

科技英語注釋讀物③

What Is Relativity?

什麼是相對論？

L. D. Landau and Y. B. Rumer

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出版說明

相對論是同愛因斯坦的名字分不開的。1879年他生於德國一個猶太人家庭，早年即以創立相對論知名，在其他方面也有卓越的貢獻，曾獲得諾貝爾獎。第二次世界大戰前夕，由於受到德國納粹分子的迫害，他移居美國，繼續進行研究工作，於1955年逝世。1979年是他誕生一百周年，離他去時也有四分之一世紀了。他不但未被遺忘，而且在世界各國掀起了紀念他的熱潮，被譽為相對論之父、二十世紀的牛頓、當代最偉大的物理學家等等。

愛因斯坦一生對科學最大的貢獻就是相對論。他於1905年，在相對性原理和光速不變的原則下，提出了狹義相對論，是用於研究物體均速直線運動的。牛頓力學只能說明低速運動的現象，而狹義相對論則是研究高速，包括接近光速的運動在內的規律。為了解答變速和宇宙間其他運動的方式，愛因斯坦又經過十年的辛勤探索，建立了廣義相對論，揭示了四維時空與物質的關係。總之，相對論是關於物質運動和時空關係的學說。它統一了時間和空間、空間和物質、質量和能量的概念。

狹義相對論所提出的原理和推論，都已得到了驗證，而成為現代物理學的基石之一，為物理學開闢了新紀元。它的應用範圍很廣，最突出的就在原子科學方面。廣義相對論由於歷史條件的限制，要加以驗證就更不容易了。可是物理學家一直在實驗室裏孜孜不倦地繼續堅持這項工作，而且是富有成果的。根據廣義相對論而提出的引力波問題，於1978年第一次得到定量的間接證明。在天文學方面，廣義相對論的應用已經遠遠超出太陽系的範圍。因此，有人認為七十年代才是精確驗證相對論的時代。不難推斷，這方面的工作將會

陸續開拓出新的前景。

相對論是一門高深的學問，據說初提出來時，全世界只有幾個人能理解它。要把它寫成一本深入淺出的通俗讀物不是件輕而易舉的事。本書作者為蘇俄兩位物理學家。其中的一位名蘭道，是著名的理論物理學家，1962年諾貝爾物理學獎獲得者，已因車禍去世。原著係俄文，在蘇俄和英國分別譯成英文出版。美國曾在《科學的美國人》(Scientific American)期刊的書評欄中，對本書予以“言簡意賅，妙語解頤”(brief, witty and never superficial)的評語，許為成功之作①。這個注釋本採用的是英國譯本，由奧利弗—博伊德公司(Oliver & Boyd, Ltd.)出版。在相對論的通俗讀物中，本書不失為佼佼者。對於某些有爭議的論點，不妨視為一家之言，可由實驗作出判斷。

愛因斯坦誕生一百周年，許多國家都紛紛舉行集會和各種活動來紀念他，極一時之盛。美國《時代》周刊1979年2月19日一期就有《愛因斯坦年》一文，茲一併加以譯注，作為附錄。此文可說是一篇愛因斯坦小傳。除了概述他的論文和學說，並以此為基礎而發展起來的原子科學、太空學、雷射、量子力學等以外，還對他的潛心科研、不慕榮利、反抗強權、呼籲和平、思想先進、生活簡樸等高尚品德都有所提及，旁徵博引，繪聲繪色，使讀者於披覽之餘，想見其為人，油然而生敬仰之心。至於他後半生所致力而未能完成的統一場論，隨著科學的進步，時間的考驗，又閃出了光芒，受到了重視。所以《時代》周刊那一期的封面總標題為《重新發現愛因斯坦》，這正表明了人們對他經久不衰的懷念。

本書的出版在提供理工科學生和科技人員學習英語之用除翻譯原文外，並詳加注釋，以便自修中參考。

編輯部 1985年10月

Authors' Note

More than fifty years have passed since Einstein proposed the principle of relativity. His theory, which had seemed a mere freak of mind¹ to many,² is now the cornerstone of physics. Modern physics cannot exist without³ 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.⁴

Regrettably, however, the theory of relativity is little known⁵ beyond a narrow circle of specialists. The theory is a "tough"⁶ one, that is true,⁷ and a stranger in physics will find it difficult to grasp its essentials.⁸

We hope that we have managed to present to the casual⁹ 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,¹⁰ he is sure to realise that the theory of relativity, like any other correct physical theory, is a teaching about the objective truth independent of¹¹ anyone's wishes and tastes. Having shed¹² the old concepts of space, time and mass, we have gained a still deeper insight into the true nature of the world.

AUTHORS

1. **freak of mind**: 痴心妄想; 異想天開。 2. **many**: *pron.* 許多人。
3. **cannot exist without ...**: 沒有...就不能存在; 非有...不可。這是一種雙重否定結構。 4. **are based on it**: 以之為基礎; 把它作為根據。 5. **little known**: 不大為人所知; 很少有人熟悉。**little** 此處是副詞。 6. **"tough"**: 難度極大的; "咀嚼不爛"的。 7. **that is true**: 那是對的; 固然不錯。這是插入語。 8. **find it difficult to grasp its essentials**: 對抓住它的要點感到困難。**it** 是形式賓語, 後面的不定式短語才是真正的賓語。 9. **casual**: 偶--為之的; 隨便瀏覽的。 10. **On the contrary**: 恰恰相反; 反之。 11. **independent of ...**: 不受影響的; 不以...為轉移的。修飾 **truth**。 12. **Having shed ...**: 在已經擺脫了...之後。這是現在分詞的完成形式, 整個分詞短語在句中作狀語, 這項動作的主體就是句子的主語。

作者序

自從愛因斯坦提出相對性原理以來，已經五十多年了。他的學說，按從前許多人的看法，似乎只不過是想入非非，而現在却成為物理學的基石。沒有狹義相對論就沒有現代物理學，正像現代物理學不能沒有分子和原子概念一樣。沒有相對論，大量的物理現象是無法解釋的。粒子加速器和核反應的計算都要以它為基礎。

然而，令人遺憾的是，在專家們的狹小圈子以外，很少有人懂得相對論。誠然，這種理論是“艱深”的，物理學的門外漢是很難掌握它的要義的。

對於偶一涉獵這門學問的讀者，我們希望已經做到了用簡明方式提供相對論的基本概念，並且希望讀者不要以為相對論是堅持“世界上一切都是相對的”。恰恰相反，他一定能體會到，相對論同其他任何正確的物理學說一樣，是闡述客觀真理的，而客觀真理是不以任何人的意志和興趣為轉移的。在擺脫了時、空、物質的舊概念之後，我們對整個世界的真正本質也就獲得了更深刻的認識。

作者

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Chapter 1

FAMILIAR EXAMPLES OF RELATIVITY

Does every Statement have a Meaning?

Evidently not.¹ 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,² the statement "This water is triangular"³ 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 sight⁴ but proves to be absurd on closer examination.⁵

Right and Left

On which side⁶ of the road is the house — on the right? 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,⁷ but if you go from the wood to

1. **Evidently not:** 顯然不是。這個省略句用來答覆上面的問話，它把整個問句都省略了。凡是籠統地否定對方的問話，而又要強調語氣時，往往可以用 **adv. + not** 這種句型，如 **certainly not, absolutely not, of course not** 等等。
2. **For instance:** 例如 (=for example)。
3. **triangular:** 三角形的。tri- 這個前綴是“三”的意思。
4. **at first sight:** 一眼看來，乍看之下。
5. **on closer examination:** 仔細一想，經過一番琢磨。on 在這裏指時間，有“一經...，立即...”的意思。
6. **On which side:** 在哪一邊。on 在這裏作“接近，靠著”解。which 在問句裏含有選擇的意思。
7. **right:** 右方。right 在這裏是名詞。後面跟的 left 也是名詞。
8. **on the left-hand side:** 在左手方，在左邊。下句中的 right-(=right-hand) 也是這個情況。

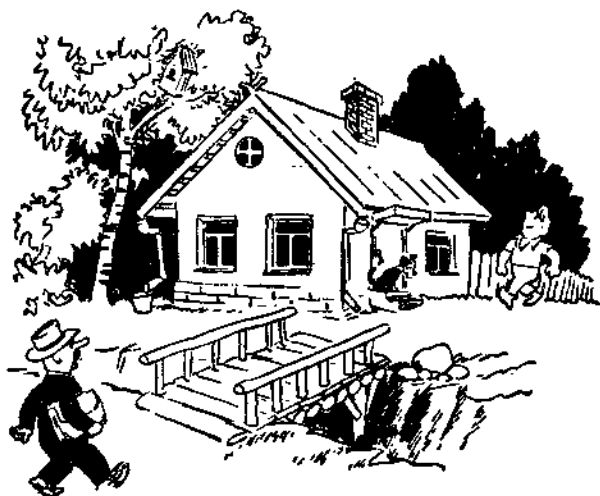


Fig. 1

the bridge you find the house on the right. Clearly to speak of¹ the right- or left-hand side of the road, you must take into account² the direction relative to³ which right or left is indicated.

It does make sense⁴ to speak of the right bank of a river, but only because⁵ the current determines the direction of the river. Likewise we can only say that cars keep to the right⁶ because the movement of a car singles out⁷ one of the two possible directions along the road.

1. to speak of...: 說起...; 談及...。這是獨立結構的一種形式, 起狀語作用, 它本身被 clearly 所修飾。 2. take into account...: 顧到...; 考慮到... (=take account of...), direction 是 take 的賓語。 3. relative to...: 相對於...; 關於...; 以...為準。這個形容詞後面短語的整個從句修飾 direction。 4. It does make sense: 這話確實有意義; 這話肯定講得通。does 在句中起加強語氣作用。 5. but only because...: 但是只因爲...。only 是副詞, 修飾連詞 because, but 後可以補充 it makes sense 或 it is so。 6. Keep to the right: (車輛)總是靠右邊行駛。 7. singles out: 選定; 挑出, 找出。這裏 single 是動詞。

We see that the notions "Right" and "Left" are relative.² They only acquire meaning¹ after the direction relative to which they are defined³ has been indicated.

Is it Day or Night just now?

The answer depends on⁴ where the question is being asked. When it is daytime in Moscow it is night in Vladivostok.⁴ There is no contradiction in this. The simple fact is that day and night are relative notions and our question cannot be answered without⁵ indicating the point on the globe⁶ 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 to⁷ 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.⁸ Evidently such

1. acquire meaning: = make sense. 2. defined: 明確(意義), 解釋清楚。relative to which they are defined 是以 after 引導的狀語從句中的一個定語從句, 修飾 direction. 3. depends on...: 視...而定, 取決於...。on 後面的 where 是連接副詞, 起連詞作用, 引進一個名詞從句, 作為 on 的賓語。4. Vladivostok [vɫædɪ'vɔstɔk]: 符拉迪沃斯托克。原名海參崴, 係我國於 1860 年割讓給沙俄的, 俄文詞的意思是“控制東方”。它現在是蘇聯東方太平洋岸的一個港口。5. our question cannot be answered without...: 除非..., 問題就得不到解答。這是雙重否定語氣。6. globe: 地球。原義是球, 指“地球”時, 要帶定冠詞 the. 7. stood closer to...: 站的位置靠近...。這裏 stood = was situated, close to 本是形容詞短語, 但用於“近”的意義時, close 往往作副詞用。下面第二個 closer 之前省略了 stood. 8. angles under which they are seen: 用以觀察它們的角度。這裏 angles = visual or optical angles.

angular dimensions of objects¹ 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.² For instance, to say: This tower is seen under an angle of 45° is to say precisely nothing.³ But the statement that the tower is seen under an angle of 45° 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 distance⁴, angular dimensions also change only by a small amount. That is why

1. angular dimensions of objects: 物體的視角大小。 2. without indicating the point in space from which they are observed: 而沒有指明從空間哪一點來觀察它們。indicating 是動名詞, 用作 without 的賓語, 它本身又以 point 為賓語, they 代替 objects。 3. to say: This tower is seen under an angle of 45° is to say precisely nothing: 說觀察這個塔的視角是 45° 度, 那和沒說一樣; 光說從 45° 度的角度來看這個塔, 就等於白說。第一個 to say 是不定式用作主語, this tower ... 45° 是它的賓語從句。第二個 to say 用作表語, 代詞 nothing 是它的賓語。 45° 讀作 forty-five degrees。 4. a small distance: 短距離。這是個名詞短語, 在句中作狀語用。

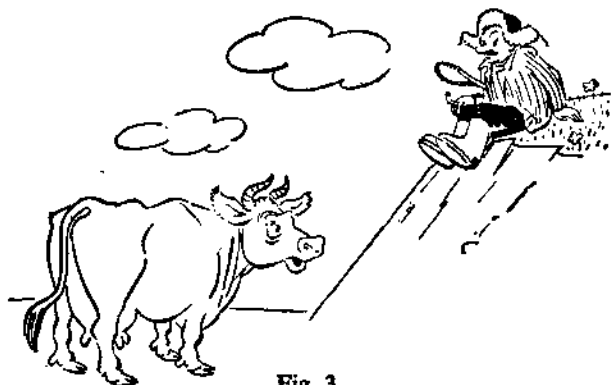


Fig. 3

angular distances are often used in astronomy. A star map¹ usually gives the angular distance between stars, i. e.,² the angle under which the distance between the two stars is observed from the surface of the earth.

We know that however much³ we move about⁴ on the Earth and whatever points⁵ 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 because⁶ the stars are such unimaginably large distances away from us that,⁷ in comparison,⁸ our movements on the Earth are negligible and can safely⁹ be forgotten. In this particular case¹⁰ we can therefore use angular distances as

1. star map: 星圖。 2. i. e. ['ai'i:]: 就是說; 即。這是拉丁語 *id est* 的縮寫, = that is. 3. however much: 無論有好多。這裏 *however* 是副詞, 引導讓步狀語從句, 常連所修飾的詞一起放在句首。 4. move about: 行動; 往來。這裏 *about* 是副詞。 5. whatever points: 任何地點。points 是 *choose* 的賓語。whatever 用作形容詞時, 是 *what* 的強勢式, 往往和所形容的名詞一起放在句首。 6. This is because...: 這是由於...。because 引導的是表語從句。 7. such...that...: 這樣的...以致...。這是相關連詞。such 是形容詞。that 引導結果狀語從句。 8. in comparison: 比較起來; 相形之下。這是插入語。 9. safely: 不成問題地; 萬無一失地。 10. In this particular case: 在這個特定的例子中。

absolute measures of distance.

If we make use of¹ the Earth's motion round the Sun it becomes possible to observe changes in angular distances between stars even although² these changes are very small. But if we were to³ move our point of observation to some⁴ other star such as Sirius, all angular distances would change so much that⁵ stars far apart in our sky might then be close together, and vice versa.⁶

The Absolute proves to be Relative

We often use the words up and down.⁷ Are these notions

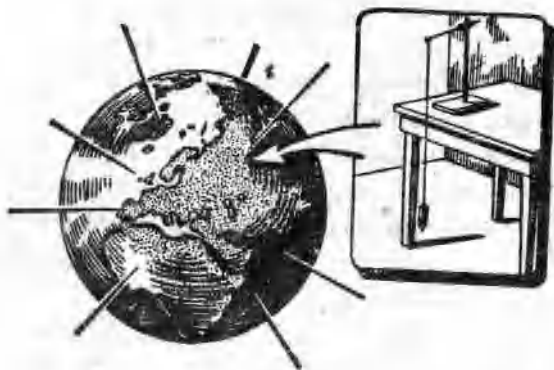


Fig. 4

1. make use of...: 應用...; 使用...。 2. even although: 即使。通常用 even though, = even if. 3. if we were to...: 假如我們要...。在虛擬語氣中, 用過去時代替現代時, 指不能實現的假設。 4. some: 某...。some 在修飾可數名詞單數時, 常表示某種不肯定的概念。 5. so...that...: 這樣地...以致...。這是相關連詞。so 是副詞, that 引導結果狀語從句。比較上頁注 7。 6. vice versa ['vaisi 'vɜ:sə]: (拉丁語) 反過來說也是一樣。意即: 在地球上看來相近的星, 在天狼星上看來却相離很遠。 7. the words up and down: 上和下這兩個詞。up 和 down 是 words 的同位語。

absolute or relative?

At different times in history the answers given to this question have differed. As long as¹ people didn't know that the Earth is a sphere and thought that it was flat like a pancake,² the vertical was taken to be an absolute direction. It was taken for granted³ that this vertical direction is the same at all points on the Earth's surface,⁴ making it perfectly natural to speak of an absolute "up"⁵ and an absolute "down".

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

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.⁷ There is no unique vertical direction in the universe. Therefore, given any direction in space,⁸ we can find a point on the Earth's surface at which this direction is the vertical.

1. **As long as...**: 只要...。這個短語在這裏作連詞用, = *provided that*.
 2. **flat like a pancake**: 像烙餅那樣扁平。*like* 這裏是介詞。
 3. **taken for granted**: [慣用語] 被看成是; 被認為理所當然。
 4. **Earth's surface**: 地面。*Earth* 第一個字母大寫是人格化。即使不大寫, 也一樣可以加 's, 成為所有格, 乃是習慣用法。
 5. **absolute "up"**: 絕對的“上”。*up* 用引號, 表示實際上並沒有所謂絕對的“上”。下面的“down”意思相同。
 6. **in people's minds**: 在人們的心中。這個介詞短語放在破折號後面, 表示前面的話說出後, 又覺意有未盡, 而加以補充或解釋。口語中常有這種情況。
 7. **ones**: 是代詞 *one* 的複數, 這裏用來代替 *notions*.
 8. **given any direction in space**: 在空間指定任何一個方向。這個分詞短語, 形式上限制主語 *we*, 意義上修飾謂語 *can find*; 過去分詞 *given* 含有被動意義, 但仍保留其直接賓語 *direction*.

“Common Sense”¹ tries to protest

Nowadays² all this seems obvious and indisputable to us. But the record of history shows that in the past it was not so easy for mankind to understand the relativity of up and down. People have the tendency to ascribe absolute meaning to³ notions as long as their relative nature is not evident from everyday experience (as in the case of⁴ “right” and “left”).

Remember the ridiculous objection to⁵ a spherical Earth which has come down to us from the Middle Ages:⁶ How could people possibly walk about upside-down?⁷

The flaw in the reasoning here is that of not recognising that,⁸ since the Earth is a sphere, the vertical is relative.

If you refuse to accept the principle of relativity for the vertical direction and assume, say,⁹ that the direction of the vertical in Moscow is absolute, you are bound to¹⁰ admit that the inhabitants of New Zealand walk upside-down. But if you do this¹¹ you should remember that for New Zealanders we are the ones walking upside-down.¹² This is no contradiction, because the notion of the vertical is not absolute but relative.

1. “Common Sense”: “常識”。
2. Nowadays: 當前; 如今。這個詞含有把現代的習俗同古時的對比之意。
3. ascribe...to...: 把...歸之於...; 賦予...以...。
4. in the case of: 就...而言。比較: in case of (如果)。
5. objection to...: 對...的反對; 對...的異議。
6. come down to us from the Middle Ages: 從中古時代流傳下來到現在。the Middle Ages [歐洲史] 中世紀; 中古時代 (約公元10—14世紀, 或泛指 5—15世紀)。
7. walk about upside-down: 顛倒著走來走去。
8. is that of not recognising that...: 是不認識...的毛病。第一個 that 是代詞, 代替 flaw; 第二個 that 是連詞, 引導賓語從句。
9. say: 比方說。這是祈使語氣 (= let us say), 用作插入語。
10. are bound to...: 必將...; 不得不...。
11. if you do this: 你若是這樣設想的話。do this 此處代替 assume that..., 以免重複。
12. for New Zealanders we are the ones walking upside-down: 對於紐西蘭人來說, 我們才是顛倒著走路的人。We 指莫斯科人自己。