MR TOMPKINS IN WONDERLAND
MR TOMPKINS EXPLORES THE ATOM

GEORGE GAMOW

This paperback volume combines and brings up to date two of Professor Gamow's well known books, *Mr Tompkins in Wonderland* and *Mr Tompkins Explores the Atom*. New stories and illustrations have been added on fission and fusion, the steady state universe, and elementary particles.

Professor Gamow has made many notable contributions to physics. Here he provides a delightful explanation of the concepts of modern physics by introducing Mr Tompkins, a bank clerk whose fantastic dreams and adventures lead him into the world inside the atom.

Some reviewers' opinions of the two books:
Enthusiastically recommended to both scientific and general readers.
- MANCHESTER GUARDIAN

Not only entertaining; the ordinary reader can learn from it a great deal about sub-atomic particles—electrons, neutrons and the rest—and the strange rules which govern their behaviour.
THE OBSERVER

Will vastly fascinate the whimsical, and is also entirely scientific.
SCIENTIFIC AMERICAN

Physicists will appreciate the deft exposition of physical theories and facts and will chuckle over the many apt analogies. Science students will find it worth while for it is definitely a good supplement to a modern physics textbook. Non-physicist readers will find the book interesting and stimulating.. .
SCRIPTA MATHEMATICA

Preface

In the winter of 1938 I wrote a short, scientifically fantastic story (not a science fiction story) in which I tried to explain to the layman the basic ideas of the theory of curvature of space and the expanding universe. I decided to do this by exaggerating the actually existing relativistic phenomena to such an extent that they could easily be observed by the hero of the story, C. G. H. Tompkins, a bank clerk interested in modern science.

I sent the manuscript to *Harpers Magazine* and, like all beginning authors, got it back with a rejection slip. The other half-a-dozen magazines which I tried followed suit. So I put the manuscript in a drawer of my desk and forgot about it.

During the summer of the same year, I attended the International Conference of Theoretical Physics, organized by the League of Nations in Warsaw. 1 was chatting over a glass of excellent Polish mind with my old friend Sir Charles Darwin, the grandson of Charles *(The Origin of Species)* Darwin, and the conversation turned to the popularization of science. I told Darwin about the bad luck I had had along this line, and he said: 'Look, Gamow, when you get back to the United States dig up your manuscript and send it to Dr C. P. Snow, who is the editor of a popular scientific magazine *Discovery* published by the Cambridge University Press.'
So I did just this, and a week later came a telegram from Snow saying: 'Your article will be published in the next issue. Please send more.' Thus a number of stories on Mr Tompkins, which popularized the theory of relativity and the quantum theory, appeared in subsequent issues of *Discovery.* Soon thereafter I received a letter from the Cambridge University Press, suggesting that these articles, with a few additional stories to increase the number of pages, should be published in book form. The book, called *Mr Tompkins in Wonderland,* was published by Cambridge University Press in 1940 and since that time has been reprinted sixteen times. This book was followed by the sequel, *Mr Tompkins Explores the Atom,* published in 1944 and by now reprinted nine times. In addition, both books have been translated into practically all European languages (except Russian), and also into Chinese and Hindi.

Recently the Cambridge University Press decided to unite the two original volumes into a single paperback edition, asking me to update the old material and add some more stories treating the advances in physics and related fields which took place after these books were originally published. Thus I had to add the stories on fission and fusion, the steady state universe, and exciting problems concerning elementary particles. This material forms the present book.
A few words must be said about the illustrations. The original articles in *Discovery* and the first original volume were illustrated by Mr John Hookham, who created the facial features of Mr Tompkins. When I wrote the second volume, Mr Hookham had retired from work as an illustrator, and I decided to illustrate the book myself, faithfully following Hookham's style. The new illustrations in the present volume are also mine. The verses and songs appearing in this volume are written by my wife Barbara.

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C. G. H: The initials of Mr Tompkins originated from three fundamental physical constants: the velocity of light c; the gravitational constant G; and the quantum constant A, which have to be changed by immensely large factors in order to make their effect easily noticeable by the man on the street.

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Acknowledgements

Thanks are due to the following for permission to reproduce copyright material: to Edward B. Marks Music Corporation for the settings of *O come, all ye Faithful ('O* Atome prreemorrdial') and *Rule, Britannia* ('The Universe, by heavn's decree') from *Time to Sing;* and to the Macmillan Company for figure A on p. 144 from *The Crystalline State,* by Sir W. H. Bragg and W. L. Bragg.

Introduction

From early childhood onwards we grow accustomed to the surrounding world as we perceive it through our five senses; in this stage of mental development the fundamental notions of space, time and motion are formed. Our mind soon becomes so accustomed to these notions that later on we are inclined to believe that our concept of the outside world based on them is the only possible one, and any idea of changing them seems paradoxical to us. However, the development of exact physical methods of observation and die profounder analysis of observed relations have brought modern science to the definite conclusion that this 'classical' foundation fails completely when used for the detailed description of phenomena ordinarily inaccessible to our everyday observation, and that, for the correct and consistent description of our new refined experience, some change in the fundamental concepts of space, time, and motion is absolutely necessary.

The deviations between the common notions and those introduced by modern physics are, however, negligibly small so far as the experience of ordinary life is concerned. If, however, we imagine other worlds, with the same physical laws as those of our own world, but with different numerical values for the physical constants determining the limits of applicability of the old concepts, the new and correct concepts of space, time and motion, at which modern science arrives only after very long and elaborate investigations, would become a matter of common

knowledge. We may say that even a primitive savage in such a world would be acquainted with the principles of relativity and quantum theory, and would use them for his hunting purposes and everyday needs.
The hero of the present stories is transferred, in his dreams, into several worlds of this type, where the phenomena, usually inaccessible to our ordinary senses, are so strongly exaggerated that they could easily be observed as the events of ordinary life. He was helped in his fantastic but scientifically correct dream by an old professor of physics (whose daughter, Maud, he eventually married) who explained to him in simple language the unusual events which he observed in the world of relativity, cosmology, quantum, atomic and nuclear structure, elementary particles, etc. It is hoped that the unusual experiences of Mr Tompkins will help the interested reader to form a clearer picture of the actual physical world in which we are living.

I
City Speed Limit

It was a bank holiday, and Mr Tompkins, the little clerk of a big city bank, slept late and had a leisurely breakfast. Trying to plan his day, he first thought about going to some afternoon movie and, opening the morning paper, turned to the entertainment page. But none of the films looked attractive to him. He detested all this Hollywood stuff, with infinite romances between popular stars.

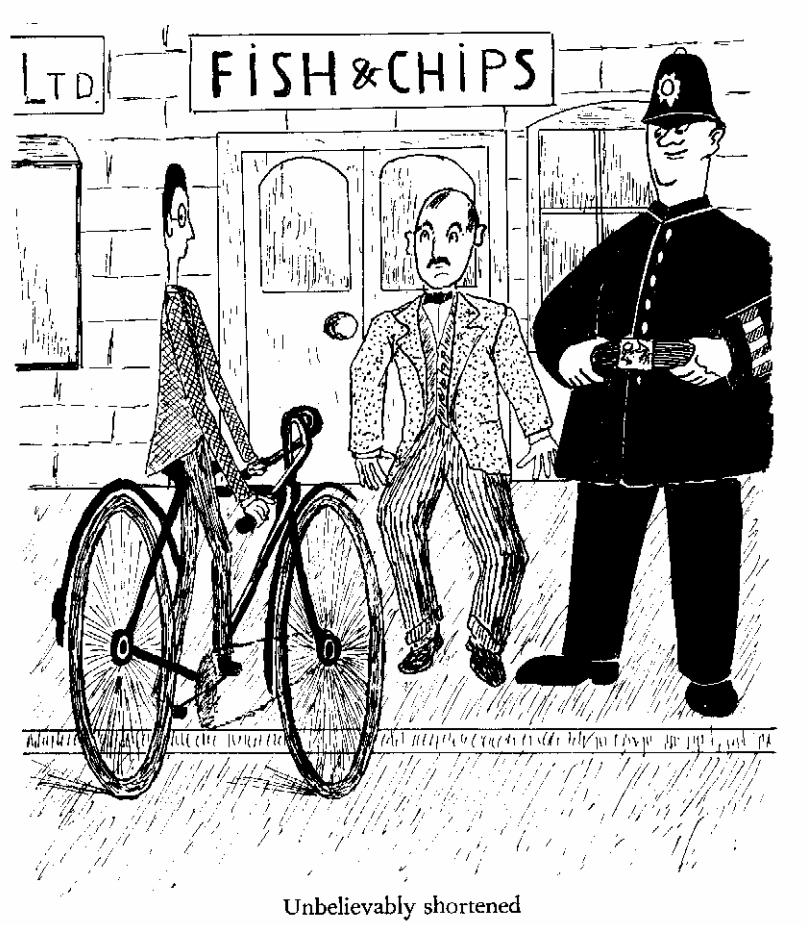
All this Hollywood stuff!

If only there were at least one film with some real adventure, with something unusual and maybe even fantastic about it. But there was none. Unexpectedly, his eye fell on a little notice in the corner of the page. The local university was announcing a series of lectures on the problems of modern physics, and this afternoon's lecture was to be about EINSTEIN'S Theory of Relativity. Well, that might be something! He had often heard the statement that only a dozen people in

the world really understood Einstein's theory. Maybe he could become the thirteenth! Surely he would go to the lecture; it might be just what he needed.

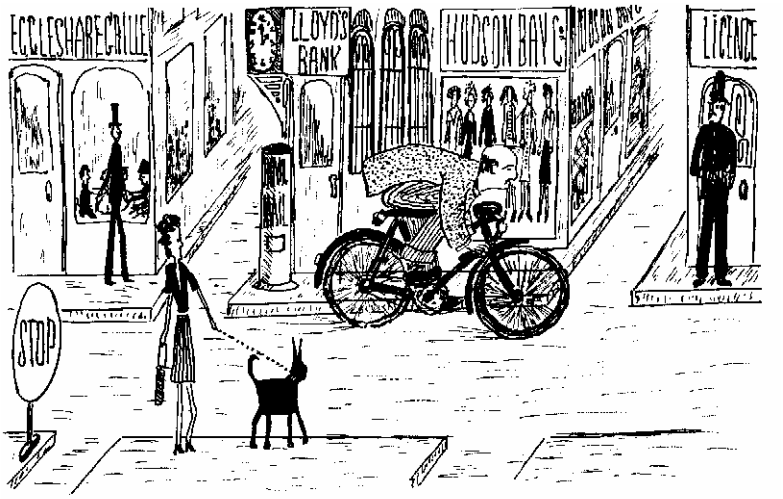
He arrived at the big university auditorium after the lecture had begun. The room was full of students, mostly young, listening with keen attention to the tall, white-bearded man near the blackboard who was trying to explain to his audience the basic ideas of the Theory of Relativity. But Mr Tompkins got only as far as understanding that the whole point of Einstein's theory is that there is a maximum velocity, the velocity of light, which cannot be surpassed by any moving material body, and that this fact leads to very strange and unusual consequences. The professor stated, however, that as the velocity of light is 186,000 miles per second, the relativity effects could hardly be observed for events of ordinary life. But the nature of these unusual effects was really much more difficult to understand, and it seemed to Mr Tompkins that all this was contradictory to common sense. He was trying to imagine the contraction of measuring rods and the odd behaviour of clocks—effects which should be expected if they move with a velocity close to that of light—when his head slowly dropped on his shoulder.

When he opened his eyes again, he found himself sitting not on a lecture room bench but on one of the benches installed by the city for the convenience of passengers waiting for a bus. It was a beautiful old city with medieval college buildings lining the street. He suspected that he must be dreaming but to his surprise there was nothing unusual happening around him; even a policeman standing on the opposite corner looked as policemen usually do. The hands of the big clock on the tower down the street were pointing to five o'clock and the streets were nearly empty. A single cyclist was coming slowly down the street and, as he approached, Mr Tompkins's eyes opened wide with astonishment. For the bicycle and the young man on it were unbelievably shortened in the direction of the motion, as if seen through a cylindrical lens. The clock on the tower struck five, and the cyclist, evidently in a hurry, stepped harder on the pedals. Mr Tompkins did not notice that he gained much in speed, but, as the result of his effort, he shortened still more and went down the street looking exactly like a picture cut out of cardboard.



Unbelievably shortened

Then Mr Tompkins felt very proud because he could understand what was happening to the cyclist—it was simply the contraction of moving bodies, about which he had just heard. ‘ Evidently nature’s speed limit is lower here,’ he concluded,’ that is why the bobby on the corner looks so lazy, he need not watch for speeders.’ In fact, a taxi moving along the street at the moment and making all the noise in the world could not do much better than the cyclist, and was just crawling along. Mr Tompkins decided to overtake the cyclist, who looked a good sort of fellow, and ask him all about it. Making sure that the policeman was looking the other way, he borrowed somebody’s bicycle standing near the kerb and sped down the street.



The city blocks became still shorter

He expected that he would be immediately shortened, and was very happy about it as his increasing figure had lately caused him some anxiety. To his great surprise, however, nothing happened to him or to his cycle. On the other hand, the picture around him completely changed. The streets grew shorter, the windows of the shops began to look like narrow slits, and the policeman on the corner became the thinnest man he had ever seen.

'By Jove!' exclaimed Mr Tompkins excitedly, 'I see the trick now. This is where the word *relativity* comes in. Everything that moves relative to me looks shorter for me, whoever works the pedals!' He was a good cyclist and was doing his best to overtake the young man. But he found that it was not at all easy to get up speed on this bicycle. Although he was working on the pedals as hard as he possibly could, the increase in speed was almost negligible. His legs already began to ache, but still he could not manage to pass a lamp-post on the corner much faster than when he had just started. It looked as if all his efforts to move faster were leading to no result. He understood now very well why the cyclist and the cab he had just met could not do any better, and he remembered the words of the professor about the impossibility of surpassing the limiting velocity of light. He noticed, however, that the city blocks became still shorter and the cyclist riding ahead of him did not now look so far away. He overtook the cyclist at the second turning, and when they had been riding side by side for a moment, was surprised to see the cyclist was actually quite a normal, sporting-looking young man. 'Oh, that must be because we do not move relative to each other,' he concluded; and he addressed the young man.

'Excuse me, sir!' he said,' Don't you find it inconvenient to live in a city with such a slow speed limit?'

'Speed limit?' returned the other in surprise,' we don't have any speed limit here. I can get anywhere as fast as I wish, or at least I could if I had a motor-cycle instead of this nothing-to-be-done-with old bike!'

'But you were moving very slowly when you passed me a moment ago,' said Mr Tompkins. 'I noticed you particularly,'

‘Oh you did, did you?’ said the young man, evidently offended. ‘I suppose you haven’t noticed that since you first addressed me we have passed five blocks. Isn’t that fast enough for you?’

‘But the streets became so short,’ argued Mr Tompkins.

‘What difference does it make anyway, whether we move faster or whether the street becomes shorter? I have to go ten blocks to get to the post office, and if I step harder on the pedals the blocks become shorter and I get there quicker. In fact, here we are,’ said the young man getting off his bike.

Mr Tompkins looked at the post office clock, which showed half-past five. ‘Well!’ he remarked triumphantly, ‘it took you half an hour to go this ten blocks, anyhow—when I saw you first it was exactly five!’

‘And did you *notice* this half hour?’ asked his companion. Mr Tompkins had to agree that it had really seemed to him only a few minutes. Moreover, looking at his wrist watch he saw it was showing only five minutes past five. ‘Oh!’ he said, ‘ is the post office clock fast?’ ‘Of course it is, or your watch is too slow, just because you have been going too fast. What’s the matter with you, anyway? Did you fall down from the moon?’ and the young man went into the post office.

After this conversation, Mr Tompkins realized how unfortunate it was that the old professor was not at hand to explain all these strange events to him. The young man was evidently a native, and had been accustomed to this state of things even before he had learned to walk. So Mr Tompkins was forced to explore this strange world by himself. He put his watch right by the post office clock, and to make sure that it went all right waited for ten minutes. His watch did not lose. Continuing his journey down the street he finally saw the railway station and decided to check his watch again. To his surprise it was again quite a bit slow.’ Well, this must be some relativity effect, too,’ concluded Mr Tompkins; and decided to ask about it from somebody more intelligent than the young cyclist.

The opportunity came very soon. A gentleman obviously in his forties got out of the train and began to move towards the exit. He was met by a very old lady, who, to Mr Tompkins’s great surprise, addressed him as ‘dear Grandfather’. This was too much for Mr Tompkins. Under the excuse of helping with the luggage, he started a conversation.

‘Excuse me, if I am intruding into your family affairs,’ said he, ‘but are you really the grandfather of this nice old lady? You see, I am a stranger here, and I never. . .. ..’ ‘Oh, I see,’ said the gentleman, smiling with his moustache. ‘I suppose you are taking me for the Wandering Jew or something. But the thing is really quite simple. My business requires me to travel quite a lot, and, as I spend most of my life in the train, I naturally grow old much more slowly than my relatives living in the city. I am so glad that I came back in time to see my dear little grand-daughter still alive! But excuse me, please, I have to attend to her in the taxi,’ and he hurried away leaving Mr Tompkins alone again with his problems. A couple of sandwiches from the station buffet somewhat strengthened his mental ability, and he even went so far as to claim that he had found the contradiction in the famous principle of relativity.

‘Yes, of course,’ thought he, sipping his coffee, “if all were relative, the traveller would appear to his relatives as a very old man, and they would appear

very old to him, although both sides might in fact be fairly young. But what 1 am saying now is definitely nonsense: One could not have relative grey hair!' So lie decided to make a last attempt to find out how things really are, and turned to a solitary man in railway uniform sitting in the buffet.

'Will you be so kind, sir,' he began,' will you be good enough to tell me who is responsible for the fact that the passengers in the train grow old so much more slowly than the people staying at one place?'

'I am responsible for it,' said the man, very simply.

'Oh!' exclaimed Mr Tompkins. 'So you have solved the problem of the Philosopher's Stone of the ancient alchemists. You should be quite a famous man in the medical world. Do you occupy the chair of medicine here?'

'No,' answered the man, being quite taken aback by this,' I am just a brakeman on this railway.'

'Brakeman! You mean a brakeman. - -,' exclaimed Mr Tompkins, losing all the ground under him. 'You mean you—just put the brakes on when the train conies to the station?'

'Yes, that's what I do: and every time the train gets slowed down, the passengers gain in their age relative to other people. Of course,' he added modestly,' the engine driver who accelerates the train also does his part in the job.'

'But what has it to do with staying young?' asked Mr Tompkins in great surprise.

'Well, I don't know exactly,' said the brakeman, 'but it is so. When I asked a university professor travelling in my train once, how it comes about, he started a very long and incomprehensible speech about it, and finally said that it is something similar to 'gravitation red shift—I think he called it—on the sun. Have you heard anything about such things as red shifts?'

' No-o,' said Mr Tompkins, a little doubtfully; and the brakeman went away shaking his head.

Suddenly a heavy hand shook his shoulder, and Mr Tompkins found himself sitting not in the station cafe but in the chair of the auditorium in which he had been listening to the professor's lecture. The lights were dimmed and the room was empty. The janitor who wakened him said: 'We are closing up, Sir; if you want to sleep, better go home.' Mr Tompkins got to his feet and started toward the exit.

2
The Professor's Lecture on Relativity which caused Mr Tompkins's dream

Ladies and Gentlemen:

In a very primitive stage of development the human mind formed definite notions of space and time as the frame in which different events take place. These notions, without essential changes, have been carried forward from generation to generation, and, since the development of exact sciences, have been built into the foundations of the mathematical description of the universe. The great NEWTON perhaps gave the first clear-cut formulation of the classical notions of space and time, writing in his *Principia:*