空观,但当时即使牛顿本人也不相信引力是超距作用。而马赫原理认为“时空结构不是绝对的,惯性系是相对宇宙整体平均作匀速运动的参考系,而一个相对宇宙整体平均作加速运动的参考系就是非惯性系。惯性力正是宇宙中所有作相对加速运动物质作用于物体的引力”。但是,马赫原理并没有解释惯性力的瞬时出现如何与引力的有限传播速度相容。爱因斯坦的相对论确定时间和空间不是绝对的,建立了在相对运动的惯性系之间时间间隔和空间间隔的变换关系,在引力场中不同空间点之间的时间间隔的变换关系,以及描述了弯曲空间的非欧几何性质。然而,为什么时空结构会是这样的呢?相对论没有给出明确的解释。这就是为什么人们通常认为相对论并没有赋予时空结构以任何物理实质。爱因斯坦本人虽然强调马赫原理与广义相对论是一致的,但是他也没有解释惯性力的瞬时出现如何与引力的有限传播速度相容。

物质运动与局域宇宙时空结构有关。而局域宇宙时空结构除了与宇宙中的物质分布有关外,是否还与物质的运动有关呢?牛顿的思考和马赫原理为我们留下了一条进一步研究的重要线索:如果引力不是超距作用,它在物质运动与局域宇宙时空结构之间的相互作用关系中应该如何体现呢?本书以当场测得的光速不变和引力不是超距作用为前提,针对物质的运动与局域宇宙时空结构之间的相互作用关系推出了一系列前后自洽的结果,与已有的相关实验或观测证据不矛盾。结合能量守恒定律可以证明相对论的理论仍然只是在弱场和低速近似条件下得到的非常精确的近似结果。但遗憾的是现有的检验技术还无法直接判断哪一个理论是更合理的。不过,在理论上,至少本书的理论能够严格满足保守场中自由粒子的能量守恒。

本书所描述的是我对物质运动与时空结构之间关系的认识和理解,它同时也反映了我的思想方法。但愿它能对和我有同样兴趣的人以及所有在理性思维方面持严肃认真态度的人有所裨益。

书中没有过于复杂的像张量分析那样的数学推导。只要具备理工科大学本科二年级数理知识水平就应该不会有阅读障碍。

但愿本书能受到关注,更欢迎提出质疑。

作　者

2013 年 6 月

Preface

In the spring 1972, one of my fellows told me the principle of invariance of light speed and the Big Bang while I was an "educated youth" at Beidahuang located in Northeast China. I was puzzled, astonished and skeptical. My education could only be limited to just a primary school education at that time because it was just the period from 1966 to 1969, the most disordered three years in the so-called "Cultural Revolution" while I should have been in middle school. Therefore, it was difficult for me to understand and accept the story. Though quite confused, I still wanted to think. I found no one can discuss with, and no information (in fact, even if there had been information in my hand, I could not have understood). So I could only think by myself. So you can imagine that I still was in a hopeless tangle and got even more skeptical. Like a curious coincidence, gradually, it unexpectedly became the biggest avocation in my life. Mr. LU Xun once said "people's silliness in life results from their learning to read and write." Whereas for me it should be that "my doubt in life results from my thinking". In 1980 when I was a postgraduate, a physics teacher told us special theory of relativity. The lecture was wonderful. However, it could not reduce my doubt. On the contrary, the doubt became a clear question as a result of my understanding of the special theory of relativity. I asked the teacher, "Since a standard ruler and a standard clock will change with their moving state, then whether the measurement of light speed in a moving coordinate can be equivalent to that in the stationary frame of reference? Now that the energy of a particle will increase with its speed, how the transformation can be arbitrarily relative between a moving coordinate and the stationary frame of reference?" Obviously, it was hard to understand when the two questions were linked together. He told me seriously that the question was worth thinking, but he could not offer me a reasonable answer at the moment. For so many years I give my thanks to the teacher in my heart because he did not pretend to have understood (personally, I think this is something quite appreciable).

Gratuitous accusing is unfair to any theory. If you want to comprehend a theory, you must learn and study it, and also you need to question it. If you do not question it, you can not understand it well, which means that you do not respect the person who established the theory. Truth is relative, and it needs to be compared and identified. After many years, at last I find that for a particle, compared with the energy transformation relation of special relativity, the energy transformation relation of general relativity in conservative field cannot meet conservation of energy. Moreover, it is very possible that the problem may result from the hypothesis principles that uphold relativity, and the principles are derived from some experiential conventions. However, if something is wrong with those principles, why general relativity has been proved to be correct by the four classical verifications aiming at general relativity in the solar system with very small error?

The relationship between motion of matter and cosmic space-time structure is the most basic problem for physics. From Ptolemy's geocentric theory to Copernicus's sun-centered theory, to Newtonian mechanics theory, and to Einstein's relativity and its subsequent development, all of them make one question such a problem: Motion of matter can be described by time and space, but what is the nature of space-time? People have offered various explanations to time and space of all ages from physics, psychics and even philosophy. Newtonian mechanics theory was built upon the idea of absolute space-time, but then Newton himself did not believe gravity was an action at a distance. Mach hold that "space-time is not absolute, and inertial system is the reference system with uniform motion to the massively average of the universe, and that a reference system with accelerated motion to the massively average of the universe is non-inertial system, inertial force is just the gravitation acting on the object from all the matter with relatively accelerated motion in the universe". But Mach never offered the explanation on how the instantaneous appearance of inertial force can be compatible with the finite propagation speed of gravity. Einstein's relativity confirmed space-time is not absolute. He built up the transformation relations of time interval and space interval between inertial systems that are relatively moving, the transformation relation of time interval between different space points in a gravitational field, and depicted the character of non-Euclidean geometry of "curled space". However, why can space-time be like that? We cannot find out clear explanation from relativity. This is why people usually hold that relativity failed to offer any explanation of physical essence to space-time. Although Einstein himself emphasized that the relation between Mach principle and general relativity is harmonious, but he also never offered the explanation on how the instantaneous appearance of inertial force can be compatible with the finite propagation speed of gravity"[2, p96].

Motion of matter has relation to local cosmic space-time structure. However, except distribution of matter in the universe, does local cosmic space-time structure have relation to motion of matter? Newton's consideration and Mach principle leave a very impotent hint to further track: If gravity is not an action at a distance, how should it embody in the interaction relationship between motion of matter and cosmic space-time structure? Based on the premise that light speed measured on the spot always keeps constant and gravity is not an action at a distance, a set of theoretical system with coherent logic is built up in this book aiming at the interaction relation between motion of matter and cosmic space-time structure, which is consistent with all the existing experimental or observation data. Combining with conservation of energy, it can be proved that relativity is still only a very close approximation under the suppositions of weak field and lower speed. However, it is a pity that the existing test technology can not directly judge which theory is more reasonable. Theoretically, for a free particle in conservative field, at least the theory of this book can exactly meet the demand of conservation of energy.

What described in this book is my understanding and comprehending to the relationship between motion of matter and space-time structure, which also reflects my way of thinking. Wish that it can help the people that have the same hobby with me and who take rational thinking seriously.

There is no too complicated mathematical deduction in this book, and for a sophomore on science and engineering, there should be no too much difficulty to read.

Wish this book would draw more attention, and welcome calling in question.

Writer
July, 2013

目　录

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第1章　绪　　论

放弃了传统的绝对时空观以后,物理学得到了空前的发展。然而,近几十年仍然观察到一些直到现在也无法用现有理论解释的自然现象,例如,“暗物质”和“暗能量”。此外,相对论与量子理论很难进一步融合,这很可能是某些基本物理问题难以澄清的原因,例如,引力的根源,四种基本相互作用之间的关系,等等。再者,为什么物质具有惯性?如何理解所谓的惯性力的瞬时出现与引力的有限传播速度不相容?牛顿本人不相信引力是超距作用的思想不仅体现了他的严谨逻辑思维和对科学研究的实事求是的态度,而且也为物理学提供了一条重要的研究线索:如果引力不是超距作用,在物质运动与局域宇宙时空结构之间的相互作用关系中它应该如何体现呢?显然,惯性力仅仅是物质运动与局域宇宙时空结构之间相互作用的表象。然而,究竟什么是惯性力的本质?所有这些问题当然都会影响到我们对物质运动与局域宇宙时空结构之间相互作用关系的理解,因此,有必要重新审视已有的物理观念。

时空结构不仅应该与宇宙中物质的分布有关,更应该与不同层次的物质和所有各种物质的运动都有关。在宇宙中,任何物质的运动都应该与局域宇宙时空结构对它的作用相关,光子的运动也不例外。爱因斯坦提出相对论的目的主要是处理牛顿力学理论和电磁理论之间的矛盾。但是,如果只要我们认定当场测定的光速(测光速时光子与光速测量仪器处于同样的时空结构环境)总保持为同一常数就可以解决这一矛盾,那么就没有必要直接假设光速绝对不变。显然,这两者之间存在显著差异。毋庸置疑,当场测定的光速不变至少在地球系统范围具有完全可信赖的实验依据,而相比之下,直接认定光速绝对不变的观点并没有完全可信赖的实验依据。如果时空结构是相对的但当场测定的光速始终是常数 c,自然地,光速和时空结构之间必然应该存在一定的相对关系,否则无法避免逻辑上的矛盾。如果假定宇宙是有限的且当场测得的光速总是常数 c,基于引力不是超距作用,因此引力势只能是以有限的速度传播这样的前提,可引出如下两个基本原理(见第3章):

(1) 极限相对固有速度取决于相对局域宇宙引力势;

(2) 物质运动会伴生引力势。

由它们可以进一步推论,光速和时空结构之间的相对关系确实是存在的,它是由时空结构的相对性所决定的,而且它与当场测定的光速始终是常数 c 的实验事实之间是不矛盾的。

所有物理理论都是建立在假设原理上的,而假设原理通常是以经验约定为基础的。所以,一种物理理论的合理性要看它的推论能否对其假设原理给出合理的解释,至少不会引起逻辑矛盾。事实上,相对论也是建立在基于经验约定的假设原理上的。因为经验约定的可靠性是相对的,某些原有的经验约定有可能诱导人们误入歧途,所以有必要经常从理论和实验两个方面检验原有的经验约定。更重要的是,如果可能,需要尽可能地追索更加可靠的经验约定,以使理论建立在更加可靠的基础上,并由此克服原有理论无法克服的困难。例如,本书中针对惯性力、"暗物质"和"暗能量"等等问题的讨论。

第 2 章　两个基本定义

按照牛顿理论，当一个质量为 m 位于 $\boldsymbol{r}$ 的粒子在 N 个质量分别为 m_1，m_2，…，m_N 且分别位于 $\boldsymbol{r}_1$，$\boldsymbol{r}_2$，…，$\boldsymbol{r}_N$ 的粒子的作用下，所受到的引力为

$$\boldsymbol{F}(\boldsymbol{r}) = -mG\sum_{i=1}^{N}\frac{m_i}{|\boldsymbol{r}-\boldsymbol{r}_i|^3}(\boldsymbol{r}-\boldsymbol{r}_i) \tag{2.1}$$

式中，G 是引力常数。相应的引力势为

$$\Phi(\boldsymbol{r}) = -G\sum_{i=1}^{N}\frac{m_i}{|\boldsymbol{r}-\boldsymbol{r}_i|} \tag{2.2}$$

牛顿理论的基础是绝对时空观，但当时牛顿本人不相信引力是超距作用。而现代物理理论认为时空结构不是绝对的，当然否认引力是超距作用。在当时那个时代牛顿是非常明智的，他给后人留下了一条重要的研究引力的线索：如果引力不是超距作用，在物质的运动与局域宇宙时空结构之间的相互作用关系理论中它应该如何体现呢？换言之，现存的物理观念是否需要相应地改变呢？

因为引力可表达为引力势的梯度，如果说引力不是超距作用，就等于说引力势的梯度只能以有限的速度传播。而引力势的梯度是由引力势的空间分布决定且由引力势的传播来维持的，这就等于说引力势也只能以有限的速度传播。然而，如果引力势只能以有限的速度传播，一个物体所受到的局域宇宙引力势作用就不仅与宇宙中所有其他物质的分布及其运动有关，而且还应该与该物体自身相对于局域宇宙引力势的运动状态有关，因为在不同的运动状态下物体与局域宇宙引力势之间的相互作用显然应该是不同的。

如果宇宙是有限的且引力不是超距作用，则在某一刻，位置 $\boldsymbol{r}_0$ 处的局域宇宙引力势 $\Phi_u(\boldsymbol{r}_0)$ 应该是来自宇宙中所有的引力势源，它当然是有限的。当 $\boldsymbol{r}_0$ 处的时空结构可以被选择为相对静止参照系时，即 $\boldsymbol{r}_0$ 处的标准测量仪器的测量尺度可以作为基准时，则 $\boldsymbol{r}_1$ 处的局域宇宙引力势 $\Phi_u(\boldsymbol{r}_1)$ 应该与 $\Phi_u(\boldsymbol{r}_0)$ 有一定关系。然而，局域宇宙引力势的绝对值是无法确定的。其原因至少是，例如，标准测量仪器的测量尺度可能是随着其运动状态和（或者）所处时空结构变化的。但是，如果物理量在不同时空结构之间存在可变换性，则局域宇宙引力势的相对值有可能被确定。为此，需先作如下定义。

2.1　相对局域宇宙引力势

定义 1　假设宇宙是有限的,基于引力不是超距作用因此引力势只能以有限的速度传播,如果 $\boldsymbol{r}_0$ 处的时空结构可被选择为相对静止参照系且 $\boldsymbol{r}_0$ 处的相对局域宇宙引力势可被确定为 $\Phi_{u_0}(\boldsymbol{r}_0)$,则由 $\boldsymbol{r}_0$ 和 $\boldsymbol{r}_1$ 处的时空结构之间的相对关系确定的 $\boldsymbol{r}_1$ 处的相对局域宇宙引力势可定义并由公式表示为

$$\Phi_u(\boldsymbol{r}_1) = \sum_j \varphi_j(\boldsymbol{r}_1) = \Phi_{u_0}(\boldsymbol{r}_0) + \delta\Phi_{(r_0,r_1)} \tag{2.3}$$

式中,$\varphi_j(\boldsymbol{r}_1)$ 是由引力源 j 在 $\boldsymbol{r}_1$ 处贡献的相对引力势,求和包括宇宙中所有引力势源在 $\boldsymbol{r}_1$ 处的贡献。$\delta\Phi_{(r_0,r_1)} = \Phi_u(\boldsymbol{r}_1) - \Phi_{u_0}(\boldsymbol{r}_0)$ 是从 $\boldsymbol{r}_0$ 到 $\boldsymbol{r}_1$ 相对局域宇宙引力势的增量。理论上,当 $\boldsymbol{r}_1$ 趋近于无穷远,相对局域宇宙引力势 $\Phi_u(\boldsymbol{r}_1)$ 将趋近于 0^-。$\boldsymbol{r}_0$ 和 $\boldsymbol{r}_1$ 可能存在三种情况:

(1)$\boldsymbol{r}_0$ 和 $\boldsymbol{r}_1$ 存在于不同的局域宇宙引力势环境中且相对静止;

(2)$\boldsymbol{r}_0$ 和 $\boldsymbol{r}_1$ 存在于相同的局域宇宙引力势环境中但相对运动(这种情况下,本书中 $\Phi_u(\boldsymbol{r}_1)$ 将被表示为 $\Phi_{u_1}(\boldsymbol{r}_0)$);

(3)$\boldsymbol{r}_0$ 和 $\boldsymbol{r}_1$ 相对运动且处于不同的局域宇宙引力势环境中。

2.2　相对固有速度

地球附近某一位置的相对局域宇宙引力势是宇宙中所有引力势源贡献的相对引力势的叠加。只要宇宙是有限的,局域宇宙引力势就应该是有限的。考虑到时空结构的相对性,在某一时空结构中由标准仪器所测量的物理量应该与它在那个时空结构中的测量尺度相关。例如,由标准尺当场测得的空间间隔或者由标准钟当场测得的时间间隔只是标准尺或者标准钟所处时空结构的坐标量,标准尺或标准钟是以它们在当地的存在状态为基准的。如果按照时空结构之间的相对关系可把当场测得的物理量变换成相对于选定的参照系的相对固有量,则可定义相对固有速度如下。

定义 2　当 $\boldsymbol{r}_0$ 所处的时空结构可选作为相对静止参照系,其局域宇宙引力势可确定为 $\Phi_{u_0}(\boldsymbol{r}_0)$,如果当场由标准尺和标准钟测定的粒子 m 相对于 $\boldsymbol{r}_1$ 的速度为 $\boldsymbol{v}'_{r_1}$,则按照时空结构之间的相对关系并且以参照系中的标准尺和标准钟的测量尺度为基准,把 $\boldsymbol{v}'_{r_1}$ 相对于 $\Phi_{u_0}(\boldsymbol{r}_0)$ 变换的结果定义为粒子 m 相对于 $\boldsymbol{r}_1$ 的