答《评阮晓钢教授的“观测相对论”》

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摘 要: 答复王令隽先生之《评阮晓钢教授的“观测相对论”》,其中,进一步阐述了观测相对论的基本思想和逻辑线路,特别指明了观测相对论的逻辑自洽性及其实证依据.

关键词: 狭义相对论; 广义相对论; 光速不变性
中图分类号: O 412 **文献标志码**: A **文章编号**: 0254 - 0037(2020)07 - 0825 - 27
doi: 10.11936/bjutxb2020030022

爱因斯坦相对论揭示了物质运动的相对论性现象,自建立以来,得到几乎所有观测和实验支持,令我们知其然. 然而,直到今天,我们的物理学依然不能解释光速为什么不变,物质运动为什么会呈现相对论性现象,令我们不知其所以然. 爱因斯坦相对论,包括狭义的和广义的,都已经建立100多年. 毕竟,人类的物理学还得继续:对于物质运动的相对论性现象,我们不能永远停滞在这种只知其然而不知其所以然的境地.

2020年伊始,《北京工业大学学报》刊载了作者的《观测与相对论:光速在爱因斯坦狭义相对论中为什么不变?》[1](以下简称《观测与相对论》),报道了一项新的理论:观测相对论(observational relativity,OR). OR从理论上证明,观测媒介的速度具有观测上的不变性,而光速不变性只是其中的个例:光速不变性是光或电磁相互作用担当观测媒介时的情形. 根据OR理论,物理学所有理论均源于观测,不同观测体系导致不同理论体系:伽利略变换和牛顿定律是理想观测体系的产物;而洛伦兹变换和爱因斯坦相对论则是光学观测体系的产物. OR理论表明,所有相对论性现象,包括光速不变性,皆观测效应,乃观测局域性所致,而非客观真实的自然现象.

OR理论,令我们对于物质运动的相对论性现象,不仅知其然,而且,知其所以然!

然而,正如作者所预料的,自2019年9月10日中国知网首发《观测与相对论》以来,还未正式见刊,不少读者,其中包括造诣深厚的物理学家,便给予了评述和质疑. 有国内位居中国科学院院士的权威物理学家一言以蔽之:“把相对论归结为观测效应完全是错误的!”

首先,作者真诚地感谢评述和质疑OR理论的读者. 无论如何,OR理论能得到大家的批判和关注,既是OR的荣幸,也是作者的荣幸.

美国田纳西大学教授王令隽先生,是第一位正式致函《北京工业大学学报》评述和质疑OR理论的物理学家. 王令隽先生在理论物理学界颇有造诣和学术影响;他对OR理论的评论和质疑富于教义,值得我们思考. 以下便是作者对王令隽先生之《评阮晓钢教授的“观测相对论”》的答复,同时,稍做引申,一并回复其他类同的评论或质疑.

1 OR理论不是制造出来的

王令隽评:“我非常赞赏阮教授和评论员敢于挑战权威,敢于批判相对论的精神. ……. 只有物理学界重新树立了文艺复兴时期建立起来的科学批判精神,才能客观地梳理20世纪理论物理学的诸多问题,走出困境. ……. ”

阮晓钢答:谢谢王令隽先生的鼓励.

需要特别说明:OR理论与“体制”无关,所涉及的是纯粹的学术问题;国内外主流物理学界对于爱因斯坦相对论所持的认知和态度并无二致.

《观测与相对论》的初衷和OR的结论都并非是对爱因斯坦相对论的“批判”. 科学的目的不是“批判”. 科学不能以“批判”为其出发点,更不能为了“批判”而“批判”.

收稿日期: 2020-03-26
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毫无疑问,爱因斯坦相对论是人类物理学史上最为伟大的成就之一. OR理论与爱因斯坦相对论是相容的. 实际上,OR理论是对爱因斯坦相对论的继承和发展.

然而,正如Hawking[2]在其《时间简史》中所言:"物理学任何理论都是暂时的,从某种意义上说,它只是一个假设:你永远无法证明它. 不管实验结果与理论一致多少次,你永远无法确定下一次的结果是否会与理论相悖. "OR向我们阐明:爱因斯坦相对论只是一个"局部理论"(如霍金所说的Partial Theory),仅当我们的观测体系以光或电磁相互作用为观测媒介时成立.

需要特别指出:OR理论不是"制造"出来的,更不是为了反对或批判爱因斯坦相对论而"设计"的;它只是个"发现",是逻辑和理论的产物.

OR只是不经意间的一个"发现".

2 一切相对论性效应皆观测效应

王令隽评:"把相对论的结论归结于'观察效应',是掩盖或抹煞相对论的本质. …….难道广岛长崎的毁灭仅仅是'观测效应'而不是物理真实?难到观测一下就可以创造出宇宙? …….'相对论观测效应'论历史上早已有之,阮教授并不是首倡者. …….这样的'批判'不仅不能解释相对论的谬误,反而可能误入相对论的巢臼而犯同样的错误. …….”

"总而言之,相对论的理论及其结论是完全不同于经典物理的革命性理论,不能仅仅归结为观测效应. "

阮晓钢答:王令隽先生质疑OR"一切相对论性效应皆观测效应"之说,其表达的观点与前面提到的权威物理学家的观点相同.

OR理论建立起来之前,作者并无任何关于"一切相对论性效应皆观测效应"的思想或观念. "一切相对论性效应皆观测效应"是OR的"发现",是OR的逻辑结论,是理论推导的结果,并非作者的主观认知或个人主张.

OR是物质运动的理论模型,既是基于思辨的,也是基于实证的. 质疑或批判物理学理论模型,有2条正确的途径:要么,通过思辨,举证其逻辑演绎和理论推导中存在的错误,否定其逻辑上的有效性或理论上的正确性;要么,通过实证,用观测和实验证伪之. 我们不能仅仅基于主观认知或个人主张批判OR理论.

的确,如王令隽先生所言:"'相对论观测效应'论历史上早已有之,阮教授并不是首倡者. "然而,那只是些基于主观认知的个人主张而已,并非逻辑和理论的产物,并未形成任何可与OR比拟的理论体系或物理模型. 不过,有一点值得思考:这些人(其中不乏资深物理学家)如此主张之时,似乎并不担心其主张可能引发"观测可以创造宇宙"或"原子弹爆炸乃观测效应"这样的悖论.

的确,许多物理人认为,原子弹爆炸所释放出的巨大能量可用爱因斯坦质能公式 $E = mc^2$ 解释:质量可以变换为能量,而且,是巨大的能量. 甚至有报道称,科学家的确发现原子弹爆炸后,物质质量减少了!(我们很难想象,科学家们怎么能测定原子弹爆炸前后的物质质量.)

实际上,爱因斯坦的质能公式只是其狭义相对论中的一个关系式,与原子核物理无关! 原子能,又称核能,是原子核内固有的能量,与强相互作用相关,与爱因斯坦相对论无关. 原子弹爆炸瞬间产生的巨大能量源于无数原子之固有能量连锁反应式的释放,与物质质量无关. 维基百科条目《质能等价》[3]有这样一段话:"有人认为这一公式直接导致了原子弹的设计和制造,但事实上质能转换公式对于原子理论和原子弹的设计和制造并无任何的直接或间接促进作用,而仅仅是后人用来解释原子弹原理的解释工具之一. "Isaackson[4]在《连锁反应:从爱因斯坦到原子弹》中也说:"与一般的认识相反,爱因斯坦对作为原子弹基础的核物理知之甚少."用爱因斯坦写给劳厄信中的话说[5]:"关于原子弹和罗斯福,我所做的仅仅是:鉴于希特勒可能首先拥有原子弹的危险,我签署了一封由西拉德起草给总统的信. "

在爱因斯坦相对论中,相对论性被视为物质运动的固有特性,被视为客观真实的物理存在. 这成为主流物理学界的观点和认识,因为,爱因斯坦相对论,包括狭义的和广义的,经历了一个多世纪的时间检验,得到几乎所有观测和实验支持. 然而,正如美国《科学》杂志(*Science*)评论员Adrian Cho[6]在其纪念爱因斯坦狭义相对论诞生100周年之际撰文所感叹的:"那么为什么还有那么些人试图证明它是错误的呢?"

如此成功的狭义相对论依然遭受质疑,其根本原因在于,人们不能理解光速为什么不变,物质运动为什么会呈现相对论性效应.

人们对于光速不变性的认识始于迈克尔逊-莫

雷实验，其本身是一种相对论性效应.

特别注意：光速不变性是爱因斯坦相对论的逻辑前提；因此，爱因斯坦相对论本身并不能解释光速为什么不变，也不能解释物质运动为什么会呈现相对论性效应.

OR 理论发现了物质运动之相对论性的本质和根源：物理学之一切理论皆依赖于并制约于观测；物质运动之一切相对论性效应皆观测效应. 这便是“观测相对论”中“观测”的含义.

从某种意义上说，“一切相对论性效应皆观测效应”是 OR 理论最重要的发现！

OR 从理论上导出了观测媒介速度不变性，揭示了光速在迈克尔逊-莫雷实验中不变的根源：光在迈克尔逊-莫雷实验中扮演着观测媒介的角色；所谓光速不变性原理，仅当光或电磁相互作用作为观测媒介时才能成立.

OR 进一步从理论上导出广义洛伦兹变换，其中的广义洛伦兹因子 $\Gamma(v,\eta)=1/\sqrt{(1-v^2/\eta^2)}$ 依赖于观测媒介速度 η，而非光速 c. 根据 OR 理论，物质运动之相对论性的根源在于观测局域性，即观测媒介传递观测信息的速度 η 有限：$\eta<\infty$. 因此，观测信息的传输需要时间；这势必导致观测信息延迟，进而产生观测上的相对论性，即“观测效应”.

一些读者有误解，以为 OR 理论完全否定了物质运动之相对论性现象的客观真实性. 需要特别解释和说明的是，OR 理论只意味着：第一，我们的物理观测和基于观测的物理模型因受制于观测局域性而呈现观测上的相对论性效应；第二，我们的观测和物理模型不仅是对真实物质存在和客观物理现实的反映，同时，还包含着观测效应. 观测媒介速度 η 越低，观测局域性和观测上的相对论性效应就越显著. OR 之广义洛伦兹因子 $\Gamma(v,\eta)=1/\sqrt{(1-v^2/\eta^2)}$ 是相对论性度的表征. 利用泰勒级数可将 $\Gamma(v,\eta)$ 划分为：$\Gamma(v,\eta)=\Gamma_\infty+\Delta\Gamma(v,\eta)$ $(\forall v<\eta)$. 式中：$\Gamma_\infty=1$ 为伽利略因子，代表客观真实的物理世界，是绝对的和不变的；$\Delta\Gamma$ 为观测效应因子，代表观测效应，取决于观测媒介速度 η 和物质运动速度 v. $\Delta\Gamma=0$ 时无观测效应；$\Delta\Gamma$ 越大，观测效应越显著. 理想情形下（如伽利略-牛顿理论体的情形）：$\eta\to\infty$，$\Gamma(v,\eta)=1/\sqrt{(1-v^2/\eta^2)}\to\Gamma_\infty=1$，$\Delta\Gamma\to0$；可见，伽利略变换和牛顿理论不包含观测效应. 然而，在光学观测体系中，$\eta=c<\infty$，$\Delta\Gamma>0$；因而，洛伦兹变换和爱因斯坦相对论涉及观测效应.

OR 理论告诉我们：真实的物理世界，并非马赫和爱因斯坦为我们描绘的相对时空，而是伽利略和牛顿为我们描绘的绝对时空.

值得注意，OR 理论体系中的广义洛伦兹变换概括统一了伽利略变换和洛伦兹变换，并且，在玻尔对应原理[7]（The Correspondence Principle）下，与伽利略变换和洛伦兹变换严格对应：$\eta=c$ 时，OR 之广义洛伦兹变换蜕化为洛伦兹变换；$\eta=\infty$ 时，OR 之广义洛伦兹变换蜕化为伽利略变换. 这种严格对应关系从一个侧面印证了广义洛伦兹变换变换以及 OR 理论逻辑上的合理性和理论上的正确性.

科学的使命在于探索未知，其中，最根本的，在于探明自然现象所蕴含的本质，即“所以然”. 现在，对于物质运动的相对论性，OR 不仅令我们知其然，而且令我们知其所以然. 基于 OR 理论，我们终于明白：光在爱因斯坦相对论中担当着观测媒介的角色；一切相对论性效应，包括光速不变性、同时性的相对性、时涨尺缩效应，甚至，时空弯曲效应和量子效应，皆观测效应！

3　关于狭义相对论的逻辑前提

王令隽评：“阮教授说：‘正是基于光速不变性假设，爱因斯坦成功地从理论上推导出洛伦兹变换，建立狭义相对论，揭示了时空和物质运动的相对性现象. 光速不变性假设不仅是爱因斯坦 SR 的基石，同时，也是爱因斯坦广义相对论的前提之一.’这段议论言过其实.”

“首先，仅仅基于光速不变性假设，是不能推导出洛伦兹变换的……”

阮晓钢答：王令隽先生说，除光速不变性假设之外，爱因斯坦狭义相对论还有其他假设，比如，要求时空变换关系是线性的；意在批评作者的对于爱因斯坦狭义相对论的无知，尽管这似乎与 OR 理论是否成立无关.

众所周知，爱因斯坦狭义相对论之逻辑前提有两大原理：第一，光速不变性原理；第二，相对性原理. 其实，还有鲜为人知的第三大原理：简单性原理[8]（The Principle of Simplicity）.

王令隽先生提到的线性时空变换关系应归结为简单性原理；依爱因斯坦自己的说法[9]，其线性时空变换归结于时空的均匀性. 如果王令隽先生细心阅读《观测与相对论》，便知其中有关于线性时空变换的内容. 关于简单性原理和线性时空变换，作者在文献[10-11]中有更为详尽的论述. 王令隽先生

若有兴趣,不妨一读.

顺便指出,文献[10-11]给出了 OR 原本的和完整的逻辑演绎过程,其中,OR 由更基本的逻辑前提出发,并未借用简单性原理或假设时空变换是线性的,也未借用相对性原理,却直接地导出了微分形式(而非代数形式)的洛伦兹变换.(这涉及王令隽先生关于 OR 逻辑与爱因斯坦逻辑的关系问题,待作者稍后答复.)

4 光速不变性假设与广义相对论

王令隽评:"其次,光速不变原理并不是广义相对论的前提之一,和爱因斯坦引力场方程的建立了无关系. 事实上,广义相对论和光速不变原理直接相悖. 这非常容易证明. ……. "

阮晓钢答:王令隽先生意在批评作者对于爱因斯坦广义相对论的无知,尽管这似乎也与 OR 是否成立无关.

王令隽先生给出了一个基于 Schwarzschild 度规[12]的引力场光速公式:$v = \mathrm{d}r/\mathrm{d}t = \pm(1 - r_s/r)c$,以说明光速在引力场中是变化的,进而证明:光速不变性并非广义相对论的逻辑前提.

根据广义相对论,引力场中的光速的确是位置的函数;这无须引用 Schwarzschild 度规. 然而,这并不排斥光速不变性乃广义相对论之逻辑前提. 或许,王令隽先生没太留意,《观测与相对论》中有关于 Schwarzschild 度规与时空弯曲的内容. 根据 OR 理论,"时空弯曲"其实也只是一种源于光之观测局域性的观测效应.

有一种说法:真正懂得广义相对论的人,世界上只有 2 个(也有说 3 个的). 有人问爱丁顿:"据说,世界上只有 3 个人真正懂得爱因斯坦广义相对论,是真的吗?"爱丁顿立刻追问道:"那第 3 个人是谁呢?"爱丁顿言下之意,真正懂得爱因斯坦广义相对论的就 2 个人:一个是创立广义相对论的爱因斯坦自己;而另一个则是他自己. 这类故事的真实性无从考证,然而,似乎确有其合理性.

爱因斯坦广义相对论建立 100 多年了. 然而,人们,包括资深物理学家,以及那些专门研究广义相对论或为广义相对论著书立说的物理学家,仍然对其持有许多模糊不清的认识. 就光速不变性是否为广义相对论逻辑前提这一问题,相关的论述便模糊不清,甚至自相矛盾.

根据文献[13]记载,爱因斯坦曾说:"光速在引力场中是位置的函数;真空中的光速不变性原理必须加以修正. ……. 光速不变性原理仍然适用于这个理论,但它已不像平常那样作为通常的相对论基础来理解了. "(看来,对于光速不变性假设是否为广义相对论的逻辑前提,爱因斯坦自己也有些含糊.)据此,刘明成和刘文芳[14]认为有必要进一步阐明光速不变性是否为爱因斯坦广义相对论的逻辑前提. 他们的结论是:"光速不变原理仍然适用于广义相对论. 但它已不像平常那样作为通常的相对论的基础来理解了. 引力场中坐标时光速是位置的函数,它不能直接被测量. 真空中光速不变原理经过修改而更为明确:光速的固有值,即局部惯性系的测量值,不变. "这像是在重复爱因斯坦的话;无论如何,其中有一点值得肯定:"光速在局部惯性系中的测量值不变. "

赵峥[15]在《广义相对论入门讲座》中写到:"爱因斯坦想,既然惯性系无法定义,不如取消它在相对论中的特殊地位,把自己的整个理论置于'任意参考系'的框架中,即假定相对性原理和光速不变原理在任何参考系中都成立,而不仅仅只在惯性系中成立. 这样,狭义相对性原理被推广为广义相对性原理. 光速不变原理适用的范围也从惯性观测者推广到任意观测者:'任意观测者测量的光速都是 c.'"我不敢相信爱因斯坦对光速不变性原理做过如此推广. 王令隽先生质疑"光速不变性也是广义相对论逻辑前提之一"的论据,似乎更适合用来质疑赵峥在文献[15]中的论述.

刘辽和赵峥[16]在其撰写的教材中说:"在广义相对论中,实验测得的物理量都是用标准钟和标准尺测得的固有量,而非坐标量. 在静态引力场中,用标准钟和标准尺测得真空中的光速与狭义相对论一样,恒等于 c. "其言下之意,光速不变性原理在静态引力场中似乎是成立的.

那么,光速不变性假设,到底是不是爱因斯坦广义相对论的逻辑前提呢?

答案是肯定的!

光速 c 为什么会出现在广义相对论和爱因斯坦场方程中? OR 理论告诉我们,这是因为:与爱因斯坦狭义相对论中的情形一样,光在爱因斯坦广义相对论中扮演着观测媒介的角色!

爱因斯坦广义相对论最令人津津乐道的逻辑前提是等效原理(The Equivalence Principle). 所谓等效原理,简而言之,指时空之引力场与惯性力场的物理效应是局域不可分辨的. 然而,人们(包括许多物理学家)却并不十分清楚等效原理在爱因斯坦广义

相对论中究竟怎么发挥作用.

特别需要指出,在爱因斯坦广义相对论中,等效原理需要借助光速不变性假设方能发挥作用! 事实上,没有光速不变性假设,光速 c 就不可能进入爱因斯坦广义相对论,当然,也就不可能进入爱因斯坦场方程.

在光学观测体系中,限于光之观测局域性,引力时空看上去是“弯曲”的,而“弯曲”时空的几何特性需要微分几何作为其形式化工具:其中,“弯曲”的时空可由“微小”的惯性时空局部地逼近. 于是,基于等效原理,爱因斯坦方能将“弯曲”的引力时空局部地“等效”为“平直”的惯性时空,其中,光速不变性原理成立,光因而能以不变的速度 c 在局部惯性中传递信息. 这令我们想起了文献[14]曾经的结论:“光速在局部惯性系中的测量值不变. ” 由此,光速 c 便获准进入了爱因斯坦广义相对论及其场方程.

可见,光速不变性假设不仅是爱因斯坦狭义相对论的逻辑前提,而且,也是爱因斯坦广义相对论重要的和不可或缺的逻辑前提!

5　观测媒介的地位和作用

王令隽评:“爱因斯坦把光置于一个特别的绝对的位置. 光就是电磁波……对于时空结构没有也不应该有决定理论架构的作用. 可是,在爱因斯坦的相对论中,光却被赋予了决定时空结构的永久性的特殊位置. ……其荒谬是显而易见的. ”

“物理量的测量必须通过媒介吗? 当我们用米尺测量桌子的长度时,我们直接比较桌子与米尺的刻度. 当我们数着白天黑夜测量时间的流逝时,我们用的是地球自传的稳定周期. 当我们……. 在所有这些测量中,都不需要媒介. ”

“阮教授……中了相对论教义维护者的圈套. ”

阮晓钢答:王令隽先生既反对爱因斯坦在狭义相对论中给予光或光速特殊的地位,同时,又反对 OR 理论的“观测媒介”说.

像许多的物理人一样,王令隽先生的困惑在于:一方面,主观地认为,爱因斯坦相对论赋予光或光速特殊地位是“荒谬”的;另一方面,又苦于无从知晓光在爱因斯坦相对论中扮演什么角色,光速在洛伦兹变换中的物理意义是什么,光速为什么会不变. 现在 OR 理论告诉我们:光在爱因斯坦相对论中扮演着观测媒介的角色;光速在洛伦兹变换中代表着观测信息的传输速度;光速不变性是一种观测效应,源于观测局域性. 若能从 OR 的视角看待光和光速在爱因斯坦相对论中的特殊地位,王令隽先生或许会释然释怀,豁然开朗.

可惜,王令隽先生不愿意接受 OR 理论.

正如《观测与相对论》所言:“人类对客观世界的认识,既依赖于观测,又制约于观测. 物理学一切理论或学说,包括伽利略变换和洛伦兹变换,都与我们的观测手段或观测媒介联系在一起,无不打上观测的烙印. ”

Landau 和 Lifshitz[17] 撰写的《理论物理学教程》(共 10 卷)在物理学教育中颇具影响,其中,特别值得一提的是,Landau 和 Lifshitz 已经意识到:光速 c 在洛伦兹变换中代表信息传递速度[17-18]. 然而,他们没能清晰地意识到:光在爱因斯坦相对论中担当着观测媒介的角色;观测媒介并非必须是光;观测媒介的速度并非必须是光速.

OR 发现:理论上,任意物质运动形式皆可为观测媒介;不同的观测媒介可以有不同的信息传递速度;不同的信息传递速度可能导致不同的理论体系. 伽利略变换和牛顿力学是理想观测体系下的理论体系,观测媒介被理想化,速度无限,信息传递无须时间. 洛伦兹变换和爱因斯坦相对论是光学观测体系下的理论体系,观测媒介乃光或电磁相互作用,信息传递速度即光速.

基于 OR 理论,我们可以建立以超声波为观测媒介的“蝙蝠相对论”或“海豚相对论”,其观测信息传递速度自然是超声波的速度. 我们会发现,这样的物理模型不仅具有理论意义,还具有现实的和潜在的应用价值.

OR 理论表明:“自然地,被观测对象的信息必须借助于一定的媒介,以一定的方式,传递至我们的感官或观测仪器,方能被我们感知或观测. ”王令隽先生不以为然:“物理量的测量必须通过媒介吗?”他举了一些不需要观测媒介的测量实例. 需要特别指出:“测量”与“观测”不是同一概念. 观测是“实时测量”;而王令隽先生此处的测量可谓“离线观测”. 另一位颇具影响的物理人,针对 OR 理论提出的观测局域性问题,表达了与王令隽先生类似的观点:“人跑不赢汽车,但人可以先走,到前面去等汽车. ”其设想的观测途径同样地仅仅局限于离线观测.

离线观测并非不需要观测媒介;这一点,王令隽先生似乎也是同意的. 当然,离线观测无须依赖于观测媒介传递观测信息的速度,不涉及观测局域性

问题和观测信息延迟问题,等效于理想观测体系的情形. 因此,如果我们的物理模型可以基于离线观测数据构建,那么,它们就必定属于理想观测体系下的伽利略-牛顿理论体系,应服从伽利略变换和牛顿定律. 换句话说,这样的物理模型也只能适用于可离线观测的情形.

严格地说,离线观测只适用于静态观测:观测者是静态的;被观测对象也是静态的.

然而,物理学之观测和实验,诸如迈克尔逊-莫雷实验、电子双缝干涉实验、电子-质子对撞实验、量子效应观测、引力波探测,乃至一切天文观测,几乎都需要实时的在线观测,其中,观测媒介扮演着不可或缺的角色,观测局域性问题和观测信息的非即时性问题无法回避.

因此,观测媒介传递观测信息的速度必然成为制约物理观测和物理模型的重要因素,正如光速制约着迈克尔逊-莫雷实验,以及洛伦兹变换和爱因斯坦相对论一样.

6 宇宙的终极速度

王令隽评:“爱因斯坦把光置于一个特别的绝对的位置. …….. 这个特殊位置的最重要的表现就是光速极限原理. 光速成了一切物体速度的上限,不管是绝对速度还是相对速度. 即使光速和光速叠加得出来的还是光速. 其荒谬是显而易见的. ”

阮晓钢答:光速不变性假设有一个直接推论:光速乃一切速度之上限,是宇宙终极速度,是任意物质运动形式所不可超越的. 的确,如王令隽先生所思,爱因斯坦相对论之“光速极限”说,是物理学界至今存在的一个普遍的错误认识.

王令隽先生意识到光在爱因斯坦相对论中被赋予了特殊地位,却不知其本质和根源;对于“光速极限”说,认为“其荒谬是显而易见的”,却不知其缘何“荒谬”.

OR 阐明了其中实质性问题之所在.

主流物理学界的观念[17-18]是:“由于相互作用的局域性,宇宙存在理论上的极限速度,并且,这一速度必定是不变的. ” 不变的速度(invariant speed)必然导致极限速度或终极速度(ultimate speed). 基于光速不变性假设,光速是不变性的,因而,宇宙终极速度就是光速.

根据 OR 理论:将速度最快的物质运动形式之速度视为“不变速度”是一个错误.

宇宙并不存在所谓的“不变速度”!

的确,基于局域性原理,可以得出这样的结论:第一,所有物质运动形式之速度都是有限的;第二,其中必有某种物质运动形式的速度是最快的. 然而,根据 OR 理论,无论何种物质运动形式,无论其速度几何,当其作为观测媒介为惯性观测者传递被观测对象之时空信息时,其速度在惯性观测者看来都是相同的或不变的. 但那并非真实的自然现象或客观的物理存在,只是一种观测效应.

光速在大多数观测和实验中呈现出不变性,原因在于,我们的观测和实验大多以光或电磁相互作用为观测媒介. 然而,特别需要指出:光或电磁相互作用并非我们可加以利用的唯一的观测媒介. 光担当观测媒介时所呈现的速度不变性,并不意味着光速是宇宙极限速度.

爱因斯坦始终认为量子理论是不完备的. 值得注意,爱因斯坦的论据正是局域性原理(The Principle of Locality)和王令隽先生提到的“光速极限原理”. 爱因斯坦的局域性观念与其光速不变性假设联系在一起. 爱因斯坦相信:宇宙不存在超距作用,并且,光速是终极速度,不可超越. 1935 年,爱因斯坦与同事 Podolsky 和 Rosen 一起构思了一个著名的思想实验,史称 EPR 佯谬[19],用以质疑量子力学的完备性. 然而,似乎越来越多的 EPR 实验支持量子纠缠现象:宇宙似乎的确存在某种(必定是超光速的)“鬼魅般的超距作用”.

宇宙不存在所谓“不变速度”,因而,也就不存在绝对的“终极速度”,即不存在绝对的速度上限. 然而,根据 OR 理论,我们的观测和实验存在观测上的速度极限:观测媒介速度. 我们不能指望以声波为观测媒介,“听到”超音速物质运动;我们也不能指望以光波为观测媒介,“看到”超光速物质运动. 因此,我们也不能指望基于爱因斯坦相对论导出超光速运动关系. (这涉及引力波和 LIGO 话题;OR 会阐明这一点.)

一直以来,爱因斯坦相对论灌输给我们的观念是:光速乃宇宙终极速度,是不可超越的. 然而,物理学家们基于其内禀的自然观探索超光速物质运动的努力却从未停止过. 王令隽先生对“光速极限原理”的认识,或许,就源于其内禀的自然观. 现在,王令隽先生的观点得到了 OR 理论的诠释.

基于 OR 理论,超光速物质运动是可以期待的!因而,超光速的观测媒介也是可以期待的!

7 观测媒介速度不变性

王令隽评:“这里我们注意到的第一个问题是,

既然阮教授的‘观测相对论’的速度叠加公式和爱因斯坦的一样，也就同样会导致光速不变，甚至更甚，不仅光速不变，如果用别的媒介观测，其速度叠加公式也会导致声速不变，电子流速度不变等等. 而这，是比光速不变还要荒唐，并且很容易实验证伪的结论. ……. ”

“既然‘观测相对论’也逻辑地导致光速不变，就与阮教授的主题‘光速并非真地不变’直接相悖. ”

阮晓钢答：“观测媒介速度不变性”是 OR 理论推导得出的逻辑结论(参见文献[1]，以及文献[10-11]). 王令隽先生说：OR 之观测媒介速度不变性比爱因斯坦的光速不变性更荒唐. 这有两重意思：第一，爱因斯坦的光速不变性假设很荒唐；第二，OR 之观测媒介速度不变性更荒唐.

首先，作者不敢苟同王令隽先生关于爱因斯坦光速不变性假设“荒唐”的说法.

光速不变性假设自有其合理性，否则，我们将无法解释爱因斯坦相对论为什么能得到观测和实验支持. 光速不变性可追溯至迈克尔逊-莫雷实验[20]，其中，光速似乎失去了速度叠加性质. 光速不变性还表现在光行差现象等其他观测或实验中. 可见，光速不变性假设是有实证依据的.

基于光速不变性假设，爱因斯坦从理论上导出洛伦兹变换，并建立狭义相对论. 众所周知，洛伦兹变换原本是一个唯象模型，由 Fitzgerald[21] 和 Lorentz[22] 提出. 理论模型与唯象模型一致，映证了光速不变性假设的合理性和洛伦兹变换的有效性. 这种相互映证关系是其逻辑自洽性的一种体现. 这也是爱因斯坦相对论得到认可的重要原因.

的确，OR 理论建立之前，人们一直未能理解光速为什么不变. 这是人们(包括王令隽先生以及许多物理学家)对于爱因斯坦相对论一直心存疑虑的根本原因. 但由此认为爱因斯坦光速不变性“荒唐”，则是偏执的和缺乏理性的.

其次，与爱因斯坦光速不变性假设不同，OR 之观测媒介速度不变性不是假设，而是经理论推导得出的逻辑结论，不能简单地以“更荒唐”蔽之.

观测媒介速度不变性可谓 OR 最重要的理论发现之一，揭示了光速不变性现象的本质：光速不变性只是观测媒介速度不变性的一个特例，仅当光作为观测媒介时成立. 理论上，任何物质运动形式皆可为观测媒介，而非仅仅是光或电磁相互作用.

王令隽先生认为，观测媒介速度不变性很容易被观测和实验证伪. 学术讨论不能想当然或主观臆断，而应以确实的观测或实验为实证依据. 与王令隽先生的想法不同，OR 之观测媒介速度不变性符合人们对物理世界的直观认识，其合理性易于理解，并且，具有实证依据.

正如《观测与相对论》已经阐明的，与其说迈克尔逊-莫雷实验是对光速不变性的支持，不如说是对观测媒介速度不变性的支持. 在迈克尔逊-莫雷实验中，光既是被观测对象，同时，又是观测媒介. 因此，根据 OR 之观测媒介速度不变性，光速相对于观测者必定呈现出不变性.

除光波或光子之外，实验物理学家完全有理由或有必要检验其他物质波或物质粒子作为观测媒介时的速度不变性.

《观测与相对论》中，作者提出了用电子作为观测媒介的实验设想，以检验非光观测媒介的速度不变性. 可以设想：用电子替代光子，模拟迈克尔逊-莫雷实验，其中，电子既是被观测对象，同时，又是观测媒介. 如此，我们不妨想象一下：电子担当观测媒介时，电子自身的信息只能由电子自己携带和传递，正如光子在迈克尔逊-莫雷实验中的情形；那么，这时的电子速度会呈现什么状态呢？实验物理学家可通过实际的物理实验检验之；而现在，我们不妨将其视为一个思想实验. 类比迈克尔逊-莫雷实验中光速所呈现的不变性，我们不难得出这样的结论：作为观测媒介时，电子速度也会呈现出类似的不变性.

通过模拟迈克尔逊-莫雷实验，其他物质波或物质粒子作为观测媒介时的速度不变性皆可与迈克尔逊-莫雷实验中的光速不变性进行类比.

光速不变性是 OR 之观测媒介速度不变性的一个特例，仅当光担当观测媒介时成立，而且，只是一种观测效应；这正说明“光速并非真地不变”，而非王令隽先生所误解的“直接相悖”.

观测媒介速度不变性既是 OR 的逻辑结论，同时，又具有实证依据，并非王令隽先生想象或期待的那样“很容易证伪”.

8　OR 理论非空中楼阁

王令隽评：“阮教授的‘观测相对论’中的相对性现象，到底是‘观测效应’还是物理真实？您不妨以声波为观测媒介，作为例子，得出相应的速度叠加公式、质速关系、相对性动量定义，以及质能公式 $E = m\eta^2$. 这里 η 是声速. 您对这些结论有解释吗？对这些结论的证伪，应该比对基于光速的相对论的结果证伪要容易得多. ”

阮晓钢答:王令隽先生进一步将其对观测媒介速度不变性的看法,扩展至整个 OR 理论,并且,同样表达了两重意思:第一,爱因斯坦狭义相对论是可以证伪的;第二,OR 理论比爱因斯坦相对论更容易证伪,而且,“容易得多”.

正如作者此前阐述过的,物理学是实证和思辨的矛盾统一体,不能想当然或主观臆断.

与王令隽先生的看法相反,一百多年来,爱因斯坦的相对论不仅未被证伪,反而得到大多数观测和实验支持. 当然,这并不能说明爱因斯坦相对论是放之四海而皆准的终极理论.

OR 理论告诉我们:爱因斯坦相对论实则是一个“局部理论”,仅当光或电磁相互作用担当观测媒介时成立. 在光学观测体系中,我们所观测到的物理现象,自然符合爱因斯坦相对论. 限于人类当今的技术条件,大多数情形下,我们的观测和实验以光或电磁相互作用为观测媒介. 这正是爱因斯坦相对论得到大多数观测或实验支持的原因.

然而,根据 OR 理论,非光观测体系中,爱因斯坦相对论必定会失效. 这时,我们就需要“非光相对论”,例如此前提到的“蝙蝠相对论”和“海豚相对论”. 王令隽先生认为这种以声波为观测媒介的情形将证明 OR 理论是错误的.

此前,我们讨论了电子作为观测媒介时的情形. 类似地,我们可以构思以声波为观测媒介的思想实验:以声波替代光波,模拟迈克尔逊-莫雷实验,其中,声波既是被观测对象又是观测媒介,自身的信息须由自身携带并传递. 类比迈克尔逊-莫雷实验中光速的情形,我们可以想象,这时声波的速度也会呈现出类似的不变性.

大家知道,GPS 系统通过若干地球同步卫星的协同,实现全球定位. 那么,这些同步卫星怎么校准时间,又怎么测定时间和空间呢? 这需要借助于爱因斯坦相对论. 这也被视为支持爱因斯坦相对论的有力证据之一. 其实,与其说这是对爱因斯坦相对论的支持,不如说是对 OR 理论的支持. 同步卫星依靠无线电波通信:其信息媒介即电磁相互作用;观测媒介速度(η)即光速($\eta = c$). 因此,自然符合爱因斯坦相对论,或者更准确地说,符合 OR 以电磁相互作用为观测媒介的情形.

深海,将会是人类未来重要的探索领域;而深海探测,将会是人类未来重要的科考活动. 我国的蛟龙号水下机器人已能下潜至水下 7 000 m,突破万米指日可待. 当多机器人在深海协同作业的时候,它们将面临与 GPS 地球同步卫星同样的问题:怎么校准时间,怎么测定时间,怎么测定距离.

水下通信不能指望光或电磁相互作用. 于是,对于深海探测活动中多机器人的协同作业,爱因斯坦相对论必定失效! 水下机器人必须以超声波为观测媒介;相应的观测媒介速度应为超声波在深海中的速度:$\eta \approx 1\,450$ m/s. 虽然水下机器人运动速度远低于卫星运动速度,然而,超声波速度与光速的比更低. 根据 OR 理论,较之于光速,深海中的超声波速度导致的观测局域性和相对论性观测效应会更为突出. 可见,为了相互间的通信,深海协同作业的水下机器人必定需要“海豚相对论”或“超声波相对论”. 同样地,潜艇水下协同作战,以及潜艇对敌舰或敌潜艇的侦测活动,必定也也需要遵循“超声波相对论”.

OR 理论并非空中楼阁,而是一个符合逻辑的理论模型,并且,具有实证依据和实际应用前景. 实际上,观测和实验对伽利略-牛顿学说的支持,就是对 OR 理论的支持;观测和实验对爱因斯坦相对论的支持,同样是对 OR 理论的支持. “超声波相对论”将会为 OR 理论带来新的实证依据.

“蝙蝠相对论”和“海豚相对论”属于“亚光速相对论”. 未来,随着科学技术的发展,人类将会发现超光速物质运动,掌握超光速观测媒介,发明超光速观测体系. 那时,我们就需要“超光速相对论”. LIGO[23-24]的引力波探测活动导致了“引力波天文学”的概念[25]. 特别注意,引力波天文学以引力波为观测媒介,需要服从“引力波相对论”. 按 Laplace 等[26]和 van Flandern[27]等的计算,引力或引力波的速度远超光速. 因此,引力波可能会成为超光速观测媒介;而引力波相对论将会是“超光速相对论”. 借助超光速观测媒介和超光速相对论,我们将会“看”到更为真实的物理世界.

9 OR 理论之逻辑演绎

王令隽评:“阮教授提出了一个‘广义洛伦兹变换’和‘观测相对论’,其思路,逻辑和结构与爱因斯坦的狭义相对论基本相同,结论也差不多. 所不同的是,‘观测相对论’中的相对论因子中的光速 c 被媒介的速度 η 所取代. ……. 阮教授的‘观测相对论’出产了爱因斯坦相对论的几乎全部系列产品. ”

阮晓钢答:王令隽先生的意思是,OR 理论并无什么创意,无非是对爱因斯坦狭义相对论之逻辑套路的照搬:“结论也差不多”.

谢谢王令隽先生给作者一个进一步阐述 OR 理论的机会：OR 理论与爱因斯坦狭义相对论因循完全不同的逻辑路线（请参阅文献[10-11]）.

正如作者一开始所强调的，OR 理论不是“制造”出来的. 洛伦兹变换中的光速 c 被观测媒介速度 η 取代，是逻辑演绎和理论推导自然形成的结果，并非作者有意为之，也非作者初衷.

作者初衷只是希望能赋予光子一点静质量.

许多伟大的物理学家，包括薛定谔和德布罗意，以及费曼，都曾为寻找光子静质量做出过努力. 在作者的科学哲学信仰中，自然辩证法始终扮演着重要角色. 依据自然辩证法的思想：宇宙是时空与物质的矛盾统一体；而时空则是空间与时间的矛盾统一体，物质则是质量与能量的矛盾统一体. 我不能想象只有能量而无质量的物质存在. 作者坚信，光子一定存在静质量.

爱因斯坦的光速不变性假设导致了 2 个重要推论：第一，光速是宇宙极限速度；第二，光子静质量为零. 根据爱因斯坦狭义相对论中的质速关系 $m = m_0/\sqrt{(1-v^2/c^2)}$，要么，光子之静质量 m_0 为零；要么，光子之相对论性质量 m 无穷大. 爱因斯坦选择将光子静质量 m_0 定为零.

在爱因斯坦相对论中，光速 c 代表着宇宙极限速度. 我想，光速或许不是宇宙极限速度；真正的宇宙极限速度（权且记作 κ）应该是物质波频率趋于无穷时的速度. 任意物质粒子之物质波频率，包括光子的频率，都是有限的，因此，κ 是不可及的. 这意味着，光速 c 应该比 κ 小：$c<\kappa$；哪怕就小那么一点点，光子便会有静质量：$m_0 = m\sqrt{(1-c^2/\kappa^2)} \neq 0$，并且，任意物质粒子便都会有自己的静质量.

那时，我以为，κ 应该是不变的，是真正的宇宙极限速度；而 c 只是 κ 的一个近似.

沿着这一思路，我着手建立一套公理体系，其中[10-11]：时间定义是最基本的逻辑前提；另有一组波粒二象性条件，给出宇宙极限速度（κ）的定义，并将 κ 与物质波频率关联起来. 我试图在这一公理体系下导出能赋予光子静质量的相对论性模型. 然而，我的逻辑演绎进程遇到了障碍：如果 κ 是不可及的，那么，相应的理论推导就无法继续下去. 我不得不放弃对 κ 的限制，允许 κ 可及，即物质运动有可能达到宇宙极限速度 κ. 问题似乎又回到了原点，光子仍然没有质量.

于是，我只能暂且放下光子静质量问题.

这时，已经建立起来的公理体系令我产生了一种预感：爱因斯坦的狭义相对论与德布罗意的物质波理论有可能在这一公理体系下统一起来. 我想，得不到光子静质量，能将霍金所说的 2 个“局部理论”统一起来也挺好. 这促使我在已建立的公理体系下继续演绎相对论性的惯性时空变换.

我的逻辑演绎和理论推导需要一个物理量，其物理意义很明确：被观测对象之时空信息相对于惯性观测者的速度（权且记作 η）. 这涉及 2 个重要问题：第一，谁为观测者传递被观测对象的时空信息；第二，观测信息的速度是什么.

理论推导产生了一个有趣的结论：$\kappa = \eta$!

这意味着：所谓“宇宙终极速度”κ，其实，只是观测媒介速度 η，取决于观测媒介. 我似乎明白了洛伦兹变换和爱因斯坦相对论为什么会与光速联系在一起：光在爱因斯坦相对论中扮演观测媒介的角色，光速因而显得不变. 这正是《观测与相对论》副标题的由来.

最终，OR 理论体系得以建立，并且，远远超越了作者的预期：得到了光子静质量；探明了物质运动之相对论性的本质和根源；概括统一了伽利略变换和洛伦兹变换；概括统一了爱因斯坦狭义相对论和德布罗意物质波论. 特别需要指出，OR 理论体系很快会开展至爱因斯坦广义相对论.

特别需要指出，OR 理论与爱因斯坦狭义相对论具有完全不同的逻辑. 《观测与相对论》只是 OR 理论体系的一个子篇：粒子动力学. 的确，为了简明，《观测与相对论》直接以“观测极限假设”为逻辑前提，因循爱因斯坦的逻辑，演绎观测相对论. 其实，“观测极限假设”并非假设；在文献[10-11]中，它是 OR 理论的逻辑结论. 这一点，《观测与相对论》有说明和解释；或许，王令隽先生未曾留意，也未曾翻阅过文献[10-11].

爱因斯坦狭义相对论以光速不变性假设为逻辑前提，其逻辑演绎进程是逆向的：由果及因；因而，令人知其然而不知其所以然. OR 理论以时间定义为逻辑前提，其逻辑演绎进程是正向的：由因及果；因而，令人知其然并知其所以然.

OR 理论与爱因斯坦狭义相对论逻辑上的不同，还有一个重要的特征[10-11]：爱因斯坦演绎洛伦兹变换的过程始于空间变换；而 OR 演绎广义洛伦兹变换的过程却始于时间变换.

特别需要指出：无须波粒二象性条件，仅用时间定义和简单性原理，或者，仅用时间定义和相对性原

理,OR 整个理论体系依然可以导出(参见文献[10-11]). 或许,这在科学方法学上具有重要意义. 恩格斯说:“哲学是一切科学的灵魂.”从一定意义上讲,原理,往往代表着某种哲学信仰. OR 的逻辑显示,基于更基本的逻辑前提,物理世界的简单性和对称性可以自然地呈现在我们的物理学理论或物理模型中. 不能说这证明了简单性原理和相对性原理,但这的确强化了我们对物理世界之简单性和相对性的认知或信仰.

10 关于文风

王令隽评:“阮教授用了许多英文字头缩写,多达十几个. 文章读起来像读密码,非常吃力. …….学术交流,最要紧的是用最有效最清晰的语言表达你的思想. 在提出新的理论的时候尤其如此.”

阮晓钢答:谢谢王令隽先生的指教. 限于篇幅,同时,为避免反复调用同一过长的词组,《观测与相对论》使用了过多的缩写.

对不起,让读者和王先生受累了.

11 结束语

OR,“观测相对论”,是逻辑和理论的产物.

OR 理论以时间定义为最基本逻辑前提,其逻辑线路与爱因斯坦的逻辑线路完全不同. 然而,OR 导出的时空变换关系却与洛伦兹变换具有完全相同的形式,即所谓“广义洛伦兹变换”. 广义洛伦兹变换概括统一了伽利略变换和洛伦兹变换:在玻尔对应原理下,既同伽利略变换严格对应,也同洛伦兹变换严格对应. 并且,OR 理论融合了物质运动的波粒二象性,统一了爱因斯坦狭义相对论和德布罗意物质波论,能一致地导出爱因斯坦公式 $E = mc^2$ 和普朗克方程 $E = hf$,以及德布罗意关系 $\lambda = h/p$. 在 OR 理论体系中,光速不变性不再是一个假设,而是 OR 的逻辑结论,是 OR 之观测媒介速度不变性的个例;$E = hf$ 也不再是普朗克量子假设,而是 OR 理论推导得出的结果.

新的理论学说融合旧的理论,概括并统一旧的理论,是其逻辑上有效和理论上正确的一种体现.

作者对 OR 理论体系的论述(包括文献[1]以及文献[10-11]),未必十分严谨. 然而,OR 理论体系在逻辑上是自洽的,其结论符合人们朴素的自然观及其对物理世界的直观认识.

OR 理论发现:宇宙本不存在绝对的终极速度;光速并非真地不变,光子并非真地无质量;伽利略变换和洛伦兹变换是不同观测体系的产物,在 OR 理论中严格对应;爱因斯坦相对论和德布罗意物质波论可统一于同一理论体系;一切相对论性现象皆观测效应,一切量子效应皆观测效应;客观上的同时性是绝对的,时间旅行之类可休矣;时空并不真的弯曲,虫洞或时空隧道之类可休矣;海森堡的不确定性只是观测上的不确定,如爱因斯坦所言,上帝果真不掷骰子;普朗克常数 h 只是更广义的物质波常数 h_η 之特例:$hc = h_\eta \eta$.

原来,真实的物理世界依然是伽利略和牛顿为我们描述的永恒宇宙和绝对时空.

作者真诚地欢迎并感谢读者对 OR 理论的质疑和批判. 建议质疑和批判 OR 理论的读者正式地和直接地向《北京工业大学学报》或者其他学术期刊投稿. 物理学是思辨和实证的矛盾统一体. 就物理学之学术研讨而言,作者赞成这样的文风:思辨以逻辑和理论为依据;实证以观测和实验为依据.

OR 理论并非空中楼阁. 作者相信,OR 理论经得起逻辑和理论推敲,经得起观测和实验检验. 我们的物理学家们如若能以积极的心态,从 OR 的视角观察物理世界,或许,会豁然开朗,并且,会有新的认识和新的发现.

时间和历史会给出答案.

致谢

作者再次真诚地感谢王令隽先生对 OR 理论的评论和批判. 同时,作者感谢《北京工业大学学报》编辑部,感谢他们为发表《观测与相对论》以及为推动 OR 理论之学术讨论所做出的巨大努力. 正如王令隽先生评论所说:“这是难能可贵的.”

Response to *On “Observational Relativity”*

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Abstract: Here, the author responds to Mr. WANG Lingjun's *On “Observation Relativity”*, further clarifies the basic idea and logic of observation relativity, especially indicates the logical self-consistency of observation relativity and its empirical basis.

Key words: special relativity; general relativity; invariance of light speed

Einstein's theory of relativity has revealed the relativistic phenomena of matter motion and has been supported by almost all observations and experiments since its establishment. However, to this day, our physics still cannot explain why the speed of light is invariant and why matter motion presents relativistic phenomena. Einstein's relativity, both the special and the general, has been established for more than 100 years. After all, human's physics still has to continue: for relativistic phenomena, we cannot stagnate in such a state where we know what but do not know why.

Journal of Beijing University of Technology published in the first issue of 2020 the author's article entitled “Observation and Relativity: Why is the Speed of Light Invariant in Einstein's Special Relativity?”[1] (“Observation and Relativity” for short) that states a new theory: observational relativity (OR for short). OR theoretically proves that the speeds of observation media are observationally invariant, in which the invariance of light speed is only a special case when light or electromagnetic interaction acts as the observation medium. According to the theory of OR, all theories of physics are rooted in observation, and different observation systems lead to different theoretical systems: the Galilean transformation and Newton's laws are the products of the ideal observation system, while the Lorentz transformation and Einstein's relativity are the products of the optical observation system. The theory of OR suggests that all relativistic phenomena, including the invariance of light speed, are observational effects that are rooted in observational locality, rather than objective and real natural phenomena.

Now, for the relativistic phenomena of matter motion, the theory of OR makes us know not only what but also why.

Not surprisingly, since the launch of Observation and Relativity on China National Knowledge Internet on Sept. 10, 2019, Many readers (including senior physicists) have commented on and questioned the theory OR. An authoritative physicist as a member of the Chinese Academy of Sciences criticized in a word, “It is totally wrong to attribute the theory of relativity to observational effects!”

First of all, the author sincerely thanks the readers who critique or question the theory of OR. Anyway, it is the honor of both OR and the author that the theory of OR can gets your critique and attention.

WANG Lingjuan, a professor at the Tennessee University, USA, is the first physicist who wrote a formal letter to *Journal of Beijing University of Technology* to comment on and question the theory of OR. Mr WANG has great attainments and academic influence in the field of theoretical physics; his comments and critiques on the theory of OR are of profound significance, and worth thinking about.

The following isthe author's response to Mr WANG's *On “Observational Relativity”*, which makes a little extension for replying other's similar comments or critiques on the theory of OR.

1　OR is not artificial

WANG's Comment: “*I highly appreciate the spirit of challenging authority and the courage of critique by Prof. Ruan and the reviewer. ···. Only when the spirit of scientific critique established in*

Renaissance is reinstalled, we can objectively evaluate the multitude of fundamental problems of theoretical physics of 20th century and get out of the abyss. It is commendable that the Journal of Beijing University of Technology published the critique on relativity by Prof. Ruan. It is a sign that there are scholars capable of independent thinking within the establishment. "

RUAN's Response: Thank you Mr WANG for your encouragement.

It should be noted thatthe theory of OR has nothing to do with *the establishment*, and only involves pure academic issues; on Einstein's relativity, the view of domestic physics circle is no difference from that of the foreign physics circle.

The theory of OR is not a *critique* of Einstein's relativity whether in terms of its original intention or conclusion. The aim of science is not to critique. Science cannot take *critiquing* as its springboard, let alone *critiquing* for the sake of *critiquing*.

There is no doubt that Einstein's relativity is one of the greatest achievements in the history of human physics. The theory of OR is compatible with Einstein's relativity. Actually, the theory of OR is the inheritance and development of Einstein's relativity.

However, as Hawking[2] said in his *A Brief History of Time*: "Any physical theory is always provisional, in the sense that it is only a hypothesis: you can never prove it. No matter how many times the results of experiments agree with some theory, you can never be sure that the next time the result will not contradict the theory." OR suggests that Einstein's relativity is a *partial theory* that is true if and only if our observation systems employ light or electromagnetic interaction as the observation medium.

In particular, the theory of OR is not artificial, let alone *designed* and *manufactured* for opposing or critiquing Einstein's relativity. OR is the product of logic and theory, and an inadvertent *discovery*.

2 All relativistic effects are observational effects

WANG's Comment: "*Interpreting relativity as 'observational effect' is to hide the essence of relativity. …. Was the disaster of Hiroshima and Nagasaki merely an 'observational effect' instead of physical reality? Can you create a universe simply by an observation? …. The argument of 'observation effect' of relativity existed long time ago. Prof. Ruan did not start this school. …. Such 'criticism' could not explain the inconsistencies of relativity. Moreover, it might be misled to the framework of relativity and repeat the same mistake. ….* "

"*All in all, the theory of relativity and its conclusions are revolutionary theories drastically different from the classical physics. It cannot be simply explained as merely observational effect.* "

RUAN's Response: Mr WANG questions OR's corollary that *all relativistic effects are observational effects*, and expresses the same view as the authoritative physicists mentioned earlier.

Before the establishment ofthe theory of OR, the author had no idea that *relativistic effects are observational effects*. It is OR's *discovery*, OR's logical consequence, and the result of theoretical derivation, rather than the author's subjective cognition or personal assertion.

OR is a theoretical model of matter motion, which is based on both speculative study and empirical study. There are two proper approaches to critiquing or questioning a theoretical model of physics: one is empirical, the other is speculative. We can either deny it directly with counterexamples from observations and experiments, or deny its logical and theoretical validity by demonstrating the mistakes in its logical deduction and theoretical derivation. However, we cannot repudiate the theory of OR only based on subjective cognition or personal assertion.

Indeed, as Mr WANG says, "The argument of 'observation effect' of relativity existed long time ago. Prof. RUAN did not start this school." However, those are merely personal assertions based on subjective cognition, not the products of logic and theory, and have not yet formed a theoretical system or physical model comparable to the theory of OR. Still, there is one point worth thinking about: when advocating that "relativistic effects are observational effects", they (among them are some senior physicists) did not seem to worry about triggering the

paradox that “observation created the universe” or that “atomic bomb explosions were observational effects”.

Indeed, many physicists believe that the huge energy released by atomic bombs can be explained by Einstein's mass-energy formula $E = mc^2$: mass can be transformed into energy, and a little mass means a huge energy. There are even reports that scientists have found that the mass of matter decreases after atomic bomb explosions. (It is hard for us to imagine how scientists can measure the masses of matter before and after atomic bomb explosion.)

Actually, Einstein's mass-energy formula is only one of the relations in his special relativity, which has nothing to do with nuclear physics. Atomic energy, also known as nuclear energy, is the inherent energy of the nuclei of atoms, which is related to strong interaction and has nothing to do with Einstein's relativity. The huge energy generated in the instant of atomic bomb explosion comes from the release of the inherent energy of countless atoms by chain reaction, which has nothing to do with the mass of matter. There is a saying in the Wikipedia entry on *Mass Energy Equivalence*[3]: “some people think that this formula directly leads to the design and manufacture of atomic bombs. But in fact, the mass-energy formula has no direct or indirect promotion to the theory, design, and manufacture of atomic bombs. It is only one of the interpretation tools used by someone to explain the principles of atomic bombs.” Isaackson[4] said in his *Chain Reaction*: *From Einstein to the Atomic Bomb*: “Contrary to common belief, Einstein knew little about the nuclear particle physics underlying the bomb.” In Einstein's own words in his letter to von Laue[5]: “As to the atomic bomb and Franklin Roosevelt, what I did was just sign a letter drafted by Szilard to the President, seeing that the danger that Hitler might first have the atomic bomb.”

Einstein's relativity deems that relativistic effects are objective physical reality and the inherent characteristics of matter motion. This has become the academic view of mainstream physics circle, because Einstein's relativity, including the special and the general, has been tested for over one century, and supported by almost all observations and experiments. However, as Adrian Cho[6], a commentator of Science, remarked in his *Special Relativity Reconsidered* (for the occasion of the 100th anniversary of Einstein's special relativity): “So why are there so many people trying to prove it wrong?”

Such a successful special relativity is still being called into question. The root cause is that people cannot understand why the speed of light is invariant and why matter motion exhibits relativistic effects.

People's knowledge of the invariance of light speed dates from the Michelson-Morley experiment, which is itself a relativistic effect of matter motion.

Note that the invariance of light speed is the logical presupposition of Einstein's relativity. Therefore, Einstein's relativity itself cannot explain why the speed of light is invariant and why the matter motion exhibits relativity effects.

The theory of OR has discovered theessence and root of the relativistic effects of matter motion: all theories of physics are dependent on and restricted by observation; all relativistic effects of matter motion are observational effects. This is the meaning of the word “*observational*” in observational relativity.

In a sense, it is the most important discovery of OR that *all relativistic effects are observational effects*.

OR has theoretically derived the invariance of observation-medium speeds, and revealed the root cause of the invariance of light speed in the Michelson-Morley experiment: light plays the role of the observation medium in the Michelson-Morley experiment; the so-called principle of the invariance of light speed is true if and only if light or electromagnetic interaction acts as the observation medium.

OR has further derived the general Lorentz transformation theoretically, in which the general Lorentz factor $\Gamma(v, \eta) = 1/\sqrt{(1 - v^2/\eta^2)}$ depends on the observation-medium speed η, rather than the light speed c. According to the theory of OR, the relativistic effects of matter motion is rooted in observational locality that is, the observation-medium speed is finite: $\eta < \infty$. It takes time for the observation medium to transmit observed information. This inevitably leads to the delay of observed information, and then to observationally relativistic effects, that is, *observational*

effects.

Some readers have misunderstood that the theory of OR completely denies the objective reality of relativistic phenomena of material motion. In particular, the theory of OR only means that: 1) our physical observations and physical models based on observations present observational relativistic effects because of being restricted by observational locality; 2) our observations and physical models not only reflect the real material existence and objective physical reality, but meanwhile also contain observational effects. The lower the observation-medium speed η is, the more significant the observation locality and the observational relativistic effects are. The general Lorentz factor $\Gamma(v, \eta)$ of OR is the representation of relativistic degree, which can be divided into two parts by Taylor series: $\Gamma(v,\eta) = \Gamma_\infty + \Delta\Gamma(v,\eta)$, where $\Gamma_\infty = 1$ is the Galilean factor representing objective physical reality, and is absolute and invariant; while, $\Delta\Gamma$ is the observation-effect factor representing observational effects, depends on the observation-medium speed η and the matter-motion speed v. There is no observational effect if $\Delta\Gamma = 0$; the larger the $\Delta\Gamma$, the more significant the observational effect. In the idealized case (such as the case of Galilean-Newtonian theoretical system), $\eta \to \infty$, $\Gamma(v, \eta) = 1/\sqrt{(1 - v^2/\eta^2)} \to \Gamma_\infty = 1$, and $\Delta\Gamma = 0$: the Galilean transformation and Newton's laws do not involve observational effects. However, In the optical observation system, $\eta = c < \infty$ and $\Delta\Gamma > 0$: the Lorentz transformation and Einstein's relativity involve observational effects.

So, the real physical world is not the relative spacetime described by Mach and Einstein, but the absolute spacetime described by Galileo and Newton.

It is worth noting thatthe general Lorenz transformation in the theoretical system of OR unifies the Galilean transformation and Lorentz transformation, and under Bohr's correspondence principle[7], strictly corresponds to the both: if $\eta = c$, the general Lorentz transformation reduces to the Lorentz transformation; if $\eta = \infty$, the general Lorentz transformation reduces to the Galilean transformation. Such a strict correspondence corroborates the logical rationality and theoretical validity of the general Lorentz transformation and the theory of OR from one aspect.

The mission of science is to explore the unknown, the most fundamental of which is to find out the essence behind natural phenomena, that is, to know why. Now, OR makes us not only know what, where, when and how, but also know why matter motion exhibits relativistic effects in our observation. With the theory of OR we have finally understood that: light plays the role of observation medium in Einstein's relativity; all relativistic effects, including the invariance of light speed, the relativity of simultaneity, time dilation and length contraction, and even spacetime curvature and quantum effects, are observational effects.

3 On the prerequisites of special relativity

WANG's Comment: "*Prof. Ruan asserts*: '*Based on the hypothesis of invariance of speed of light, Einstein successfully derived Lorentz transformation, established special relativity, revealed the relativistic phenomena of spacetime and matter. The invariance of speed of light is not only the foundation of special relativity, but also one of the fundamental premises of general relativity.*' *It is an overstatement.*"

"*First of all, one could not derive Lorentz transformation simply based on the invariance of speed of light.* …."

RUAN's Response: Mr WANG says: "More hypotheses must be added to do that. For example, the transformation must be assumed to be linear. Linearity of a transformation is not self-evident. There is no reason to restrict a transformation to be linear." He means to criticize the author's ignorance of Einstein's special relativity, although this has nothing to do with whether or not the theory of OR is validity.

Asis known to all, Einstein's special relativity has two principles as its logical prerequisites: the first is the principle of the invariance of light speed; the second is the principle of relativity. Actually, it has still the little-known third: the principle of simplicity[8].

The linear transformation mentioned by Mr WANG should be attributed to the principle of simplicity;

according to Einstein himself, it should be attributed to the homogeneity of spacetime[9]: “In the first place it is clear that the equations must be linear on account of the properties of homogeneity which we attribute to space and time.” If he was more careful, Mr WANG could read the contents of the linear transformation of spacetime in *Observation and Relativity*. There is a more detailed exposition on the principle of simplicity and the linear transformation of spacetime in References [10] and [11]. Mr WANG might as well read it a little if interested.

By the way, References [10] and [11] have described the original and complete logical deduction of OR, in which, starting from the more basic prerequisites, OR has directly deduced the Lorentz transformation in differential (not algebraic) form without the principle of simplicity and the hypothesis of linear transformation. (This involves Mr WANG's question about the relationship between OR's logic way and Einstein's logic way, which the author will response later on.)

4 Hypothesis of the invariance of light speed and Einstein's general relativity

WANG's Comment: “*Next, the invariance of speed of light is not one of the fundamental postulations of general relativity, having nothing to do with the construction of Einstein's field equation. As a matter of fact, general relativity directly contradicts the invariance of speed of light. It can be easily shown.* ….”

RUAN's Response: Mr WANG means to criticize the author's ignorance of Einstein's general theory of relativity, although this also has nothing to do with whether or not the theory of OR is validity.

Mr WANG offers aspeed formula of light in gravitational fields derived from the Schwarzschild metric[12]: $v = \mathrm{d}r/\mathrm{d}t = \pm(1 - r_s/r)c$, to show that the speed of light is variant in gravitational fields, and then asserts that the invariance of light speed is not one of the logical prerequisites of Einstein's general relativity.

According to Einstein's general theory of relativity, the speed of light indeed depends on the position in gravitational fields, even without the Schwarzschild metric. However, this does not mean to exclude the invariance of light speed from the list of the logical prerequisites of Einstein's general theory of relativity. Perhaps, Mr WANG did not pay much attention to the contents of Schwarzschild metric and curved spacetime in *Observation and Relativity*. According to the theory of OR, *curved spacetime* is also an observational effect caused by the observational locality of light as the observation medium.

As the story goes, Eddington was asked: “People says there are only three persons in the world who really understand Einstein's general theory of relativity. Is that true?” “So, who is the third?” retorted Eddington at once. Eddington meant that only two persons understood Einstein's general theory of relativity: one was Einstein himself who established the general theory of relativity; the other was Eddington himself. There is no way to verify the authenticity of such stories; however, they seem reasonable.

Einstein's general theory of relativity has been established for more than 100 years. However, people (involving senior physicists, and those who specialize in general relativity or write textbooks for general relativity) still hold many ambiguous views about general relativity. As for whether or not the invariance of light speed is one of the logical prerequisites of Einstein's general relativity, the relevant interpretations are still ambiguous, and even self-contradictory.

According to Reference [13], Einstein ever said: “The speed of light is a function of the position in gravitational fields; the principle of the invariance of light speed in vacuum must be modified. …. The principle of the invariance of light speed is still applicable to this theory, but it is no longer understood as the basis of relativity theory as usual.” (It seems that Einstein himself was also a little vague about whether or not the invariance of light speed is one of the logical prerequisites of Einstein's general relativity.) Accordingly, LIU Mingcheng and LIU Wenfang[14] thought that it needed to further clarify whether or not the invariance of light speed is one of the logical prerequisites of Einstein's general relativity. Their conclusions are that: “The principle of the invariance of light speed is still applicable to general relativity, but it is no longer understood as the basis of

relativity theory as usual. The speed of light is a function of the position in gravitational fields, which cannot be measured directly. The principle of the invariance of light speed in vacuum becomes clearer after being modified: the intrinsic value of light speed (that is, the measured value in a local inertial frame) is invariant." This is a little like repeating Einstein's words; in any case, there is one point in their conclusions worth affirming: "the measured value of light speed is invariant in local inertial frames".

ZHAO Zheng[15] wrote in his *Introductory Lectures on General Relativity*: "Einstein thought that, as the inertial frame could not be defined, it was better to cancel its special status in relativity theory, and put the whole theory in the framework of any reference frame. He assumed that the principle of relativity and the principle of the invariance of light speed held in any reference frame, not just in the inertial frame. Then, the special relativity principle has been generalized as the general relativity principle. The principle of the invariance of light speed has also been generalized to any observers: the light speed measured by any observer is exactly c." I cannot believe that Einstein had done such a generalization to the principle the invariance of light speed. Mr WANG's arguments that question that "*The invariance of light speed is also one of the logical prerequisites of Einstein's general theory of relativity*" seems more suitable for questioning ZHAO's statements in Reference [15].

LIU Liao and ZHAO Zheng[16] wrote in their book: "In the general theory of relativity, the physical quantities measured in experiments are the intrinsic quantities measured by the standard clock and the standard ruler, not the coordinate quantities. In a static gravitational field, the speed of light in vacuum measured by the standard clock and the standard ruler is the same as that of special relativity: identically equal to c." These words seem to mean that the principle of the invariance of light speed holds if and only if light travels in static gravitational fields.

So, is the hypothesis ofthe invariance of light speed one of the logical prerequisites of Einstein's general theory of relativity?

The answer to this is yes!

Why does the light speed c come into Einstein's general theory of relativity and Einstein's field equation? The theory of OR tells us that this is because light plays the role of the observation medium in Einstein's general theory of relativity, just as in Einstein's special theory of relativity.

The most interesting logical prerequisite of Einstein's general relativity is the equivalence principle. The so-called equivalence principle, in short, means that the physical effects of the gravitational field and the inertial force field are locally indistinguishable. However, people (including many physicists) don't know fully how the equivalence principle works in Einstein's general relativity.

In particular, in Einstein's general theory of relativity, the equivalence principle can work only by the aid of the hypothesis of the invariance of light speed. In fact, without the hypothesis of the invariance of light speed, the light speed c would not emerge in Einstein's field equation or Einstein's general theory of relativity.

In the optical observation system, the gravitational spacetime *looks* a little *curved*. The geometric property of such a *curved spacetime* has to be formalized by means of differential geometry, in which the *curved* spacetime can be approximated locally by micro inertial spacetimes. Thus, based on the equivalence principle, Einstein could make the *curved* gravitational spacetime locally equivalent to *flat* inertial spacetime, where the hypothesis of the invariance of light speed holds, and therefore light can transmit observed information at the constant speed c. It reminds us of the conclusion in Reference [14]: "the measured value of light speed is invariant in local inertial frames". In this way c has been allowed to join in Einstein's general theory of relativity and the field equation.

So, the hypothesis of the invariance of light speed is not only the logical prerequisite of Einstein's special relativity, but also the important and essential logical prerequisite of Einstein's general theory of relativity.

5 Role of observation media

WANG's Comment: "*Einstein placed light in an absolutely special position. Light is nothing but the*

electromagnetic wave …. It should not play any role in determining the structure of space-time. However, Einstein endowed light with a permanent and special position. …. The absurdity is quite evident. "

"*Do measurements have to be done through media? When we measure the length of a table, we directly compare it with a meter stick. When we measure the time by counting days and nights, we make use of the stable period of rotation of the earth. When we measure the weight of an object, we compare it with the weights and marks of a balance. When we …. In all these measurements, no medium is needed.* "

"*Prof. Ruan … has fallen into the trap of defenders of relativity doctrine.* "

RUAN's Response: Mr WANG is strongly opposed to Einstein's endowing light or the speed of light with a special status in special relativity, and at the same time to OR's theory of *observation media*.

Like many physicists, Mr WANG's confusion lies in that: on the one hand, he subjectively asserts it is *absurd* for Einstein's relativity to endow light or the speed of light with a special status; on the other hand, he suffers from the inability to comprehend what role light plays in Einstein's relativity, what the physical significance of light speed is in the Lorentz transformation, and why the speed of light is invariant. Now the theory of OR tells us that: light plays the role of the observation medium in Einstein's relativity; the speed of light in the Lorentz transformation represents the transmission speed of observed information; and the invariance of the speed of light is an observational effect rooted in observational locality. In case he understands the special status of light in Einstein's relativity from the perspective of OR, Mr WANG will feel a sense of relief and become enlightened.

Unfortunately, Mr WANG is not willing to accept the theory of OR.

As *Observation and Relativity* remarked: "Human cognition of the objective world not only depends on observation but is also restricted by observation. All theoretical systems or spacetime models of physics, including the Galilean transformation and the Lorentz transformation, are linked to our observation means or observation media, and branded with observation. "

The Course of Theoretical Physics (ten volumes in total[17]) written by Landau and Lifshitz has a great influence in physics education. In particular, Landau and Lifshitz had realized that: the light speed c in the Lorentz transformation represents the transmission speed of information[17-18]. However, they had not clearly realized that: light plays the role of the observation medium in Einstein's relativity; the observation medium does not have to be light; the transmission speed information does not have to be the speed of light.

OR discovers that: theoretically, any form of matter motion can be employed as the observation medium; different observation media may have different speeds to transmit observed information; different transmission speeds of observed information may lead to different theoretical systems. The Galilean transformation and Newton's laws belong to the theoretical system under the idealized observation system, in which the observation medium is idealized: its speed is infinite and it takes no time for observed information to travel. The Lorentz transformation and Einstein's relativity belong to the theoretical system under the optical observation system, in which the observation medium is light, and the transmission speed of observed information is of course the speed of light.

Based on the theory of OR, we can build *the bat theory of relativity or the dolphin theory of relativity* where ultrasonic wave works as the observation medium and the transmission speed of observed information is naturally the speed of ultrasonic wave. We will find that such physical models not only have theoretical significance, but also practical and potential application value.

The theory of OR suggests that: "Naturally, observed information must be transmitted from observed objects to our sensory organs or observation instruments in some manner, or by means of certain media, so that we can perceive or detect the observed objects. " Mr WANG disagrees: "Do measurements have to be done through media?" He provided some instances of measurement without an observation medium. Noted that *measurement* and *observation* are not the same

concept. Observation is *real-time* measurement; while Mr WANT's measurement here is *off-line* observation. On the problem of observational locality presented in OR, another influential physicist expressed a view similar to Mr WANG's: "One cannot run faster than a car, but he or she can go first and wait for the car in front." Actually, the observation he proposed is also limited to off-line observation.

Off-line observation also needs observation media, and Mr WANG seems also to agree to this. Of course, the off-line observation does not have to rely on the speeds of observation media, does not involve of observational locality and the delay of observed information, and is equivalent to the case in the idealized observation system. Therefore, if our physical models can be constructed with off-line observation data, then they must belong to the Galilean-Newtonian theoretical system under the idealized observation system, and should follow the Galilean transformation and Newton's laws. In other words, such models are only applicable to the case of off-line observation.

Strictly speaking, off-line observation is only applicable to *static* observation: the observer is static; the observed object is also static.

However, our observations and experiments, such as the Michelson-Morey experiment, the double-slit interference of electrons, the collision experiment of electrons and protons, the observation of quantum effects, the detection of gravitational waves, and all celestial observations, almost need real-time and on-line observation, in which observation media play the crucial role, and observational locality and the delay of observed information are inescapable issues.

So, the speeds of observation media must be a crucial factor that restricts physical observations and physical models, just as the speed of light restricts the Michelson-Morey experiment, the Lorentz transformation and Einstein's theory of special relativity.

6 Ultimate speed of the universe

WANG's Comment: "*Einstein endowed light with a permanent and special position, the most significant manifestation being the speed limit of light. The speed of light became the speed limit of everything, be it absolute or relative. Even the superposition of two photon speeds yields the same speed of light. The absurdity is quite evident. ….*"

RUAN's Response: The hypothesis of the invariance of light speed has a direct corollary: the speed of light is the upper limit of all speeds, that is, the ultimate speed of the universe, which cannot be exceeded by any form of matter motion. Indeed, as Mr WANG thinks, the ultimate speed of the universe is a common misconception in today's physics circle.

Mr WANG realizes that light is endowed with a special status in Einstein's relativity, but did not realize its essence and root; on the theory of the ultimate speed, he thinks that "the absurdity is quite evident", but he did not know why it is *absurd*.

OR illustrates the essence of the problem.

Mainstream physics circle claims that[17-18]: "Due to the locality of interactions, there exists theoretically an ultimate speed in the universe, and it is invariant." The invariant speed inevitably leads to the ultimate speed. Based on the hypothesis of the invariance of light speed, the speed of light is invariant. Therefore, the ultimate speed of the universe is the speed of light.

According tothe theory of OR, it is a mistake to take the speed of the fastest form of matter motion as *invariant speed*.

There is no *invariant speed* in the universe!

Indeed, based on the principle of locality, we can draw the following conclusions: 1) the speeds of all forms of matter motion are limited; 2) there must be a form of matter motion with the *maximum* speed. However, according to the theory of OR, no matter what form of matter motion, no matter what its speed, when it acts as the observation medium to transmit the spacetime information of the observed object for inertial observers, its speed is invariant or the same relative to different observers. Nevertheless, that is not a real natural phenomenon or objective physical reality, but only an observational effect.

The speed of lightexhibits invariance in most observations and experiments, because we employ light or electromagnetic interaction as the observation medium in most observations and experiments. But

note that light or electromagnetic interaction is not the only observation medium we can make use of. The invariance the speed of light exhibits when light or electromagnetic interaction acts as the observation medium does not mean that the speed of light is the ultimate speed of the universe.

Einstein always thought that quantum theory was incomplete. Note that Einstein's arguments are based on the principle of locality and the theory of the ultimate speed mentioned by Mr WANG. Einstein's view on locality is connected with his hypothesis of the invariance of light speed. Einstein believed that there was no action at a distance in the universe, and that light speed was the ultimate speed and could not be exceeded. In 1935 Einstein, Podolsky, and Rosen conceived a famous thought experiment, known as the EPR paradox[19], to question the completeness of quantum theory. However, it seems that more and more EPR experiments support the phenomenon of *quantum entanglement*: there does seem to be *spooky action at a distance* in the universe, and such an action must be superluminal.

The universe has no so-called *invariant speed*, and therefore has no absolute *ultimate speed*, that is, no absolute upper limit of speed. However, according to the theory of OR, there exists the observational limit of speed in our observation and experiment: the speed of observation medium. We cannot expect to *hear* supersonic motion by means of sound wave as the observation medium; and we cannot expect to *see* superluminal motion by means of light wave as the observation medium. So, we cannot expect to derive the relation of superluminal motion from Einstein's theory of relativity. (This involves the topic about gravitational waves and LIGO; OR will illustrate this.)

Always, it has been a delusion fed by Einstein's relativity to us that: the speed of light is the ultimate speed in the universe and cannot be exceeded. However, inspired by their intrinsic view of nature, physicists have never stopped their efforts to explore superluminal motion of matter. Mr WANG's view on the *ultimate speed* of the universe may exactly be due to his intrinsic view of nature. Now, Mr WANG's view has been illustrated by the theory of OR.

Based on the theory of OR, superluminal matter motion can be expected; so, superluminal observation media can also be expected.

7 Invariance of observation-medium speeds

WANG's Comment: "*The first problem we notice is that, since the formula of velocity superposition in Prof. Ruan's 'Observational Relativity' is the same as that of Einstein, it will lead to the invariance of speed of light, even more. Not only the speed of light is constant, it will lead to the invariance of speed of sound, speed of electron current and so on, if other media are used. And this is more absurd than the invariance of speed of light and more easily falsifiable. ….*"

"*Since 'Observational Relativity' logically leads to the invariance of speed of light, it directly contradicts the main proposition of Prof. Ruan: 'The speed of light is not really invariant'.*"

RUAN's Response: *The invariance of observation-medium speeds* is a logical inference derived from the theory of OR (see References [1], [10] and [11]). Mr WANG asserts that OR's invariance of observation-medium speeds is more absurd than Einstein's invariance of light speed. This has two meanings: first, Einstein's the invariance of light speed is absurd; second, OR's invariance of observation-medium speeds is even more absurd.

First, the authorcannot agree to Mr WANG's statement that Einstein's hypothesis of the invariance of light speed is *absurd*.

Einstein's invariance of light speed has its own rationality, otherwise we cannot explain why Einstein's relativity has been supported by observations and experiments. The invariance of light speed can be traced back to the Michelson-Morley experiment[20], in which the speed of light seems to lose the property of velocity addition. The invariance of light speed also presents in other observations or experiments such as the aberration of light. So, the invariance of light speed has its own empirical basis.

Based on thehypothesis of the invariance of light speed, Einstein theoretically derived the Lorentz transformation and established his special theory of

relativity. As is well known, the Lorentz transformation was originally a phenomenological model proposed by FitzGerald[21] and Lorentz[22]. The theoretical model is consistent with the phenomenological model, which to some extent corroborates the rationality of hypothesis of the invariance of light speed and the validity of the Lorentz transformation. Such mutual corroboration is the embodiment of logical self-consistency, which is also an important reason for Einstein's relativity to be recognized.

Indeed, before the establishment ofthe theory of OR, people had never been able to understand why the speed of light was invariant. This is the fundamental reason why people (including Mr WANG and many physicists) had their doubts about Einstein's relativity. But it is radical and irrational to think Einstein's invariance of light speed is absurd.

Second, different from Einstein's hypothesis of invariance of light speed, OR's invariance of observation-medium speeds is not a hypothesis, but a logical conclusion derived in theory, and cannot simply be denied in two word: "more absurd".

The invariance of observation-medium speeds is one of the most important theoretical discoveries of OR, which brings to light the essence behind the phenomenon of the invariance of light speedt: the invariance of light speed is just a special case of the invariance of observation-medium speeds, and it is true only when light acts as the observation medium. In theory any form of matter motion can be employed as the observation medium, not just the light or electromagnetic interaction.

Mr WANG asserts that OR's invariance of observation-medium speeds can easily be falsified by observations and experiments. Academic discussion cannot be taken for granted and based on subjective supposition, but should be grounded on reliable empirical basis. Contrary to Mr WANG's view, OR's invariance of observation-medium speeds accords with people's intuitive understanding of the physical world, its rationality is easy to comprehend, and it possesses empirical basis.

As has beenstated in *Observation and Relativity*, the Michelson-Morley experiment did not provide so much support for the invariance of light speed as for the invariance of observation-medium speeds. In the Michelson-Morey experiment, light is not only the observed object, but also the observation medium. So according to OR's invariance of observation-medium speeds, the speed of light must exhibit invariance relative to observers.

In addition to light waves or photons, experimental physicists haveevery reason or need to test OR's invariance of observation-medium speeds by employing other matter waves or matter particles as the observation medium.

In *Observation and Relativity*, the author proposes an experiment that employs the electron as the observation-medium, so as to test the invariance of the speeds of nonlight observation-media. Suppose that we emulate the Michelson-Morley experiment by the electron instead of the photon, in which the electron is not only the observed object but also the observation medium. So, let's imagine that: the electron acts as the observation medium, the information of the electron has to be carried and transmitted by the electron itself, just like the case of the photon in the Michelson-Morley experiment; then, what will at that moment the speed of the electron be? Experimental physicists can test it with practical experiments; but for now, we might as well take it as a thought experiment. By analogy with the invariance of the speed of light in the Michelson-Morley experiment, we can logically conclude that the speed of the electron will also exhibit the similar invariance when the electron acts as the observation medium.

Throughemulating the Michelson-Morley experiment, the invariance of the speeds of all other matter waves or particles as the observation medium can be analogized with the invariance of the speed of light in the Michelson-Morley experiment.

The invariance oflight speed is a special case of OR's invariance of observation-medium speeds, which is true only when light acts as the observation medium and just an observational effect. This exactly shows that "the speed of light is not really invariant", rather than that "it directly contradicts …" misunderstood by Mr WANG.

Theinvariance of observation-medium speeds is the logical conclusion of OR, and possesses empirical basis, which is not so “easy to falsify” as Mr WANG imagined or expected.

8 OR is not a castle in the air

WANG's Comment: “*Are the relativistic phenomena in Prof. Ruan's Observational Relativity merely observational phenomena or physical reality? Why don't you use, for example, the sound wave as the medium of observation and derive the formula of velocity superposition, mass-velocity relationship, definition of relativistic momentum and the mass-energy relationship* $E = m\eta^2$, *where* η *is the speed of sound. Can you explain these results? It should be much easier to falsify these relationships than the results of relativity based on the invariance of speed of light.*”

RUAN's Response: Mr WANG further extends his view on the invariance of observation-medium speeds to the whole theory of OR, and also expresses two meanings: first, Einstein's special relativity can be falsified; second, the theory of OR is easier to be falsified than Einstein's relativity, and “*much easier*”.

As stated above, physics is the contradictory unity of speculative study and empirical study, and cannot be taken for granted or based on personal subjective supposition.

Contrary to Mr WANG's view, for more than 100 years, Einstein' relativity has not been falsified, but has been supported by most observations and experiments. Of course, this does not mean that Einstein's relativity is the ultimate theory that is universally true.

The theory of OR suggests that Einstein's relativity is actually a *partial theory*, and is true only when light or electromagnetic interaction acts as the observation medium. Under the optical observation system, the physical phenomena we observe naturally conform to Einstein's relativity. Limited to the current technology, in most cases, our observations and experiments employ light or electromagnetic interaction as the observation medium, which is the reason why Einstein's relativity has been supported by most observations or experiments.

However, according to the theory of OR, Einstein's theory of relativity must be invalid in non-optical observation systems. So, we need the non-optical theories of relativity, such as the bat and dolphin theories of relativity. Mr WANG believes that the case where sound act as the observation medium will demonstrate that the theory of OR is wrong.

Previously, we discussed the case of the electron as the observation medium. Similarly, we can conceive a thought experiment with sound as the observation medium: to emulate the Michelson-Morley experiment with sound instead of light, where sound is both the observed object and the observation medium, and the information of sound has to be carried and transmitted by sound itself. By analogy with the invariance of the speed of light in the Michelson-Morley experiment, we can logically imagine that the speed of sound will also exhibit the similar invariance when sound acts as the observation medium.

We all know that the GPS system carry on global positioning through the cooperation of many synchronous satellites. So, how do these synchronous satellites calibrate their times, and how do they measure time and space? That has to depend on Einstein's relativity. This is also deemed as one of the strong evidences supporting Einstein's relativity. In fact, this is not so much support for Einstein's relativity as for the theory of OR. Those synchronous satellites communicate with one another by radio: the observation medium is electromagnetic interaction; the observation-medium speed (η) is exactly the light speed ($\eta = c$). So, that must follow Einstein's relativity, or to be more exact, follow the theory of OR as electromagnetic interaction acts as the observation medium.

In the future, the deep ocean will be an important exploration field for mankind, and the exploration of the deep ocean will be an important scientific activity of mankind. China's Jiaolong, an underwater robot, has already been able to dive to 7 000 meters underwater; the breakthrough of 10 000 meters is around the corner. When multi robots work together in the deep ocean, they will face the same problems as GPS's synchronous satellites: how to calibrate their

time, how to measure time, and how to measure distance.

Underwater communication cannot depend on light or electromagnetic interaction. So, for the cooperative operation of multi robots in deep ocean, Einstein's relativity must fail. Underwater robots must employ ultrasonic wave as the observation medium; the corresponding speed of observation medium should be the speed of ultrasonic in the deep ocean: $\eta \approx 1\ 450$ m/s. Although the speed of underwater robots is much lower than the speed of earth satellites, the ratio of ultrasonic speed to light speed is much lower. According to the theory of OR, the observational locality and the observational relativistic effects are more prominent caused by the speed of ultrasonic than that caused by the speed of light. So, in order to communicate with one another, underwater robots working together in the deep ocean are bound to need the dolphin theory of relativity or *the ultrasonic theory of relativity*. Similarly, the cooperative combat of underwater submarines, and underwater submarines' detection to enemy warships or submarines, will have to depend on the ultrasonic theory of relativity.

The theory of OR is not a castle in the air. It is a logical and theoretical model with empirical basis, and has practical application prospect. In fact, the support of observations and experiments for the Galilean-Newtonian theory is the support for the theory of OR; the support of observations and experiments for Einstein's relativity is also the support for the theory of OR. The ultrasonic theory of relativity will provide new empirical evidences for the theory of OR.

The bat theory of relativity and the dolphin theory of relativity belong to subluminal relativity. In the future, with the development of science and technology, mankind will discover superluminal matter motion, grasp superluminal observation media, and invent superluminal observation systems. Then, we must need the superluminal theory of relativity. LIGO's detection[23-24] of gravitational wave leads to the concept of *gravitational wave astronomy*[25]. In particular, gravitational wave astronomy employs gravitational wave as the observation medium, and needs to obey *the gravitational theory of relativity*. Perhaps, as calculated by Laplace et al[26] and van Flandern[27], the speed of gravity or gravitational wave is far faster than the speed of light. So, gravitational wave may become a superluminal observation medium; the gravitational theory of relativity will be the superluminal theory of relativity. With the aid of superluminal observation media and superluminal theory of relativity, we will *see* a more real physical world.

9 Logical deduction of OR theory

WANG's Comment: "*Prof. Ruan proposed a 'generalized Lorentz transformation' and 'Observational Relativity', the thread of thinking, logic and structure of which are basically the same as that of Einstein's special relativity, with almost the same results. The difference is that in 'Observational Relativity' the speed of light c in the relativistic factor is replaced by the speed of medium η. ···. Prof. Ruan's observational relativity has produced almost all products of Einstein's relativity.*"

RUAN's Response: Mr WANG implies that the theory of OR is nothing more than a copy of Einstein's logic way of special relativity: "with almost the same results".

Thank Mr WANG for giving the author an opportunity to further elaborate the theory of OR: the theory of OR follows an original logic way totally different from Einstein's special theory of relativity (see References [10] and [11]).

As emphasized at first the theory of OR is not artificial. It is the result of logical deduction and theoretical derivation and not intended by the author that, in the Lorentz transformation, the light speed c is substituted by the observation-medium speed η.

The author's original intention is just to give the photon a tiny bit of rest mass.

Many great physicists, including Schrodinger, de Broglie, and Feynman, made efforts to find the rest mass of the photon. Dialectics of nature plays an important role in my philosophical belief of science. According to the thought of dialectics of nature: the universe is the contradictory unity of spacetime and matter; while, spacetime is the contradictory unity of space and time, and matter is the contradictory unity of

mass and energy. I cannot imagine such a sort of material existence or physical reality that has only energy but no mass. The author firmly believes that the photon must possess its own rest mass!

Einstein's hypothesis of the invariance of light speed has two important inferences: 1) the speed of light is the ultimate speed of the universe; 2) the photon has no rest mass. According to the mass-speed relation $m = m_0/\sqrt{(1-v^2/c^2)}$ in Einstein's special theory of relativity, either the rest mass m_0 of the photon is zero, or the relativistic mass m of the photon is infinite. Einstein had chosen the former: to set the rest mass m_0 of the photon to zero.

In Einstein's relativity, the light speed c represents the ultimate speed of the universe. I thought that the speed of light might not be the ultimate speed of the universe; the real ultimate speed of the universe (temporarily denoted as κ) should be the speed as the matter-wave frequency approaches infinity. The matter-wave frequency of any matter particle (including the photon) is limited, and therefore, κ is inaccessible. This means that the light speed c should be smaller than κ: $c < \kappa$; even if it is a tiny bit smaller, the photon will have its own rest mass: $m_0 = m\sqrt{(1-c^2/\kappa^2)} \neq 0$, and any matter particle will have its own rest mass.

At thatmoment I thought that κ should be invariant and the real ultimate speed the universe; while, c is only an approximation of κ.

Following this line of thought, I started work on establishing an axiom system[10-11], in which the definition of time is the most basic logical prerequisite; a set of rules of wave-particle duality are employed to define the ultimate speed (κ) of the universe and link κ to the matter-wave frequency. Under this axiom system, I tried to deduce a relativistic model that could give the photon a tiny bit of rest mass. However, my logical deduction ran into difficulty: if κ was inaccessible, then the corresponding theoretical derivation could not go on. I had to give up the restriction on κ and allow it to be accessible. The problem seems to be back to the origin, and the photon is still massless.

So, I had to temporarily lay aside the rest-mass problem of the photon.

At this time, the established axiom system gave me an intuitive feeling that Einstein's special theory of relativity and de Broglie's theory of matter waves might be unified under this axiom system. I thought, even though we could not get the photon's rest mass, it is good to unify the two *partial theories* that Hawking referred to. This prompted me to continue to deduce the relativistic transformation of inertial spacetimes under the established axiom system.

My theoretical deduction needed a physical quantity with the explicit physical meaning: the speed (temporarily denoted as η) of the spacetime information of the observed object relative to the inertial observer. This involves two important questions: 1) who is the messenger to transmit the spacetime information of the observed object to the observer; 2) how fast is the observed information.

An interesting conclusion is drawn from the theoretical deduction: $\kappa = \eta$.

This means that, in fact, the so-called *ultimate speed* κ of the universe is just the speed η of the observation medium, and depends on the observation medium. I seem to understand why the Lorentz transformation and Einstein's relativity are connected with the speed of light: light plays the role of the observation medium in Einstein's relativity, so the speed of light appears to be invariant. This is the origin of the subtitle of *Observation and Relativity*.

At last, the theoretical system of OR has been established, which is much more than the author's expectation: the photon gets its own rest mass; the essence and root of relativistic effects of matter motion are revealed; the Galilean and Lorentz transformations are generalized and unified; Einstein's special theory of relativity and de Broglie's theory of matter waves are also generalized and unified. In particular, the theoretical system of OR will yet be extended to Einstein's general theory of relativity.

Itis worth noting that the theory of OR has its own exclusive logic way that is totally different the logic way of Einstein's relativity. *Observation and Relativity* is only a subchapter of the theoretical system of OR: the

dynamics of matter particles. For simplicity *Observation and Relativity* directly takes *the hypothesis of observational limit* as the logical premise of OR, and follows Einstein's logic way to deduce observation relativity. In fact, the hypothesis of observational limit is not a hypothesis: in References [10] and [11], it is OR's logical inference. This has been explained in *Observation and Relativity*. Mr WANG might have not paid much attention to References [10] and [11].

Einstein's special theory of relativity takes the hypothesis of the invariance of light speed as its basic prerequisite, and its logical deduction is in the negative direction: from effect to cause; so, special relativity makes us know only what but not why. The theory of OR takes the definition of time as its basic prerequisite, and its logical deduction is in the positive direction: from cause to effect; so, OR makes us know not only what but also why. There is still an important feature of the logical difference between the theory of OR and Einstein's special theory of relativity[10-11]: Einstein's deduction of the Lorentz transformation starts from the transformation of space; while, OR's deduction of the general Lorentz transformation starts from the transformation of time.

In particular, without the rules of wave-particle duality, the whole theoretical system of OR can still be derived by combining the definition of time and the principle of simplicity or by combining the definition of time and the principle of relativity (see References [10] and [11]). Perhaps, this is of great significance in methodology. Engels ever remarked: "Philosophy is the soul of all sciences." In a sense, principles represent people's philosophical beliefs. OR's logic way suggests that, based on the more basic logical prerequisites, the simplicity and symmetry of the physical world can naturally present in our physical theories or physical models. We cannot assert that proves the principle of simplicity and the principle of relativity, but that indeed strengthens our cognition or belief in the simplicity and symmetry of the physical world.

10 On writing style

WANG's Comment: "*Prof. Ruan uses more than a dozen acronyms Reading his article is like reading enigma. It is very difficult. …. In academic communication, the most important thing is to express and explain your ideas with the clearest language. It is more important when you are proposing a new theory.*"

RUAN's Response: Thank you Mr WANG for your advice. Due to limited space, and to avoid the repeated calls to those overlong phrases, *Observation and Relativity* employs too many acronyms.

I am sorry to bother readers and Mr WANG.

11 Conclusion

OR, i. e., is, observational relativity, is the product of logic and theory.

The theory of OR takes the definition of time as the most basic logical prerequisite. Its logic way is totally different from Einstein's logic way. However, OR has derived the general Lorentz transformation that possesses the exactly same form as the Lorentz transformation. In particular the general Lorentz transformation has unified and generalized the Galilean and Lorentz transformations: under Bohr's correspondence principle, it not only corresponds strictly with the Galilean transformation, but also strictly with the Lorentz transformation. Moreover, the theory of OR has generalized the wave-particle duality, unified Einstein's special theory of relativity and de Broglie's theory of matter waves, and uniformly derived Einstein's $E = mc^2$, Planck's $E = hf$, and de Broglie's $\lambda = h/p$. In the theoretical system of OR, the invariance of light speed is no longer a hypothesis, but a logical inference of OR, and a special case of the invariance of observation-medium speeds; $E = hf$ is also no longer a hypothesis, but the result of theoretical derivation.

It is the embodiment of its logical rationality and theoretical validity that a new theory can integrate, generalize, and unify old theories.

The author's statements of the theory of OR in References [1], [10] and [11] might not be very rigorous. However, the theoretical system of OR is logically self-consistent, and its conclusions conform to people's simple view of nature and their intuitive understanding of the physical world.

The theory of OR discovers that: there is no absolute ultimate speed in the universe; the speed of light is not real invariant and the photon is not really massless; the Galilean transformation and the Lorentz transformation are the products of different observation systems, and is strictly corresponding in OR; Einstein's theory of relativity and de Broglie's theory of matter waves can be unified in the identical theoretical system; all relativistic phenomena are observational effects, and all quantum effects are observational effects; objective simultaneity is absolute, and the theories of time travel and the like can be stopped; spacetime is not really curved, and the theories of wormholes and the like can be stopped; Heisenberg's uncertainty is only observational uncertainty, and as Einstein's remarked, God does not play dice with the universe; Planck's constant h is only a special case of the general matter-wave constant h_η: $hc = h_\eta \eta$.

It turns out that the real physical world is still the eternal universe and absolute spacetime described by Galileo and Newton.

The author sincerely welcomes and appreciates readers to critique or question the theory of OR. It is suggested that readers who critique or question the theory of OR contribute to *Journal of Beijing University of technology* or other academic journals formally and directly. Physics is the contradictory unity of speculative study and empirical study. As for as academic discussion in physics is concerned, the author is in favor of such a style of writing: speculative study is based on logic and theory; empirical study is based on observation and experiment.

The theory of OR is not a castle in the air. The author believes that the theory of OR can stand up to logical and theoretical scrutiny, and can stand up to observational and experimental test. Physicists may become enlightened and have new insights and discoveries, if they observe the physical world from the perspective of OR with a positive mentality.

Time will tell and history will judge OR.

Acknowledgements

The author sincerely thanks Mr WANG Lingjuan again for his critiques and comments on the theory of OR. Meanwhile, the author is grateful to the editorial staff of *Journal of Beijing University of Technology* for their great efforts in publishing *Observation and Relativity* and promoting the academic discussion of the theory of OR. As Mr WANG said in his comment: “It is commendable”.

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5 A suggestion about the writing style

Prof. Ruan uses more than a dozen acronyms (ILS, POL, HOL, IOMS, GLT, OR, LT, GT, LPW, OI, STI, WPD, OPW, PPL, TD, LC and etc.) Reading his article is like reading enigma. It is very difficult. I have translated almost all acronyms back into original Chinese when quoting Prof. Ruan to make it easier for the readers. It seems to have become a fashion lately in academic community to invent all kinds of acronyms. Chinese language is highly expressive and powerful. It is better to use as much Chinese as possible. If there is no adequate Chinese word to express the meaning of certain terminology, the English words need to be spelled out. The acronyms may be used for communication after your theory has been widely accepted by academic community. Relativity has been prevalent for over a hundred years, becoming the Bible of mainstream physics community, but many terminologies in relativity are still not replaced with acronyms. In academic communication, the most important thing is to express and explain your ideas with the clearest language. It is more important when you are proposing a new theory.

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