

WHAT IS RELATIVITY?

什么是相对论?

$$E=mc^2$$

L.D. Landau and Y.B. Rumer

科普英语注释读物

What Is Relativity?

# 什么是相对论?

L. D. Landau and Y. B. Rumer

Translated into English by

N. Kemmer

曹丽顺 杨枕旦 合译

曹丽顺 注释

商务印书馆

1982年·北京

L. D. Landau and Y. B. Rumer  
WHAT IS RELATIVITY?  
Translated by  
N. Kemmer  
OLIVER AND BOYD

科普英语注释读物  
**什么是相对论?**  
〔苏〕兰道 卢默尔 原著  
曹丽顺 杨枕旦 译注

---

商 务 印 书 馆 出 版  
(北京王府井大街 36 号)

新华书店北京发行所发行  
北京第二新华印刷厂印刷

统一书号: 9017 · 1153

---

1982 年 5 月第 1 版	开本 787×1092 1/32
1982 年 8 月北京第 1 次印刷	字数 156 千
印数 0—8,000 册	印张 5 5/8

定价: 0.63 元

“... it is nevertheless beyond question that<sup>1</sup> traditional mechanics<sup>2</sup> was a copy<sup>3</sup> of real motions of moderate velocity, while<sup>4</sup> the new physics<sup>5</sup> is a copy of real motions of enormous velocity.”<sup>6</sup>

“The mutability of human conceptions of space and time no more refutes the objective reality of space and time than<sup>7</sup> the mutability of scientific knowledge of the structure and forms of matter in motion refutes the objective reality of the external world.”<sup>8</sup>


V. I. LENIN

---

1. **it is ... that...**: **it** 为形式主语; 真正主语是 **that** 引导的从句。主句中的 **beyond question** 是表语, 作“毫无疑问, 不容置疑”解。 2. **traditional mechanics**: 传统力学。也称牛顿力学或经典力学。 3. **copy**: *n.* 摹本; 复制品。 4. **while**: 此处是并列连词, 表示“对照”关系, 作“而”解。 5. **new physics**: 新物理学。也称 **modern physics** (现代物理学)。 6. 这句引语的中译文, 见人民出版社 1957 年版《列宁全集》第 14 卷第 280 页(《唯物主义和经验批判主义》第 5 章)。 7. **no more ... than**: 同...一样不...; 并不比...更...。 8. 这句引语的中译文, 见上书第 179 页(同篇文章第 3 章)。

“…力学是缓慢的实在运动的模写，新物理学是极迅速的实在运动的模写，毕竟还是不容置疑的。”

“正如关于物质的构造和运动形式的科学知识的可变性并没有推翻外部世界的客观实在性一样，人类的时空观念的可变性也没有推翻空间和时间的客观实在性。”



弗·伊·列宁

More than fifty years have passed since Einstein proposed the principle of relativity. His theory, which had seemed a mere freak of mind<sup>1</sup> to many,<sup>2</sup> is now the cornerstone of physics. Modern physics cannot exist without<sup>3</sup> the special theory of relativity just as it cannot exist without the concept of molecules and atoms. An immense number of physical phenomena would never be explained without the theory of relativity. Particle accelerators and calculations of nuclear reactions are based on it.<sup>4</sup>

Regrettably, however, the theory of relativity is little known<sup>5</sup> beyond a narrow circle of specialists. The theory is a “tough”<sup>6</sup> one, that is true,<sup>7</sup> and a stranger in physics will find it difficult to grasp its essentials.<sup>8</sup>

We hope that we have managed to present to the casual<sup>9</sup> reader the fundamentals of the theory of relativity in a clear and simple enough manner, and that the reader will not think that the theory of relativity contends that “everything in the world is relative”. On the contrary,<sup>10</sup> he is sure to realise that the theory of relativity, like any other correct physical theory, is a teaching about the objective truth independent of<sup>11</sup> any-

---

1. **freak of mind**: 痴心妄想; 异想天开。 2. **many**: *pron.* 许多人。 3. **cannot exist without ...**: 没有...就不能存在; 非有...不可。这是一种双重否定结构。 4. **are based on it**: 以之为基础; 把它作为根据。 5. **little known**: 不大为人所知; 很少有人熟悉。little 此处是副词。 6. **“tough”**: 难度极大的; “咀嚼不烂”的。 7. **that is true**: 那是对的; 固然不错。这是插入语。 8. **find it difficult to grasp its essentials**: 对抓住它的要点感到困难。it 是形式宾语, 后面的不定式短语才是真正的宾语。 9. **casual**: 偶一为之的; 随便浏览的。 10. **On the contrary**: 恰恰相反; 反之。 11. **independent of ...**: 不受...影响的; 不以...为转移的。修饰 truth.

one's wishes and tastes. Having shed<sup>1</sup> the old concepts of space, time and mass, we have gained a still deeper insight into the true nature of the world.

## AUTHORS

---

1. **Having shed...**: 在已经摆脱了…之后。这是现在分词的完成形式，整个分词短语在句中作状语，这项动作的主体就是句子的主语。

自从爱因斯坦提出相对性原理以来,已经五十多年了。他的学说,按从前许多人的看法,似乎只不过是想入非非,而现在却成为物理学的基石。没有狭义相对论就没有现代物理学,正象现代物理学不能没有分子和原子概念一样。没有相对论,大量的物理现象是无法解释的。粒子加速器和核反应的计算都要以它为基础。

然而,令人遗憾的是,在专家们的狭小圈子以外,很少有人懂得相对论。诚然,这种理论是“艰深”的,物理学的门外汉是很难掌握它的要义的。

对于偶一涉猎这门学问的读者,我们希望已经做到了用简明方式提供相对论的基本概念,并且希望读者不要以为相对论是坚持“世界上一切都是相对的”。恰恰相反,他一定能体会到,相对论同其他任何正确的物理学说一样,是阐述客观真理的,而客观真理是不以任何人的意志和兴趣为转移的。在摆脱了时、空、物质的旧概念之后,我们对整个世界的真正本质也就获得了更深刻的认识。

作 者



# CONTENTS

1	FAMILIAR EXAMPLES OF RELATIVITY .....	1
	Does every Statement have a Meaning? .....	1
	Right and Left .....	1
	Is it Day or Night just now? .....	3
	Who is bigger? .....	3
	The Relative seems Absolute .....	4
	The Absolute proves to be Relative .....	6
	“Common Sense” tries to protest .....	8
2	SPACE IS RELATIVE .....	9
	The same Place or not? .....	9
	How does a Body move in Reality? .....	12
	Are all Points of View equivalent? .....	13
	Rest is found! .....	15
	The Laboratory at Rest .....	16
	Is the Train moving? .....	16
	Rest is lost for good .....	19
	The Law of Inertia .....	21
	Speeds too are relative! .....	23
3	THE TRAGEDY OF LIGHT .....	23
	Light does not spread instantaneously .....	23
	Can the Speed of Light be altered? .....	24
	Light and Sound .....	25
	The Principle of Relativity of Motion seems	
	to be shaken .....	26
	“World Ether” .....	29

A difficult Situation arises .....	31
Experiment must decide .....	32
The Principle of Relativity triumphs .....	34
Out of the Frying Pan into the Fire .....	35
4 TIME PROVES TO BE RELATIVE .....	37
Is there in Fact a Contradiction? .....	37
We go on a Train Journey .....	39
“Common Sense” in Disgrace .....	40
Time suffers the same Fate as Space .....	43
Science Triumphs .....	46
Speed has a Limit .....	47
Earlier and Later .....	50
5 CLOCKS AND RULERS PLAY TRICKS .....	52
We get on the Train again .....	52
Clocks go slow systematically .....	56
The Time Machine .....	58
Journey to a Star .....	61
Objects get shortened .....	64
Velocities play Tricks .....	68
6 WORK CHANGES MASS .....	72
Mass.....	72
Mass increases .....	73
How much does a Gram of Light cost? .....	76
SUMMING UP .....	78
APPENDIX: The Year of Dr. Einstein .....	83
参考译文 .....	116—170
译注后记 .....	171

# Chapter 1

## FAMILIAR EXAMPLES OF RELATIVITY

### Does every Statement have a Meaning?

Evidently not.<sup>1</sup> Even if you choose perfectly sensible words and put them together according to all the rules of grammar you may still get complete nonsense. For instance,<sup>2</sup> the statement “This water is triangular”<sup>3</sup> can hardly be given any meaning.

Unfortunately, however, not all examples of nonsense are so obvious and it often happens that a statement appears perfectly sensible at first sight<sup>4</sup> but proves to be absurd on closer examination.<sup>5</sup>

### Right and Left

On which side<sup>6</sup> of the road is the house — on the right<sup>7</sup> or on the left? It is impossible to answer this question directly.

If you are walking from the bridge to the wood, the house will be on the left-hand side,<sup>8</sup> but if you go from the wood to

---

1. **Evidently not:** 显然不是。这个省略句用来答复上面的问话,它把整个问句都省略了。凡是笼统地否定对方的问话,而又要强调语气时,往往可以用 **adv. + not** 这种句型,如 **certainly not**, **absolutely not**, **of course not** 等等。 2. **For instance:** 例如 (=for example)。 3. **triangular:** 三角形的。tri- 这个前缀是“三”的意思。 4. **at first sight:** 一眼看来;乍看之下。 5. **on closer examination:** 仔细一想;经过一番琢磨。on 在这里指时间,有“一经...,立即...”的意思。 6. **On which side:** 在哪一边。on 在这里作“接近,靠着”解。which 在问句里含有选择的意思。 7. **right:** 右方。right 在这里是名词。后面跟的 left 也是名词。 8. **on the left-hand side:** 在左手方;在左边。下句中的 right-(=right-hand)也是这个情况。



Fig. 1

the bridge you find the house on the right. Clearly to speak of<sup>1</sup> the right- or left-hand side of the road, you must take into account<sup>2</sup> the direction relative to<sup>3</sup> which right or left is indicated.

It does make sense<sup>4</sup> to speak of the right bank of a river, but only because<sup>5</sup> the current determines the direction of the river. Likewise we can only say that cars keep to the right<sup>6</sup> because the movement of a car singles out<sup>7</sup> one of the two possible directions along the road.

---

1. **to speak of...**: 说起...; 谈及...。这是独立结构的一种形式, 起状语作用, 它本身被 **clearly** 所修饰。 2. **take into account...**: 顾到...; 考虑到... (=take account of...). **direction** 是 **take** 的宾语。 3. **relative to...**: 相对于...; 关于...; 以...为准。这个形容词短语后面的整个从句修饰 **direction**。 4. **It does make sense**: 这话确实有意义; 这话肯定讲得通。does 在句中起加强语气作用。 5. **but only because ...**: 但是只因为...。only 是副词, 修饰连词 **because**, **but** 后可以补充 **it makes sense** 或 **it is so**。 6. **keep to the right**: (车辆) 总是靠右边行驶。 7. **singles out**: 选定; 挑出, 找出。这里 **single** 是动词。

We see that the notions “Right” and “Left” are relative: They only acquire meaning<sup>1</sup> after the direction relative to which they are defined<sup>2</sup> has been indicated.

### Is it Day or Night just now?

The answer depends on<sup>3</sup> where the question is being asked. When it is daytime in Moscow it is night in Vladivostok.<sup>4</sup> There is no contradiction in this. The simple fact is that day and night are relative notions and our question cannot be answered without<sup>5</sup> indicating the point on the globe<sup>6</sup> relative to which the question is being asked.

### Who is bigger?

In Fig. 2 the shepherd is obviously bigger than the cow, in Fig. 3 the cow is bigger than the shepherd. Again there is no contradiction. The reason is that the two drawings have been made by people observing from different points: One of them stood closer to<sup>7</sup> the cow, the other closer to the shepherd. The picture is determined not by the actual sizes of the objects but by the angles under which they are seen.<sup>8</sup> Evidently such

---

1. **acquire meaning:** = make sense.    2. **defined:** 明确(意义); 解释清楚。relative to which they are defined 是以 after 引导的状语从句中的一个定语从句, 修饰 direction.    3. **depends on...:** 视...而定; 取决于...。on 后面的 where 是连接副词, 起连词作用, 引进一个名词从句, 作为 on 的宾语。  
4. **Vladivostok** [v.lædi'vɒstɒk]: 符拉迪沃斯托克。原名海参崴, 系我国于 1860 年割让给沙俄的, 俄文词的意思是“控制东方”。它现在是苏联东方太平洋岸的一个港口。    5. **our question cannot be answered without...:** 除非..., 问题就得不到解答。这是双重否定语气。    6. **globe:** 地球。原义是球, 指“地球”时, 要带定冠词 the。    7. **stood closer to...:** 站的位置靠近...。这里 stood = was situated, close to 本是形容词短语, 但用于“近”的意义时, close 往往作副词用。下面第二个 closer 之前省略了 stood。    8. **angles under which they are seen:** 用以观察它们的角度。这里 angles = visual or optical angles.

angular dimensions of objects<sup>1</sup> are relative. It makes no sense to speak of the angular dimensions of objects without indicating the point in space from which they are observed.<sup>2</sup> For instance, to say: This tower is seen under an angle of  $45^\circ$  is to say precisely nothing.<sup>3</sup> But the statement that the tower is seen under an angle of  $45^\circ$  from a point 15 metres away has a definite meaning; from this you can conclude that the tower is 15 metres high.



Fig. 2

### The Relative seems Absolute

If the point of observation is moved a small distance<sup>4</sup>, angular dimensions also change only by a small amount. That is why

**1. angular dimensions of objects:** 物体的视角大小。 **2. without indicating the point in space from which they are observed:** 而没有指明从空间哪一点来观察它们。indicating 是动名词, 用作 without 的宾语, 它本身又以 point 为宾语。they 代替 objects。 **3. to say: This tower is seen under an angle of  $45^\circ$  is to say precisely nothing:** 说观察这个塔的视角是  $45^\circ$  度, 那和没说一样; 光说从  $45^\circ$  度的角度来看这个塔, 就等于白说。第一个 to say 是不定式用作主语, this tower ...  $45^\circ$  是它的宾语从句。第二个 to say 用作表语, 代词 nothing 是它的宾语。 $45^\circ$  读作 forty-five degrees。 **4. a small distance:** 短距离。这是个名词短语, 在句中作状语用。

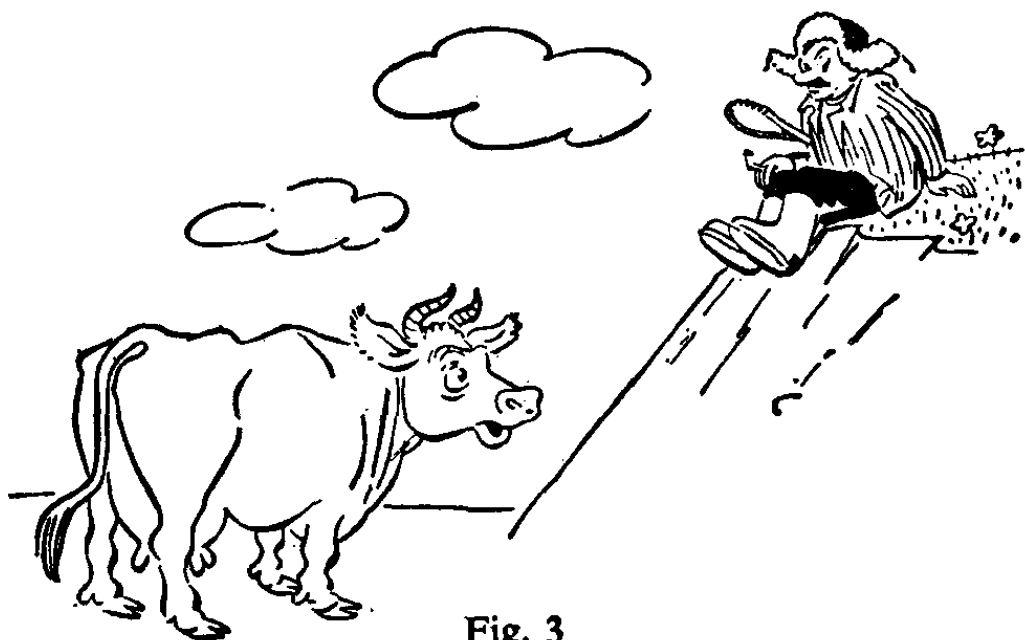


Fig. 3

angular distances are often used in astronomy. A star map<sup>1</sup> usually gives the angular distance between stars, i. e.,<sup>2</sup> the angle under which the distance between the two stars is observed from the surface of the earth.

We know that however much<sup>3</sup> we move about<sup>4</sup> on the Earth and whatever points<sup>5</sup> on the globe we choose to observe from, we always see the stars in the sky at the same distances from each other. This is because<sup>6</sup> the stars are such unimaginably large distances away from us that,<sup>7</sup> in comparison,<sup>8</sup> our movements on the Earth are negligible and can safely<sup>9</sup> be forgotten. In this particular case<sup>10</sup> we can therefore use angular distances as

1. star map: 星图。 2. i. e. ['ai'i:]: 就是说; 即。这是拉丁语 *id est* 的缩写, = *that is*. 3. however much: 无论有好多。这里 *however* 是副词, 引导让步状语从句, 常连所修饰的词一起放在句首。 4. move about: 行动; 往来。这里 *about* 是副词。 5. whatever points: 任何地点。points 是 *choose* 的宾语。whatever 用作形容词时, 是 *what* 的强势式, 往往和所形容的名词一起放在句首。 6. This is because...: 这是由于...。because 引导的是表语从句。 7. such...that...: 这样的...以致...。这是相关连词。such 是形容词, that 引导结果状语从句。 8. in comparison: 比较起来; 相形之下。这是插入语。 9. safely: 不成问题地; 万无一失地。 10. In this particular case: 在这个特定的例子中。

absolute measures of distance.

If we make use of<sup>1</sup> the Earth's motion round the Sun it becomes possible to observe changes in angular distances between stars even although<sup>2</sup> these changes are <sup>极小的</sup>very small. But if we were to<sup>3</sup> move our point of observation to some<sup>4</sup> other star such as Sirius, all angular distances would change so much that<sup>5</sup> stars far apart in our sky might then be close together, and vice versa.<sup>6</sup>

### The Absolute proves to be Relative

We often use the words up and down.<sup>7</sup> Are these notions

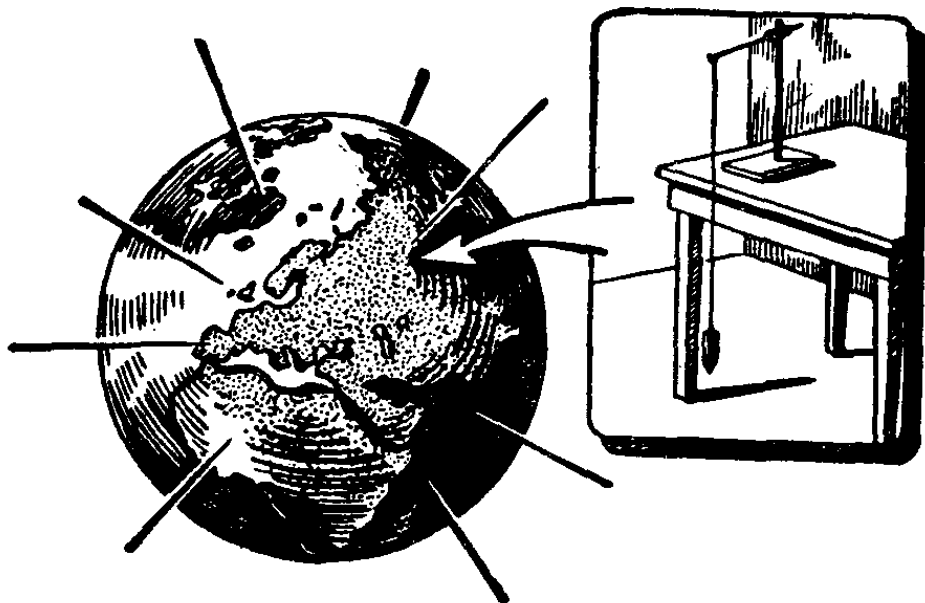


Fig. 4

---

1. make use of...: 应用...; 使用...。 2. even although: 即使。通常用 even though, = even if. 3. if we were to...: 假如我们要...。在虚拟语气中, 用过去时代替现在时, 指不能实现的假设。 4. some: 某一。some 在修饰可数名词单数时, 常表示某种不肯定的概念。 5. so...that...: 这样地...以致...。这是相关连词。so 是副词, that 引导结果状语从句。比较上页注 7。 6. vice versa ['vaisi 'vɜ:sə]: [拉丁语] 反过来说也是一样。意即: 在地球上看来相近的星, 在天狼星上看来却相离很远。 7. the words up and down: 上和下这两个词。up 和 down 是 words 的同位语。



absolute or relative?

At different times in history the answers given to this question have differed. As long as<sup>1</sup> people didn't know that the Earth is a sphere and thought that it was flat like a pancake,<sup>2</sup> the vertical was taken to be an absolute direction. It was taken for granted<sup>3</sup> that this vertical direction is the same at all points on the Earth's surface,<sup>4</sup> making it perfectly natural to speak of an absolute "up"<sup>5</sup> and an absolute "down".

When it was proved that the Earth is a sphere the vertical began to totter — in people's minds.<sup>6</sup>

Indeed, if the Earth is a sphere, the direction of the vertical depends decisively on where on the Earth's surface the vertical is drawn.

Different points on the Earth will have different verticals. The notions up and down now cease to have meaning unless the point on the Earth's surface to which they refer is defined. Thus these notions change from absolute to relative ones.<sup>7</sup> There is no unique vertical direction in the universe. Therefore, given any direction in space,<sup>8</sup> we can find a point on the Earth's surface at which this direction is the vertical.

---

1. As long as...: 只要...。这个短语在这里作连词用, = provided that.  
2. flat like a pancake: 象烙饼那样扁平。like 这里是介词。 3. taken for granted: [惯用语] 被看成是; 被认为理所当然。 4. Earth's surface: 地面。Earth 第一个字母大写是人格化。即使不大写, 也一样可以加 's, 成为所有格, 乃是习惯用法。 5. absolute "up": 绝对的“上”。up 用引号, 表示实际上并没有所谓绝对的“上”。下面的“down”意思相同。 6. in people's minds: 在人们的心中。这个介词短语放在破折号后面, 表示前面的话说出后, 又觉意犹未尽, 而加以补充或解释。口语中常有这种情况。 7. ones: 是代词 one 的复数, 这里用来代替 notions。 8. given any direction in space: 在空间指定任何一个方向。这个分词短语, 形式上限制主语 we, 意义上修饰谓语 can find; 过去分词 given 含有被动意义, 但仍保留其直接宾语 direction。