

**Mike Johnson**

## **RUTHERFORD'S DREAM**

**Before** Rutherford split the atom it was an unknown entity; no-one knew what it contained. Rutherford treated it like a black box, the secrets of which had never been penetrated by science. No scientist had ever been able to lift the lid of this box - if it had a lid - and peer inside. There was no periscope that could angle around the corners of space and reflect that world back into the human eye. Like those mysterious obelisks in Arthur C. Clark's fantasy of evolution, unbreakable and impenetrable, the atom offered no foothold to the mind, no clue as to its internal structure. Teasingly, the atom announced itself as a physical boundary to the rational world, just as, out on the boundless surface of space, the big bang announced the beginning of time. At this point, the atom said, another universe begins, another dimension; beyond this point you may not pass except to meet yourself upon the return journey.

This was not so completely understood then as it is now. For Rutherford the black box was a challenge; how do you find out what is inside a black box given that it is apparently seamless and you can't look directly in? Rutherford asked himself. Simple. You hit it with something. You hit it and see what it does, what kind of noise it makes. You hit it and put your ear to it. And that's what he did. He had already discovered radiation, and two kinds of emitted particles which he named with characteristic simplicity: alpha and beta particles. By using these particles to hit the black box of the atom, he set the course for experimental physics for the next fifty years.

His apparatus was very simple: an alpha gun, to aim the particles, and a strip of gold foil for a target. It was a Boer War kind of approach to physics. The problem was simple; the harder you hit the black box the more information you get out of it, so how to hit the black box as hard as possible? The solution is simple too, said Rutherford. Make your particles go faster. The faster the particles are going, the harder they will hit the black box.

The particle accelerator was born.

The main problem you will have, he counselled other physicists, is the tendency for mistakes to be made, for errors to creep into the measurements, into the alignment of the components. If errors, foolish human errors, crept into the system, the experimental result would be distorted. And a distorted result would give rise to a distorted picture of the world. With correct procedures, and no errors, the black box would be opened.

Simple. But here the analogy must break down. An atom is not, after all, a black box, nor a mysterious slab given over to ghostly voices. It is not in any way solid but open and full of huge orbital distances, and when he hit it, it shivered, dissolved, exploded into a flower of luminous traces.

Study photographs of Rutherford and you see a strong, no-nonsense face. A man from a practical, no-nonsense New Zealand background. A background in which reason and practice were so securely harnessed that there was barely a chaff or rub in the strap. The face on top of the invariably neat, Edwardian suit, displays a solid calm, the calm of assured reason. Just as a tree would fall as the axe landed, so the world would fall where reason dictated; the rule of reason was limitless and absolute. So why not be calm? His approach to experimental physics came from the same no-nonsense attitude, the same calm, the same certainty that the world, even the black box, was accessible to rational explanation. The universe would yield a rational explanation of all of its phenomena. Cause and effect reign supreme; as the axe lands, the tree falls.

We can ask, as we must, if the assumption that the universe would cooperate 100 percent with Assured Reason is itself rational. Is it even possible to formulate a rational basis for the basis of rationality without getting into logical difficulties? Historical record has it that Rutherford found these arguments uncongenial; he was a nuts and bolts man, from a country where any man can fix anything or make anything work with a piece of number eight fencing wire and a pair of pliers. Where's that black box - we'll hit it with the spade first and if that doesn't work, we'll go and get the bloody pick. It was up to philosophers to niggle at epistemological issues if they chose. For the New Zealander the world is divided into two species, those who do

things and those who talk about doing things. "There is only one thing to say about physics," he loftily proclaimed. "The theorists are on hind legs and it's up to us to get them down again."

And yet all this practical four-legged calm is itself something of a black box, hiding more than it reveals. All the Edwardians look that way in photographs. They must have believed this was the correct way to be in front of a camera; solid, square, stony faced. It is suggestive of how they saw themselves in mirrors. What is concealed is the passionate, fanatic basis of the whole quest. The God of Reason is a jealous god, an exclusive god, and will brook not a single exception to his rule. A dictate to which Rutherford joyfully acceded. The universe must conform with Assured Reason 100 percent, 100 percent of the time, and everywhere, equally. Herein lay its strength, its strenuous predictive capacity; but also its weakness, for a single exception cracks the whole facade. One joker in the deck of rationality, one wild card, sends a shiver through the whole deck.

Furthermore, not only must there be no exceptions, there must be no possibility of exceptions: no shady areas, no dubious insertions, no troublesome paradoxes or infinities, no ripple on the surface of the calm. Here is the clue to what drew Rutherford to the black box, particle gun in hand. The black box contained the possibility of anomalies, and, close on the heels of anomalies, contradictions and irrationalities. As long as it remained a black box, the atom remained unassimilated into the benevolent dictatorship of Assured Reason. The atom had to be conquered, brought to heel, fitted neatly with the laws of continuity, cause and effect, and all the requirements and paraphernalia of Assured Reason.

Until this colonization of the potentially irrational was complete, there would be no rest: no rest for Rutherford, no rest for his team. Day and night they slaved over their machine, the machine with which they would lay siege to the black box; they worked until they were hollow eyed, driven we can say by an absolute faith, the missionary zeal that must bring every last lost sheep into the fold. The atom would succumb, its secrets would be revealed, the rule of Assured Reason would be strengthened. The black box would be no more.

As he saw it, no other science offered this challenge. No other science revealed in such a way the rational underpinnings of the

universe, a science which would, one day, gather everything into itself. "All science is either physics or stamp collecting," he declared.

Was there never a tremor of doubt, a shiver of uncertainty? Wasn't Rutherford himself made of mortal, indeed, atomic flesh. If the stuff out of which his own brain was made was a black box, what certainty could there be about anything?

As the machines were rolled into place, the particle gun aimed, was there not, perhaps, some hesitation, some moment of prescience? Some sense that if you knock hard enough on the door to the unknown, the unknown may answer you in its own language, not yours? Perhaps there was. Dr Farthing, one of Rutherford's colleagues, relates that the phlegmatic Rutherford had a strange experience the night before the first crucial test.

First he dreamed he was at the lab working, working so hard that he fell asleep on the sofa, not an unusual occurrence in waking life. This dream-self also dreamed, and in that dream-within-a-dream he saw a figure dozing in his own easy chair, a play of light and shade on his face. Suddenly, in the dream, he awoke to find he was not alone in the lab and he knew an immediate, unreasoning terror. This terror may have been a subconscious reaction to the double trap in which the dream held him, and yet there was somebody moving around in the lab, tinkering with his equipment! It was vital that the equipment not be touched, not even breathed upon, for fear of error creeping in, the terrible heresy of error. Not wishing to reveal his presence while he was still lying, helpless, he slowly and quietly got up, shaking off the last of his sleep, preparing for action, even violence. His dreaming self remembered his experiences as a front row forward at Nelson's Boys' College; you put your head down and run straight for their balls.

The lab was subtly different. As in a game of chess in which one player has two white knights, the arrangement of the light looked wrong, the angles obverse. The window was where the door should be, the particle gun and its target, the strip of gold foil, had reversed positions. The particle gun was aiming straight back at him instead of towards the gold foil.

Somebody was facing him across the equipment, their hands outstretched. Rutherford was about to speak when he was forestalled by a sudden intuition that the intruder was a person of great authority,

the bearer in fact of a secret seal from some all powerful scientific illuminati and would forbid the experiment to go forward if Rutherford revealed himself. The facelessness of the creature reinforced his impressions. It was as faceless as any examiner he had faced. Fear that the experiment would be axed, turned into some historical oddity, like an alchemist's sealed vessel, that history would sideline him and Assured Reason forever turn him stone-still.

At the same time there was a graininess, a certain haziness to the outlines of some of the objects, particularly the crucial objects of the experiment, the particle gun and the gold foil. The more he stared at them, the less certain their outlines became; these familiar objects became unreadable, as if in some way they were altering their natures, or more exactly, as if unfamiliar shapes lay within familiar ones, and the particle gun and the gold foil were disguises for something else. The foil in particular appeared to be reflecting some bent shape he could not identify. Within that shape, that blossom of shadow caught in the foil, lurked some monstrous terror, the real source of his own

Rutherford now awoke for the second time, seeing upon his retina an after-image of the bulging shape within the foil, still heavy with the fear that the experiment would be called off. Not only that, but he had the powerful intuition that there was somebody in the room! But of course he was not in the lab, he was at home in his own room, recovering from a distasteful dream which he remembered very clearly.

Then who was in the room with him? Slowly and carefully, he climbed off his bed and stood very still, watching and listening. The silence confirmed itself, but the room was not as it should be. There was a door where there should be a wall, as if his bed had been moved. Impossible. He must still be under the spell of the dream. To break that spell he had to move, turn the light on. He took a couple of shuffling steps and stopped again. The intruder too had moved. Now he could see the outline of a human form standing in the doorway facing him.

"What do you want?" He said, using his voice to break the spell.

The intruder didn't answer.

I won't let the experiment be cancelled, Rutherford thought in panic. He tried to bring the intruder more clearly into focus but there was a peculiar blurring effect, a fuzziness in the outlines.

Then it all fell into place and he laughed aloud. When he laughed the terror vanished. This real intruder was none other than himself, reflected in the full length mirror hanging on the wall. The room now righted itself, putting itself back together as it had been, the door in the correct wall, the mirror no longer mistaken for the door. His reflection was blurred because he didn't have his glasses on. Every mysterious aspect of his experience yielded to rational explanation as of course it must. And since it was still the early hours of the morning he went back to sleep, this time in his easy chair, awakening later that morning with the sun on his face, refreshed and ready for a successful experiment.

However, while some of the alpha particles passed through the gold foil, confirming that the atom was porous, and some were deflected, others bounced right back in cheeky defiance! What could possibly cause this? Simple, said Rutherford, there is another black box inside the atom, a little particle of hardness he called the nucleus. It would be necessary to bombard the nucleus with alpha particles in order that it surrender its secrets. Better instruments must be devised. What might be discovered if the nucleus was split?

What was not immediately apparent, but which quickly became apparent to almost everybody except Rutherford, was that his opening of the black box of the atom had hardly extended the dominion of Assured Reason one jot.

To begin with, Rutherford had been able to postulate a comfortable three particle atom, two positively charged particles for the nucleus, with negatively charged electrons in orbit. But soon more and more particles came to light. Particles! Anti particles! Virtual particles! Particles with taste, strangeness and spin. A particle zoo. As many particles as could dance on the end of a pin: a whole theology of particles, so many they became as embarrassing as the epicycles of Ptolemy. How could they be described as fundamental if there so many of them?

Then a new physical boundary to the rational world announced itself in the sinister form of Heisenberg's Uncertainty Principle which placed a limit on knowledge of events in the particle universe, the quantum realm. A particle may only be partially seen, as it were, between regions of blurry fuzziness. As well there was Schrodinger's unhealthy speculations that a cat, locked in a black box with a

murdering device set to go off at a randomly produced signal, cannot be said to be alive or dead until it is observed to be so. The insidious implication here was that these quantum events, events Rutherford had seen himself at close range, do not happen unless they are observed to happen. What sophistry! A contention cleverly protected from any verification, for how could a quantum event be not observed to happen, or observed not to happen for that matter? That was as absurd as Einstein insisting on the particle nature of light. How could you have a particle without mass?

Did these German's call themselves physicists?

Rutherford's black box turned out to be more like a Chinese finger trap for the emissaries of Assured Reason, despite Rutherford's protests. This ancient Chinese device consisted of a box containing carefully angled bamboo barbs. To relieve the pressure, the victim pushes his finger deeper, further entrapping it. Rutherford was already inside the circular logic of the quantum when he rejected Einstein's theory of the particle nature of light. Light could not be a particle since solid experiment proved that it was a wave; there was no arguing with diffusion patterns. Experiments set up to show the wave nature of light confirmed the fact. Einstein should have known better.

This trap was fully sprung when, some years later, Einstein's particle theory of light was confirmed by experimental observation. Now two opposing and contradictory theories were confirmed by experiment! Worse than this paradox was the suggested solution. Light was either a wave or a particle depending on the experiment you set up; look for particles and you find particles, look for waves and you find waves. That the universe might conform to expectation in this rather plastic and unpleasant manner held no appeal for Rutherford at all. Nor was it much comfort to say that somehow light is both wave and particle, manifesting these different aspects of its nature under different conditions, since, in this case, the real nature of light is left vague, hovering, as it were, between the two states in some mathematical fiction called a probability front, to be, like Schrodinger's cat, neither one thing nor the other until the universe calls upon it to make a choice!

What nonsense! The real nature of light retracts into another black box, this time made of mathematical formulae and hidden away in

abstract space. Thus, like conjurors stuffing the rabbit back into the hat and turning it upside-down to show there is nothing there, no trickery, these sophists who called themselves physicists would bundle light right out of the real world altogether, leaving Assured Reason in absolute darkness.

Small wonder Rutherford became impatient with it all. Small wonder, too, that Rutherford made no contribution to the great debate on the significance of quantum events that took place in the 1920s and 1930s, even today.

And how would he feel if he could see how it all turned out? How hard experiment was left behind in the heady plunge of theory. It was inevitable, from the moment Rutherford's alpha particles hit the gold foil that one day extrapolation and projection would take the place of costly experiment; scientists have recently calculated that to test for a graviton, predicted by quantum field theory and known to exact mass, would require a particle accelerator as long as the Galaxy is long.

How would he feel if he knew that the verities of hard fact, the feel of the pliers on the wire, had given way to the cryptic oracle of S matrix theory, mathematicians hovering over the entrails of particle scatter patterns to read the shape of the world. How would he feel to see reality itself become a speculative issue, known only by inference from the ballet dance of numbers?

How would he have felt about the discovery of the latest black box, the world of the superstring, as small in relation to the particle as the particle is to us? How would he have reacted to the notion that the world of particles, the world on which this physical, practical world is built, may be the interference pattern of vibrations caused by colliding strings, and that these strings must have, rolled up inside them as tightly as a swagger's blanket, six other dimensions, unseen, but required by the formalism of the equations?

Would he have refrained, stopped himself from going ahead with the experiment?

In the year of his death in 1937 all this madness lay before his beloved science, once the great bastion of Assured Reason; and although the writing was on the wall in Heisenberg's principle and Schrodinger's obnoxious speculations about dead cats, Rutherford was determined not to read it. He had forgotten, too, the dream he'd



had and the subsequent unpleasantness upon waking, and why shouldn't he? Why remember some momentary disorientation experienced after a foolish dream?

A few weeks before his death, however, he was reminded of this dream by another. It was an afternoon dream, occasioned by a doze in his favourite easy chair. He was sitting outside on the porch, a pleasant afternoon light playing through the trees. In this second dream he was compelled to visit his lab by a vague anxiety for the experiment. His dream-self remembered something very important. Someone had been tampering with the equipment! Months of painstaking work were in jeopardy. He hurried into the lab and straight over to the equipment, bending over it and checking it out. Nothing, it seemed, had been touched. The particle gun, shaped to direct the alpha particles, was still aligned. The gold foil gleamed in the half light. But his uneasiness did not go away.

There was somebody else in the lab. He turned slowly, taking in the room as he turned. The experiment must go on, the equipment defended at all costs. His old fear of errors slipping into the system returned. There will be no errors, he reassured himself, just as there will turn out to be nobody in the room. It was then that his dream-self remembered his earlier dream, and the confusion upon waking of mistaking himself in the mirror as an intruder. Something similar must have happened; hadn't he been asleep just now, dozing off in a large easy chair?

Before he had time to work out the ramifications of this, he saw the intruder, a large tired looking man asleep on a sofa in a corner of the lab. Since the memory of the early dream was still with him, it was not such a shock to recognize himself. He saw a vigorous, hard working young man crumpled in exhaustion.

How hard I worked in those days, the old man thought enviously.

Taking care not to disturb his sleeping image, he turned back to the equipment, allowing his eyes to rest with satisfaction on the exact alignment of the equipment. Tomorrow. Tomorrow, for that young man, history would be made. He focused on the strip of gold foil. Tomorrow, for that young man, the lid of the black box would open a fraction. Just then he noticed there was something different about the gold foil, something not right about the target. He leaned forward to

get a better look. From this distance, the strip of foil looked a burnished mirror. But it was not regular, as it should be, but somehow warped, like a crazy-house mirror, and in its distorted depths there was something moving, flickering, in a world of blurred edges. These flickering images he recognised, with shock, as human forms engaged in monstrous obscenities, murdering and copulating on a killing-floor of blood, all the while on fire, the fire eating through their skins and into their bones, writhing and twisting as if the flames themselves were copulating and murdering.

At the same time he became aware that the sleeping figure on the couch behind him was showing signs of disturbance, muttering and turning over. His dream-self understood that his younger self was having the very dream he had earlier remembered, was in fact right now dreaming that there was an intruder in the lab, a human figure hunched over the equipment. He had to warn this young dreamer, somehow, that there was something wrong with the equipment, with the foil. An error had crept in! Although securely mounted, the foil had somehow twisted. He must stop the experiment at once.

There was one thing that could prevent him from doing this; he might wake up before he could get the message across. Already his agitation was waking him up; the thought of waking up was waking him up. Before he woke up he heard his younger self rousing from sleep and he knew it was too late. He'd been foolish to think he could avert the course of events.

Rutherford opened his eyes, feeling the reassuring supportive bulk of the easy chair beneath and the dapple of sunlight and shade on his face, the familiar weight of his years. He smiled wryly at an old man's fears, prepared to admit to himself, now, that those days before the experiment had been fraught with anxiety. Anxiety caused by sleeplessness and overwork. The exacting requirement of keeping errors out of the system. He felt that surge of relief we all feel when we have dreamed something terrible has happened and wake up to find it is not so.

Of course there had been, in reality, nothing wrong with the equipment, with the gold foil; the experiment had proceeded successfully! He chided himself for his silly visions of blood and copulating flame, realized that the unsteady light outside, the chaotic play of light

and shade, the varying intensities caused by the clouds over the sun, had danced these shapes upon his retina through corpuscular, blood filled eyelids closed in slumber, thus transported directly into his dream and projected upon the gold foil. There was not and had never been any monstrous terror in the foil.

Then there was the matter of the dream within a dream, in which younger self had seen a figure dozing in the very chair he was now occupying, with the same play of light across its face, as if time had curled back on itself like a snake taking hold of its own tail and he could hold hands with himself across the years! This apparent anomaly soon gave way to rational analysis, however, since he had often sat in that chair, even as a young man, and so to dream of it hardly even stretched coincidence. There were no such oracles of the soul.

There was further relief to be found in this sensible explanation. Clearly what had happened was that he'd carried the memory of his earlier dream for all these years, only to have it surface again in this later dream. This explained why he should find, in his later dream, his own form sleeping on the sofa in the lab and not at home where he had really been. The later dream was simply inaccurate, placing his sleeping form in the lab, heedless of how it might have happened.

It annoyed him that his subconscious had not seen fit to honour historical record and have his younger self sleeping at home. In such small ways inaccuracies set in, errors develop. And yet it has to be, perhaps, for in this way, he meditated, dreams display their unreal nature, their subtle ability to falsify memory. If they did not we might be the more deceived by them. These blatant inaccuracies and distortions of the record were our safeguard, he decided, against us taking our dreams too seriously.

Likewise, the monstrosities he'd seen in the foil gave the dream away. By their distortions and absurdities, dreams are unmasked and the record remains untainted. Reality is the dividend. In 1902 the real Rutherford had risen, gone to the lab and conducted a successful experiment; no dream process had, or even could have, interfered with that. Historical record shows a clean spray of particles from that gold foil. Nothing else. So the 1937 Rutherford prepared to die happily, free of any visions of ghostly intruders, creeping errors, mal-aligned equipment, or the writhing and twisting of bodies in flame.