THE *Bluffer's*® GUIDE TO

THE QUANTUM UNIVERSE

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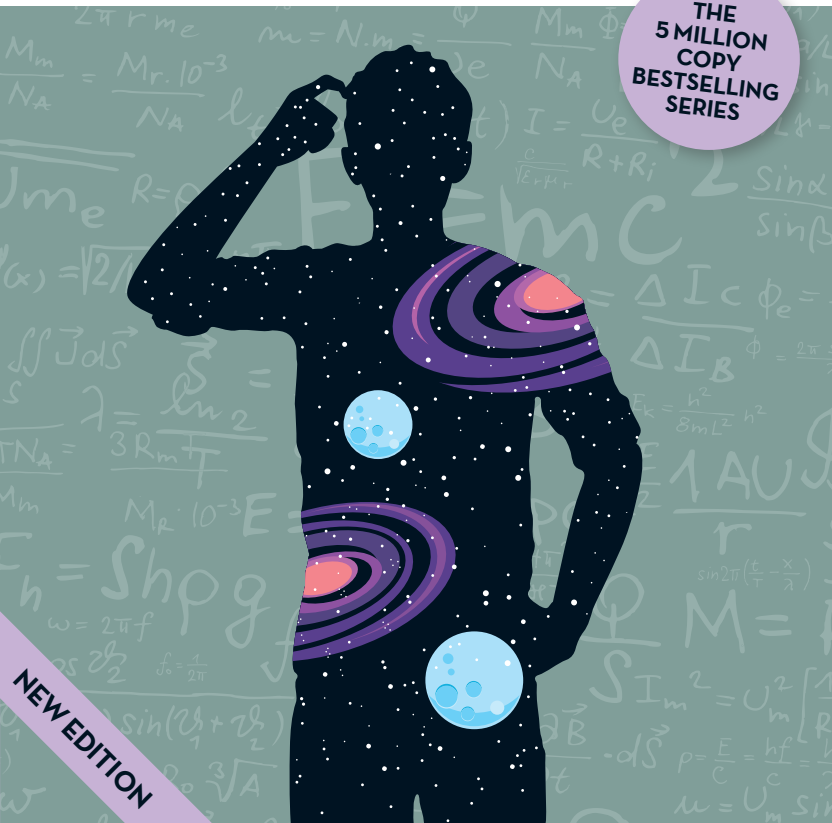

NEW EDITION

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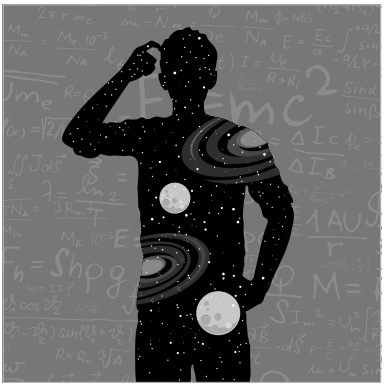

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LET'S GET QUANTUM PHYSICAL

Whether you are trying to explore the universe, which is very, very big, or the 'quantum realm', in which particles of light and matter are very, very small, nothing can be stated with clearer conviction than this: nobody really understands what's going on. So, if you have ever lamented your own incomprehension, let yourself off the hook immediately. Welcome to a bluffer's paradise, where no one need feel afraid, nor should anyone feel stupid.

Of course, where physicists do have knowledge and understanding, prudence dictates that astute bluffers gain some appreciation of it. This will not be too difficult. The universe is, after all, very large, and the smallest entities are extremely small – and their conduct is unusual, to say the least.

Happily, such an appreciation may be obtained without formulas, equations or fractions. It may seem to be taking the word 'appreciation' too far, but you are going to have to feign, find or affirm some sense of wonder. Nature is full of marvels at the best of times. In the quantum realm,

as the great Danish physicist, Niels Bohr, used to say: if people didn't find these phenomena shocking, wild and confusing, they weren't taking it in.

And Bohr was understating it, of course. Indeed, however bizarre a description of subatomic phenomena may be, there'll always be some smarty-pants saying: 'That's underselling it'. Agree fervently and move on.

So, needless to say, overwhelming questions will continually come up. Nowadays these can be neatly batted away with the words: 'Yes, well, of course they're looking into that at Cern'. You hint at deeper knowledge by saying that Cern is an acronym for Conseil Européen pour la Recherche Nucléaire and by being specific about the actual location of the famous 'collider' – near Geneva, beneath the Franco-Swiss border. Not too far away from Goldfinger's lair in the eponymous Bond book, actually.

Mentioning Cern will become an automatic response for you, and one that falls somewhere between 'They deal with that in accounts', 'Give the ball to Brian', and 'Do you mind if I have another glass of wine?' No one should ever tire of saying, 'Yes, they're addressing that at Cern'.

Nothing conveys the impression of substantial intellect so much as even the sketchiest knowledge of quantum physics, and since the sketchiest knowledge is all anyone will ever have, never be shy of holding forth with bags of authority about subatomic particles and the quantum realm without having done any science whatsoever.

After all, what else is the act of bluffing about?

This book sets out to guide you through the main

danger zones encountered in discussions about the quantum universe, and to equip you with a vocabulary and an evasive technique that will minimise the risk of being rumbled as a bluffer. It will lend you a few easy-to-learn hints and methods that will allow you to be accepted as a physics expert of rare ability and experience. But it will do more. It will give you the tools to impress legions of marvelling listeners with your knowledge and insight – without anyone discovering that before reading it you didn't know the difference between a boson and a hadron, or, indeed, a fermion or a meson, or come to that a photon, pion or gluon. Time to put a smileon, get ready to putiton and readon.

The Italian physicist Enrico Fermi said that if he could remember all the names given to particles he would have been a botanist, and if such things really do interest you, you need to get out more.

PREPARING YOURSELF

DOES SIZE MATTER?

Whichever way you approach discussions about the universe and the quantum realm, the notion of scale will somehow always be present. But remember that it should be beneath you to be impressed by size; it is for other people to reel and gasp. Scale is something with which you must appear to be comfortable and familiar.

Physicists naturally possess what bluffers must somehow acquire: the ability to drop phenomenally massive numbers into the conversation with ease, airily disparaging 'gee-whizzery' while trotting out unimaginably awe-inspiring facts and figures.

Where the tendency is towards 'big', you need to appreciate that a light year measures the distance you could cover in a Julian year (that's a normal calendar year of 365.25 days), zooming at 186,283 miles per second. The nearest galaxy to earth, newly discovered, is a trillion miles away – remarkably near as galaxies go, but still pretty far, even for a commercial traveller. (And if you do go, don't talk to strangers.)

At the other extreme, you need to have some idea of what is meant by 'small'. All matter can be broken down into atoms. Atoms are small. They are smaller than affordable apartments in Manhattan, they are smaller than average portions at The Ritz, they are even smaller than the chance that a politician will give you an honest answer. The full stop at the end of this sentence will be a tiny blob of ink about a quarter of a millimetre wide which will contain close to four billion atoms.

Having taken that into account, a reminder is necessary. To a human being, or to a full stop, an atom is small. But to a subatomic particle, any one of those four billion atoms in that full stop is enormous.

At the centre of an atom is a nucleus – itself made of particles. The nucleus feels within the atom as a regulation red ball might feel in a cricket ground. The electrons that surround the atom would be akin to peanuts circling at the outskirts of the ground's car park. There are no players, spectators or refreshment-sellers around. Atoms are usually described as being made up of 99.9999999999999% 'empty space'. Without that empty space, the entire human race would fit into a space the size of a sugar cube.

Pointing to such a cube, or mentioning how many atoms there are in a grain of coffee, or Parmesan cheese, or beach sand, or, best of all, in a pretty freckle on human skin, may be a game well worth the candle for the confident bluffer. But you can take it further.

With the concept of 'touch' of any kind – innocent, compromising or downright culpable – the physics of today

provides a most helpful get-out clause. No atoms of any one object can ever touch the atoms of another.

For hundreds of years, people have talked of great performers having magnetism, or public moments having electricity, but it has taken humanity more than a few millennia to realise how much electromagnetism lies within everything and how powerful it can be.

The 'empty space' in atoms, while devoid of mass – of matter, of 'stuff' – carries a tremendous electromagnetic charge. People don't fall through the ground as they walk through a town or city because the negative electromagnetic charge on the outside of the atoms in a pavement exerts a repulsive force on the negative charge of the atoms in the soles of a shoe. That is the same repulsive force in action when hammers hit nails, boxing gloves punch heads or rackets thwack tennis balls.

The charges around the atom create the illusion and even the feeling of touch. Still, however hard they are pushed, the force surrounding atoms far exceeds even the most powerful bar magnets, so atoms cannot be made to come into contact with each other. There is always that layer of separation, even around scissors and hair, food as it's digested and, therefore, between two pairs of lips.

Whatever the status of human relationships, lovers have no option but to accept the age-old adage: 'There is always space in togetherness.'

THE PARADOX OF THE BELIEF SYSTEM

Few forms of knowledge are so closely interwoven with human belief systems as studies concerning the quantum universe.

When discussing the very tiniest particles of light and matter, or wrestling with the very big universe, your belief system, and the belief systems of the people whom you will be impressing, will be powerfully challenged.

Because you are dealing with fundamental entities in nature, it will be impossible to avoid disturbing and challenging the most basic beliefs of those around the table. The mere mention of a particle will raise the issue of consciousness in snails, and how this relates to God.

Everything that anyone has ever held dear, every blind assumption, every hard-won prejudice may be horribly threatened. Clearly, this sort of thing should not be allowed; and, certainly, no one else should have to witness it.

To prepare yourself for 'deipnosophy' (the noble art of excelling at dinner parties), you need to know where you stand. Behind closed doors you will have resolved all those profound questions which, however slightly, might have upset your own world view. You will have absorbed this knowledge – and been shaken and stirred – but you will have managed to keep your cherished notions intact. Before you re-emerge to re-engage and mingle with your friends, you will have discovered how to use the very same knowledge to provide you with an opposite, more pleasing interpretation.

It will involve no effort at all to find some subatomic

occurrence that has a bearing on religion, or politics, or marriage or morals, or art or azaleas, or music or marmalade, or snooker or sex. Each precious phenomenon must be seized on, every analogy squeezed until it squeaks.

TWO SCHOOLS OF THOUGHT

It has been said that there are two types of people: those who divide the world into two types of people and those who don't. Ideas about quantum mechanics can divide people in trillions of ways, but it is instructive to consider this relatively new science by considering two distinct views of the universe, two schools of thought. Here's how you can see them coming.

1. The Holists

Members of this school are, broadly speaking, holistic. Holists are interested in the whole picture, except when it comes to the letter 'w'. As time goes on, more and more holists are likely to come out of the (w)ood(w)ork.

2. The Reductionists

Those who belong to this school are interested in the parts of the picture. All they want to know is 'How small?', 'How many?', 'How wide?', etc., as if the quantum universe was a watch that could be taken apart to the smallest screw to find how it all works.

Holists are generally interested in quality. Reductionists are interested in quantity.

Holists, to paraphrase the poet William Blake, can see the universe and eternity in an atom – or even a grain of

sand. They have likened the universe to an enormous ball of string. No one can see its end or its beginning, yet if you draw on the string at any part of the ball, the ball becomes tighter throughout. Try to pull one strand of it, and all of it changes. Holists say that this involves a deeper reality than mere interrelationship. For them, wherever you tweak the string, there is the entire universe because all of it changes. Everything is part of everything, every part is part of every part. There is oneness and only oneness. If it sounds like religion, it depends on how you define religion.

Modern physics, like love, or football, or being a teenager, defies language.

Reductionists concentrate on the individual atom without relating it to anything else. They think you should chop up the string ball and measure the bits.

Holists think the scientific discoveries of the twentieth century should encourage us to rethink everything. This is sometimes called a 'paradigm shift' – the altering of a model, in this case the whole model. They want to unite, to bind, to join. Reductionists don't. They like the word 'discrete', meaning 'separate from everything else'.

Reductionists think it is unnecessary to make so much of the fact that the iron at the core of planets is also contained

in human haemoglobin. Holists think it's poetic and meaningful that human beings have stardust in their blood.

Holists find coincidences intensely moving; reductionists demonstrate why they aren't coincidental. Holists accept a certain floppiness in their ideas; reductionists insist on rigour.

Holists quite like the circuitous approach. A reductionist will even do a cutting gesture while explaining that space itself is curved so you will, at least, get that straight.

THE LANGUAGE BARRIER

When you come up against the limits of the quantum universe, and indeed the limits of your own understanding, you will inevitably come up against the extremes of what you can express linguistically, so to speak.

For instance, the notion that in the beginning everything was in one place and, lo, that place was nothing. No thing. It was a nothingness, so nothing like its nothingness took nothingness to untold extremes of nothingness. (Modern physics, like love, or football, or being a teenager, defies language.)

It has never been easy for anyone to find words to explain the deep mysteries of the universe. How to explain new phenomena? How to describe them? How to tell people about entities and occurrences which are so far removed from anything hitherto known about or understood that the brain starts doing backflips and wants to join the circus.

The difficulties begin with names. You will, as it happens, encounter many words in the quantum realm which end in '-on'. There are hadrons, which may be baryons or mesons,

and mesons which may be pions or kaons, while muons and tauons are leptons, not to be confused with sleptons – and so on.

You may be tempted to sort them out. Don't. At the University of California at Berkeley, in an almanac which records new particles, the list was already running to more than 2,000 pages in the 1990s. The Italian physicist Enrico Fermi said if he could remember all the names given to particles he would have been a botanist, and if such things really do interest you, you need to get out more. Besides, as early as 1964, the American physicist Murray Gell-Mann and others have felt that all those differently named entities were actually combinations of a relatively few truly elementary particles. It is perhaps small wonder that the Nobel Prize-winning Gell-Mann is these days devoting himself more to the study of language than to physics.

Niels Bohr, who used to have days of intense discussion about almost every word he used, was called a bad lecturer, but often he just wanted to get the language right. He once paused for a long moment before saying, '…and', then took another very long pause before he said, '…but'. (It was he who reportedly gave a baffled French ambassador the happy and fulsome greeting: '*Aujourd'hui!*') At least he conceded that there was a problem. It took him several weeks of hard thought and discussion to come up with this: 'We are somehow suspended in language.'

You could do no better yourself.

Blaming language is your parachute, your cavalry, your safety net. A reminder about linguistic difficulties will send

sharp questions ricocheting back to their posers; and if or when you have dropped yourself in it, talking about the lack of suitable words can soften the horror-movie eyes around the table.

The language used by physicists is mathematics – though many of them need help with it from real mathematicians. Their best-known trick is to shut their eyes and find some Greek letters to make it seem deep and meaningful. Physics is chock-full of words which have been poached and which may once have had a sporting chance of meaning something. Most could not be more confusing if they were designed to be so, and the suspicion is that they were.

It may also be a useful gambit to cite languages other than your own, such as Algonkian spoken by the Blackfoot people of Alberta, Canada, which emphasises change and movement in nature, rather than finding names for things. For example, instead of saying, 'I saw someone long ago', they say, 'I saw him/her in the far away.' This so impressed the eminent American scientist David Bohm that he proposed that an entirely new kind of language should be developed for the quantum universe. An English one, of course.

TACTICS FOR TIGHT CORNERS

Whenever the universe becomes a topic of conversation, certain questions will always be hovering around the edges – if there are any edges (and that's one of the questions). These include:

- How did the universe begin?

- Who cares?
- If the universe had a beginning, will it have an end? Or a new series in the Autumn?
- What has 'quantum' got to do with it?
- I sort of get it, but just when I do, I lose it again. It's as if it's in the cracks of my understanding. Is that where it should be?
- Can I have a large Bloody Mary?

Some of these penetrating queries may seem to be unanswerable. And that is because they are. But defeatism is alien to science as well as to bluffing. And since the scientists who are bold enough to deal with these questions are so often conjecturing, you may as well follow suit. So try one of the following if the bluffing muse has come upon you: 'Physicists now believe that before the universe began, everything was a substance not dissimilar to bubblegum'; or, 'Last week, cosmologists declared that the universe was stacked between two bookends; now they're saying it's shaped like the upside-down torso of a man in boxer shorts.' Or, 'The smallest particle, the carryon, is even smaller than the one found last February, the dreamon, and last Tuesday's equally minuscule particle, the whatson.'

But remember to balance conviction with caution.

Never commit yourself about the outer limits of the universe or the quantum realm even with a 'probably'. Anything you utter with certainty, or declare to be 'probably true', could return to haunt you and, it can be said with

confidence, probably will. If you know what's good for you, a 'possibly' is the farthest you will go.

To avoid being thought a delinquent in the light of tomorrow's new data, you need to make the lack of language work for you by:

a) saying that we are up against the limits of it;

b) frequently using the word 'possibly' as an insurance policy; and

c) capping all statements about problems that have not been solved and theories that have been proved unassailable, or the finding of the smallest particle in the universe, with the caveat 'so far'.

With some of the more difficult questions, a gentle attack may be a good defence. The 'dismissal' tactic is ideal since it conveys the impression of very deep and thorough knowledge and prevents any deviation from your chosen conversational course. The dismissal is best exemplified by the simple but salutary sentence: 'The question doesn't apply.'

For decades scientists said that there was no before. That is to say: no 'before' before the Big Bang. Everything was in one spot and that spot was nothing. Less than nothing. And then that less-than-nothing went 'pop' and the universe just 'grew'.

How could they know that? Well, they interpreted it from the mathematics.

And what was there before the 'pop'? The answer was as cold as a padlock: 'the question doesn't apply'.

Everyone who was not a physicist was at that time hectored into not thinking of a 'before'. The question didn't apply. Even so much as considering a 'before' had to be avoided because there was nothing there, indeed there was no 'there' there, just as there was no 'because' because 'because' needed a 'dum-de-dum' in order to have gone from 'dum-de-dum' to 'dum-de-dee' because of 'blah-de-blah'. Which didn't happen, nor did 'happen' happen, nor did 'there', nor did 'anywhere.'

Well, time passed and slowly but surely a substantial number of influential physicists came to accept what everyone else could see was blindingly obvious.

The universe had to have a Before. After all, there must have been something 'before' the Big Bang.

There was no apology from physicists. There was not even an acknowledgement. Not one of them came out and said, 'Your splutterings were perfectly reasonable. We patronised you, in fact we were really rather rude, but of course we were talking nonsense. So sorry. You were right.'

How do scientists get away with such high-handed behaviour? The question doesn't apply.