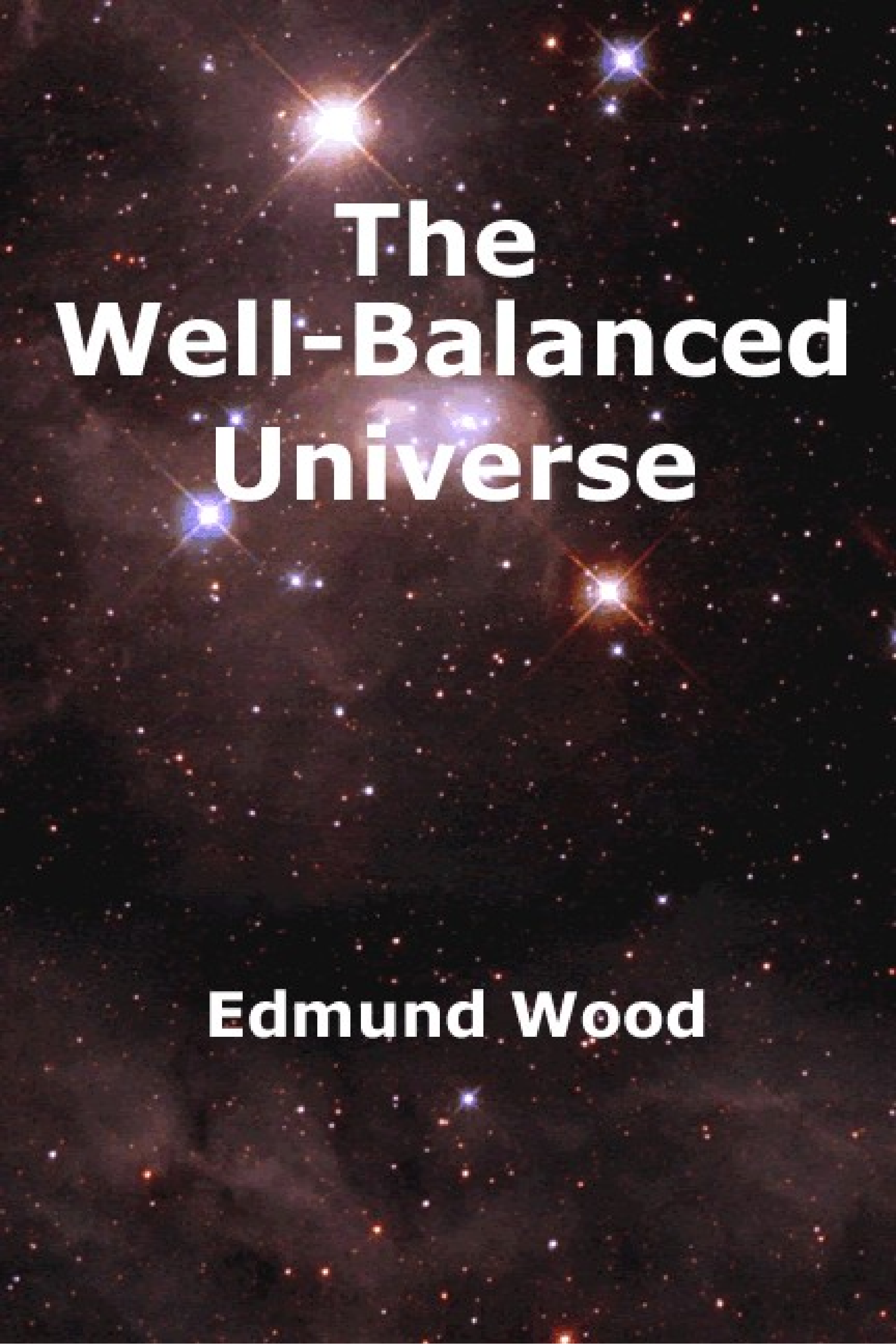

The Well-Balanced Universe

Edmund Wood

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by Edmund Wood

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Overview

If you want to produce an explanation of the cosmos, where do you begin?

It has become traditional since the time of Newton for theories about the universe to be based upon the law of gravity, because it is believed that gravity is the dominant influence acting on matter everywhere. The big bang theory, for instance, has been developed directly from Einstein's updated version of the law of gravity, the theory of general relativity. This procedure for explaining the universe has been adopted without question, despite the fact that the understanding of gravity on both the small and the large scale is incomplete.

Firstly, it has not been explained how gravity works on the level of particles — indeed, this has become the most important unsolved problem in physics. Secondly, there is no proof that gravity acts in exactly the same manner in other parts of the universe; it is simply assumed. Whenever observations have indicated that this assumption might be false, alternative explanations have always been preferred, however wild, rather than lose faith with Newton, general relativity and the big bang.

For example, it has been found necessary to invent two strange, invisible substances, known as dark matter and dark energy. Astronomers now believe that these alien materials make up 95% of the universe, and they have no idea what they are.

The article that follows presents a different way of understanding the universe. Instead of the law of gravity, the starting point is the law of energy flow, which is arguably even more fundamental, and is understood on the level of particles. The article explains this simple law with the aid of everyday examples, and it goes on to look at the energy flow in the Earth's environment.

The case is then presented that energy flow is the dominant process operating in the universe. The consequences of this proposition are explored, and they are found to be consistent with observation, without the need for any strange inventions.

At the same time, a more complete understanding of gravity emerges, some long-standing problems that confounded both Newton and Einstein are resolved, and the universe acquires a new sense of balance.

The Well-Balanced Universe

Law of nature

If you place a bowl of ice cream on a table in a room, it warms up. Put a cup of coffee there, and it cools down. These are examples of a fundamental law of nature that is so familiar and obvious we normally don't give it much consideration: *energy in the form of heat flows spontaneously out of hot objects and into cold objects*.

There is another way of saying this: *every system of matter and energy prefers to be in a state in which all its parts are at the same temperature*. Such a state is called "equilibrium", from the Latin meaning "even balance". If the above-mentioned ice cream and coffee are left, eventually they, the table, and the room will all reach an equal temperature and remain like that. Equilibrium is the most natural state for any system.

Strangely, our world does not seem to be in equilibrium. Far from it. Our bodies, our immediate environment, the atmosphere, the Earth's surface, its centre, space, the Sun's surface, its centre — they are all at different temperatures ranging from minus 270° Celsius up to 15 million° Celsius.

This is a puzzling state of affairs, but it is also fortunate. If there are temperature differences there will be a flow of energy, and life needs a flow of energy in order to exist — at the very least, for its chemical processes. At perfect equilibrium there could be no processes involving energy transfer of any kind. Furthermore, all information about the world would be lost. This is because at perfect equilibrium the frequencies of energy that are absorbed, radiated, transmitted, and reflected by objects all come to a perfect balance everywhere. Consequently, objects lose all their identifying differences, and everything merges into a bland, uniform glow.

In such an environment, life would clearly be impossible. So, the very fact that we are here wondering about the nature of our universe means that there must be one part of it, at least, that is not in perfect equilibrium.

How could this come about if equilibrium is the most natural state? How could our world contain objects with such different temperatures when we know that energy has been flowing backwards and forwards for billions of years? Did the universe start out so far from equilibrium that it still hasn't got there? Or is there something wrong with our understanding?

Law abandoned

The currently accepted explanation is particularly tortuous.

According to the big-bang theory, the whole universe exploded out of a speck of nothingness about 14 billion years ago. At first, everything had to be at equilibrium and at a very high temperature, because it was all so close together. However, if everything remained in equilibrium, no structures such as galaxies could form, because all the particles of matter would have been dispersing too uniformly, and so gravity everywhere would have been too evenly balanced. In order for matter to gravitate into galaxies in this rapidly expanding environment, the matter and energy of the universe must have abandoned equilibrium.

Of course, this goes against the law of energy flow as it stands, and consequently new concepts had to be created in order to make everything work out ("Quantum deviations of the Higgs field created inhomogeneities in the spacetime continuum") and no one is really sure yet whether these are valid. Meanwhile, after forming all the galaxies, and galaxy clusters, and galaxy superclusters, the universe is supposedly trying to return to equilibrium.

Start again

Such a complicated solution was necessary in order to keep a long-established theory intact. But what if we put aside any preconceived notions and take the law of energy flow on its own as the basis of our thinking? If we do that, then it seems to me there can be only one solution that makes any real sense: the universe must be in equilibrium now and always, despite appearances, because that is its natural state.

This means that the energy of the universe is in perfect balance from a "God's-eye" point of view, even though it appears to be out of balance from here on Earth. How can this be possible? To find out we need to take a closer look at what is going on in a system at equilibrium.

To start, let us go back to the ice cream and coffee that were abandoned on the table. By now, they and the other objects in the room are at equilibrium. This is not perfect equilibrium, because there is still a certain flow of energy through the windows, walls, ceiling and floor. However, this does not matter for our present purpose.

You might wonder how the objects in the room know at what temperature to be in order to remain at equilibrium. They know, because the particles they are made from are continuously exchanging energy.

The world of particles (a bit of light physics)

Every object is made up of particles, and these particles are in motion. Not only that, they are forever changing their motion. Any change of motion is called acceleration. This can be positive (speeding up), or negative (slowing down), and it can involve a change of direction.

In order to accelerate, a particle must absorb or emit energy in the form of an energy particle, called a photon. These energy photons travel at the speed of light, and they have a frequency like a wave — the higher the frequency, the higher the energy that they transmit. The ones with the lowest energy are called radio waves; then come microwaves, infrared, visible light, ultraviolet, X-rays, and, finally, gamma rays, with the highest energy. This sequence is called the energy “spectrum”.

So, the space between matter is not empty — it is full of photons carrying energy backwards and forwards. If a matter particle somewhere slows down, this has to be balanced by another matter particle speeding up in an equivalent way; the energy and other information for this is transmitted by a photon.

When a system of objects is not at equilibrium, the objects, of course, do not all have the same temperature. If one object is hotter than its surroundings, the particles it is composed of will have higher energy, on average, than those in neighbouring objects. Its particles will, therefore, be more likely to lose energy to the surroundings than to gain energy. The opposite is true for an object colder than its surroundings. This is the reason why everything tends towards equilibrium.

When a system reaches equilibrium, the energy exchange does not stop but continues to maintain a balance. All the matter particles are still relentlessly accelerating, but now they are just as likely to speed up as to slow down. It is all a matter of probabilities and of continuous adjustment.

Since the energy of particles in a system at equilibrium is governed by probability and not by certainty, the particles never all have exactly the same energy at the same time but have a range of energies. There will, however, be one energy that is the most likely, and this is determined by the temperature of the system as a whole: the higher the temperature, the higher the energy level attained by the greatest number of particles.

This means that at equilibrium there is a distinctive pattern to the range, or spectrum, of energy emitted by an object or a system. This emission spectrum has one brightest frequency, while other frequencies are successively less bright the further they are from the peak. In physics, for an obscure reason, this emitted pattern of frequencies at equilibrium has become known as “black-body radiation”. Instead, for clarity, I will simply call it “an equilibrium glow”.

A further consequence of the fact that at equilibrium all particles are still randomly accelerating is that, at each instant, an object is not necessarily emitting exactly the same amount of energy as it is receiving: there is still a chance that an object might, for example, receive slightly more energy than it emits, for a brief moment. If this happens, then in that instance, its particles will be slightly more likely to emit than to receive energy, because their energy level will be marginally higher than the surroundings.

The point is that, even at equilibrium, things are happening, slight changes are always occurring, adjustments are continuously being made, and everything takes time. If we had some sensitive-enough thermometers, it would be possible to detect very slight fluctuations in temperature between objects after they have reached equilibrium. Since photons travel at 300 million metres per second, these fluctuations would be fleeting.

The wider world

Such is the case with a system the size of a room, but what about the universe, where energy takes a very, very long time to travel across regions and between regions? For instance, it takes hundreds of thousands of years for photons to cross a galaxy, and millions or billions of years for them to travel from one galaxy to another. Any adjustments of temperature between systems at such separations would be on similar kinds of time scales.

When we look out at the universe from our vantage point we see galaxies in every direction, as far as we can see, and this visible light is part of an energy transfer from those systems to our system. However, these photons of light are not telling us about the energy changes happening in those systems now. The information the photons carry concerns events that occurred when they set out on their long journeys, and it is vastly out of date. By the time our local system gets this information and adjusts to it, all those systems have changed, and each by a different amount.

Consequently it can never be possible for everything to be at the same temperature at the same time. In fact, the concepts "same temperature" and "same time" become very woolly indeed on the scale of the universe, and this means that there is always uncertainty about the temperature of the universe.

The result of this is that the matter in each region is in a continuous process of adjustment of temperature towards the matter in all the other regions; these adjustments will be ponderous and eternal, like gentle undulations of a gigantic ocean.

Two opposite processes

The next step is to see how this idea fits with reality. To do this, we will examine what the universe should look like from inside these undulations and check whether there is any correspondence with what we see from here on Earth.

If all the matter in the universe is in a continuous process of adjusting its temperature towards the matter in the rest of the universe, then, in any one region, the matter there could be going through one of two opposite processes at any period: it could be either heating up towards the apparent warmer temperature of the rest of the universe, or cooling down towards the apparent colder temperature of the rest of the universe. This is similar to the way in which a part of the surface of an undulating ocean could be in the process of either rising or falling in relation to the rest of the ocean. (There is also a third possible state: the momentary pause as the processes swap over, like the crest or trough of a wave. In essence, this is a brief, tantalising experience of perfect equilibrium.)

So, what we need to do is to imagine what the universe would look like to an observer inside a region going through each of the two main processes, heating and cooling.

(At this point it might be helpful to note the distinctions between heating and hot, and between cooling and cold. A cup of *hot* coffee on a table is a *cooling* system, because it is losing energy to the surroundings. A bowl of *cold* ice cream is a *heating* system because it is gaining energy. At around room temperatures, objects radiate and absorb mainly at infrared frequencies, which come between microwaves and visible light in the energy spectrum. Infrared light is invisible to the eye, but there are cameras that are sensitive to it. In an infrared camera the cooling coffee would appear bright, because it is radiating energy; the heating ice cream would appear dark, because it is absorbing energy.)

Heating region

What could the universe possibly look like from inside a region of space that is heating up relative to everything else, in a universe full of other regions that are either heating or cooling (or momentarily in between)?

Well, the fact that the region is heating means that it is receiving more energy from the rest of the universe than it is giving out. This implies that, relative to matter in the local region, the background sky would be bright. Since the universe as a whole is at equilibrium, the background sky would have an equilibrium glow with a temperature higher than matter in the local region, and so with higher frequencies of energy.

Matter in the local region would generally be dark, because it is absorbing energy overall, and so it would stand out in silhouette against the bright background. However, this matter would be diffusing because of the overall positive acceleration of the particles in the region (heating matter expands). To an inside observer, it would seem as if some kind of repulsive force was acting between the matter.

Looking into the outer universe, other heating regions would appear dark and would be expanding, for the same reasons. They would appear as remote, dark splodges against the bright hot background, at all distances beyond the local region.

The cooling regions, on the other hand, would be bright, because they would be emitting energy overall. They would therefore be harder to recognise, because they would merge into the bright background. Nevertheless, it should be possible to detect them, because their radiation would not have the same pattern as the hot equilibrium glow from the background.

Since the local region is expanding, this would have the strange effect, to an inside observer, of making the outer universe appear as if it was contracting inwards. Of course, this would not be real, but would purely be an effect caused by the continual speeding up of matter in the local region relative to matter in the rest of the universe.

This picture of the universe is clearly nothing like our view from here on Earth, consequently there is no way that we could be inside a heating undulation of an equilibrium universe. The next picture, though, might seem more familiar.

Cooling region

As you probably will have guessed, everything in a cooling region is the opposite way round from a heating region.

Because a cooling region would be receiving less energy from the rest of the universe than it is radiating, the background sky would be dark, relative to matter in the local region. There would still be an equilibrium glow coming from the distant universe, but this would be cool, with an effective temperature lower than all matter locally, and with appropriately low frequencies. Inlaid into this dark, cold background would be bright objects. These would be cooling matter in the local region, as well as cooling regions in the distant universe.

The distant heating regions would appear dark, because they are absorbing energy, and so they would merge into the dark background and not be so obvious. One way to detect their presence might be to study the light arriving from bright, faraway cooling regions: this would no doubt have passed through occasional heating regions on its journey and be partly absorbed by them, leaving some tell-tale signature. Also, since the heating regions would be expanding, they would appear as relatively large bubbles of space, empty of any radiating objects, in between the bright cooling regions.

The matter in the local cooling region would be condensing and contracting together because of the overall negative acceleration of the particles there (cooling matter contracts). From the point of view of an observer inside the region it would appear as if there was some kind of force acting between the particles, attracting them together into clumps.

This continuous and generalised contraction of space in the local region would have the strange, relative effect of making objects in the outer universe appear as if they were moving away. Objects further away would appear to be receding faster than objects closer to, because their light would have been travelling for a greater proportion of the period during which space in the local region had been contracting. (Any light coming from before the local region began to cool would be merged into the cold background equilibrium glow.) Accordingly, it would appear as if the whole of the outer universe was expanding, but, of course, this would be an illusion experienced only by observers within cooling regions.

Familiar view

This picture of the universe is definitely more like the one we are used to. Our night sky is dark, and it is inlaid with bright objects — stars in our galaxy, and other, remote galaxies full of their own stars. In fact, our daytime sky would also be dark and inlaid with bright objects if there was no atmosphere to scatter the sunlight. This is confirmed by the experience of astronauts on the Moon: they saw the Sun and the Earth surrounded by a black sky in which stars were also visible.

It has been a matter of debate for many centuries why the night sky is dark. If you think about it, there is no obvious reason why it should be: if the universe is full of shining stars, then you might expect the night sky to be bright. In an equilibrium universe the explanation is simple: if we are living in a cooling region, then the rest of the universe will be absorbing more energy than it is giving, so the background sky should be dark.

Background glow

A further similarity with our view from here on Earth is the fact that we do see a low-temperature equilibrium glow coming from our distant universe. This was discovered in 1965, and it is only detectable with special telescopes that are sensitive to low-energy microwaves. The big surprise when it was discovered was that this glow had the same intensity and the same temperature in every direction; it was as if the whole universe was at perfect equilibrium with an effective temperature of minus 270° Celsius.

Astronomers call this glow the “cosmic microwave background radiation”. Their explanation for it is that it is radiation coming from the early universe just after the initial explosion — before equilibrium had to be abandoned. Because everything at that early stage was hot, they say that the expansion of space since then must have cooled the radiation to its present very low temperature.

In a cooling region of an undulating equilibrium universe, on the other hand, a low-temperature equilibrium glow coming from the rest of the cosmos would be expected to be observed, as explained. Also, if galaxies are the cooling regions or parts of cooling regions, they would naturally be present throughout the universe, and so there would be no need to break the law of energy flow and invent new concepts in order to explain their formation. Since galaxies are objects radiating into cold space they are certainly cooling systems.

It may seem difficult to think of stars, like the Sun, or systems of stars, like our galaxy, as things that are cooling. However, the process we are concerned with is somewhat more general than simply going from a higher to a lower temperature. The process of cooling involves all reactions going from a higher to a lower energy state, with the release of energy particles. This includes the nuclear reactions operating inside stars.

Expanding universe

The original reason that the big bang theory was proposed was to explain the apparent recession of the galaxies: in 1929, Edwin Hubble discovered that all galaxies outside our local group appear to be moving away from us and that the further away the galaxy, the faster it appears to be receding. This was interpreted to mean that the universe is expanding. If the universe is expanding, it was argued, then, going back in time, everything must have been ever closer together, and so denser. This in turn led to the idea of an explosion out of nothing at some finite time in the past.

None of this would be necessary in an equilibrium universe, because exactly such an impression of recession of matter outside the local region is predicted for an observer inside a cooling region. The continuous contraction of local space would make objects outside the region appear as if they were moving away; the further away they are, the faster they would appear to be moving because the longer their light would have been travelling during this contraction.

The fact that the galaxies in our local group do not appear to be moving away from us, but rather towards us, would imply that they are part of our local cooling region.

Uneven distribution

All other discoveries, too, seem to fit perfectly well with the idea that we are looking out from a cooling region of an equilibrium universe. For instance, in the 1970s and 80s, large surveys of galaxy distances and positions were carried out in order to produce three-dimensional maps of galaxy distribution throughout space. The revelation was that there are regions of the universe that are completely devoid of galaxies, like dark, empty bubbles of space; these were named “voids”. In between the voids are dense conglomerations of galaxies, named “superclusters”. The overall conclusion was that the universe has a distinctly foam-like structure. This is just what you would expect if the universe is made up of heating, expanding regions in between cooling, contracting regions.

Big bang theorists, on the other hand, had predicted that galaxies should be evenly distributed, so the surveys were an unpleasant surprise and caused a major rethink. The result has been the invention of two hypothetical substances called “dark matter” and “dark energy”. Dark matter makes space contract, and dark energy makes space expand. They each have to be distributed in the right places in the right amounts to produce the correct foam effect. This is achieved by trial and error using supercomputers running for weeks on end.

The main problem with this solution is that the proposed new substances cannot be made of normal, familiar matter or energy, otherwise they would be visible in some kind of telescope. Consequently, nobody knows for sure what they could consist of, though there have been several exotic inventions put forward.

Speeding up

In 1998, theorists received another jolt. Results came in from new and more accurate studies of the speeds at which galaxies appear to be moving away. These showed that galaxies further away (and therefore, supposedly, closer to the big bang, because of the time lag of the light) had lower speeds of recession than expected.

The theorists concluded that the rate of expansion of the whole universe must have been lower in the past than now. This was the exact opposite of what had been predicted. The expectation had been that the gravity of all the matter in the galaxies would gradually slow down their outward flight, thus making the rate of expansion *higher* in the past.

Surprised but undaunted, the theorists have simply dispensed a sufficient, extra quantity of dark energy throughout the entire universe, enough to counteract the gravity of the galaxies and make the universe expand at an increasing rate. In fact, so much dark energy is needed for this that it becomes the major constituent of the universe. According to the latest calculations, the universe must be made from 70% dark energy, 25% dark matter, and only 5% normal energy and matter.

Once again, the idea that we are inside a cooling region of an equilibrium universe would fit perfectly well with the observations, without any tinkering. In this picture, the apparent expansion of the outer universe is a relative effect caused by the cooling of local space. This cooling would be expected to be lower in the past, because the region would have begun to cool gradually, and then more rapidly — in the same way that a wave builds up gradually at first and then more rapidly. This would make the apparent expansion of the universe increase.

Sometime in the future, the rate of cooling would be expected to ease off back down to zero as the region prepares to change over to become heating — part of the endless cycle. From the point of view of someone inside the region, the universe would then appear not only to stop expanding, but also to come to an end as the cooling ceases, because all normal processes would gradually come to a stop, and all information about the universe would then be lost in a total equilibrium glow. The region would experience a brief taste of perfect equilibrium with the rest of the universe at the point of changeover, before starting to heat up.

Looking back

For a similar reason, the universe would also appear to have a beginning, to the inside observer. This "beginning" would be the moment just before the region began to cool. The cause of this illusion is that information from everything beforehand would be lost in the background equilibrium glow coming from the previous changeover time. Although such an impression would clearly be false from a God's-eye point of view (wherever that is!), for the observer it would seem real.

One set of observations in particular that supports this is the discovery that our galaxy and the universe both have the same apparent age. The age of the galaxy is estimated from the nuclear-burning state of its oldest stars; that of the universe, by measuring the rate of its apparent expansion, and then working backwards to the time when everything should have been in one place. They are both close to 14 billion years.

This result makes sense if our galaxy is a cooling region in an equilibrium universe, or part of one, because the illusion of expansion of the universe would have begun at the same time as the region started to cool.

In the big bang theory, this equivalence is rather awkward, because it means that in the young, expanding universe our galaxy must have started to form straight away. Since astronomers don't like to think that our galaxy is somehow special by being the first to form, they say that *all* galaxies must have started to form at the same time straight after the beginning of the universe.

Unfortunately, this explanation is becoming harder to justify. It seems that however far away astronomers look with the latest telescopes (and so however far back in time), they find mature galaxies full of old stars: they can find no period when there were only young galaxies. Also, there just doesn't seem to be enough time for the mature galaxies to have formed after the assumed initial explosion. After all, our galaxy has taken 14 billion years to form so far, and it is still not full of old stars. To make matters worse, some galaxies in the nearby universe (which, therefore, have had a long time to mature) have been found to be full of only recently formed stars.

The theorists explanation for all this is that some galaxies must have been forming very, very quickly and others very, very slowly, for some unknown reason.

The weight of history

Probably the most intriguing prediction for a cooling undulation of an equilibrium universe is that the overall negative acceleration of particles of matter in the region would make it appear as if some kind of force of attraction was operating there, causing matter to gather into clumps. Could it possibly be the case that what Isaac Newton called a “force of gravity” and what Albert Einstein called a “curvature of spacetime around matter” is really an effect produced by the process of cooling?

Most people seem to believe that the present understanding of gravity has been proved beyond reasonable doubt and so there is no need to look further. In fact, both Newton and Einstein were plagued by problems with gravity after they had published their theories, and these problems have never been satisfactorily resolved.

When Newton explained his Universal Law of Gravitation in 1687, he described it as a force that acts between all particles of matter according to the same formula everywhere in the universe. He had come to this conclusion by observing the way objects fall on Earth, and the way the Moon, the planets and comets move in orbits in space, and by realising that the same effect was operating in both environments.

To Newton and to everyone else this was an astounding revelation. Previously it had been believed that objects and processes on Earth were completely separate from those “in Heaven”. So it is not surprising that Newton thought he had stumbled upon a universal truth although he had no evidence from outside the Solar System.

Newton was proud of his achievement, but there were two niggling difficulties with his theory which he couldn't entirely dismiss. The first was that the concept of a force had always before been applied to the pushing and pulling of objects through some form of physical contact, and he could not explain how his force of gravity could act from one body to another across completely empty space.

The second was that, if gravity acts in the same way everywhere in the universe, then all the stars and everything out there should fall together into one clump. This was clearly not happening, and so there had to be something wrong somewhere.

Despite much effort, he was never able to resolve either of these problems.

New image

Einstein needed to revise Newton's gravity in order to make it compatible with his theory of relativity. He completely changed the concept, and the mathematics, but he fully endorsed Newton's belief that the effect was universal. The result was called the "general theory of relativity" and was published in 1915.

Einstein had cleverly circumvented Newton's first problem. Gravity was now no longer a force but rather a "curvature in the geometry of space and time" caused by the presence of mass. It was believed that this removed the need to explain how gravity acted across empty space.

Newton's second problem turned out to be much more stubborn. When Einstein subsequently applied his equations to the whole universe, he discovered, to his utter annoyance, that it would be unstable and everything would still collapse into one clump.

Overcoming gravity

Help was at hand. Alexander Friedmann in Russia and George Lemaître in Belgium both demonstrated that Einstein's equations could produce a universe a bit more like the real one if it was expanding, because this would at least delay the collapse caused by universal gravity and could even overcome it.

At first, Einstein dismissed this idea, because an expansion of the universe would require some kind of cause itself, which created more problems. Then Hubble made his discovery of the receding galaxies and this seemed to support the expansion hypothesis, so Einstein changed his mind. It was some time later that the idea of an explosion-out-of-nothing was put forward by the physicist George Gamow as a way of causing the expansion.

Everything then seemed to be satisfactorily resolved. Well, almost everything. There were a couple of slightly-worrying, new consequences of his theory that Einstein hoped to iron out, given time.

Full of holes

The first of these came from the work of a German astronomer, Karl Schwartzschild. He showed that, according to Einstein's equations, if any massive object, such as a star, could be compressed within some small radius which would depend on its mass, then it would continue to collapse, unstoppably, into itself. The result would be the space equivalent of an infinitely deep well out of which nothing could escape, not even light. Such an entity has become known as a “black hole”.

It has been calculated that when a star with more than only about ten times the mass of the Sun runs out of nuclear fuel at its centre, it will collapse under its own gravity at an accelerating rate, producing a black hole with infinite density at its centre.

Accordingly, our galaxy must already contain a great many of these monsters. If any matter gets too close to one, the matter will be sucked in by gravity and disappear forever; at the same time, the black hole will increase in mass and power.

The other consequence of his theory that still worried Einstein was that the universe itself must be like a black hole in reverse. If the universe has been expanding all the time, then, going back into the past, it must have been ever denser. According to the equations of general relativity, the universe must have started out with infinite density. This means that either the matter and energy of the universe has done the impossible and somehow escaped from a black hole, or else we, and everything else, are still inside one.

Infinite problems

Einstein was not so much concerned about the prediction of the existence of strange entities, but rather that his equations were predicting infinite quantities. Infinite quantities may be manageable on paper, but in the real world they are impossible. As the famous physicist Stephen Hawking puts it in his book *A Brief History of Time*: "General relativity, by predicting points of infinite density, predicts its own downfall."

During the rest of his life Einstein made various attempts to sort out the problem. Unfortunately, he never succeeded, nor has anyone else. General relativity is, nevertheless, the accepted theory of gravity. This is because the great majority of physicists (famous and otherwise) believe that when the problem of the infinities is sorted out, the only thing that will change will be our understanding of what happens when matter becomes extremely dense, and that therefore the general understanding of gravity will remain unaffected.

Universal matters

By the time that Einstein published his theory of general relativity, some evidence had been gathered that gravity operates in a similar way outside the Solar System. The clearest confirmation had come from the discovery of binary stars in our galaxy: these are pairs of stars that orbit each other — a motion obviously caused by some sort of attraction between the stars. There was also some rather vague evidence that all the stars in our Milky Way galaxy might be orbiting about a central point.

At that time it was generally believed that the whole universe was contained within our galaxy. It was not until 1924 that Hubble proved that some tiny clouds were really separate galaxies of stars far outside our Milky Way. There were then indications that these systems of stars were rotating, which could imply that they were held together by gravity of some form.

So, all that was known was that there appeared to be some form of attraction operating in these various remote places. There was still no proof that whatever was happening complied with either Newton's or Einstein's equations. To prove that, it would be necessary to know the exact masses of the objects, the distances apart, and the rates of motion. In many cases the distances apart and the rates of motion could be estimated fairly well, but there was no way of knowing the true masses.

This problem remains to this day. The reason is that the only way of knowing the true mass of an object is either to weigh it, or to accelerate it with a known force. This is clearly not possible for heavenly bodies. It is certainly true that astronomers estimate the masses of stars, planets and galaxies, but in almost every situation they do this by first assuming that the equations of gravity are correct, and then using the equations to get the masses from the known distances apart and rates of motion. Since they have already assumed that the equations are correct, they cannot then use these masses to prove that the equations are correct.

There is, however, one independent way of estimating a value for the mass of an object. This is to measure the amount of energy the object is radiating and then to compare the amount with the energy and mass of the Sun. This still doesn't give a true mass, because the mass of the Sun is calculated by using the equations of gravity; nonetheless, the comparison can be useful.

Astronomers have estimated the masses of stars and galaxies in this way, and they have compared the masses with distances apart and rates of motion in different systems. The results have surprised everybody. For many situations in our galaxy, for all other galaxies, and for all galaxy clusters, the equations have failed miserably. The discrepancies are large: in order to come close to validating the equations, the masses would need to be anything from ten to 400 times higher than the estimates, depending on the system under investigation.

Wild card

Despite these results there have been no headlines yet stating that Newton and Einstein were wrong. To most astronomers and physicists that is unthinkable.

Instead, it has been decided that the masses of the systems studied really are as high as they should be and the systems are just not radiating sufficiently. The explanation put forward is that they must contain a lot of dark matter (which is supposed to have mass without radiating at any frequency).

This way of thinking is succinctly stated by the physicists Michael Riordan and David Schramm in their book all about dark matter *The Shadows of Creation*: "As we peer out to still greater distances, we discover that even more of the apparent mass seems not to be there." And they continue: "It's not the mass that is missing (if we believe Newton), but the light! The mass *must* be there to make the galaxies move as they do; it is simply not shining."

The results have been seen as strong support for the existence of dark matter, even though nobody knows what the sinister substance is made from. At one time, black holes were thought to be a possible candidate, because they would have mass and be invisible; but calculations showed that there would have to be so many of them that they would interfere with starlight in a way that is just not observed.

Other dark objects are ruled out for the same reason, and also because they would radiate at some frequency, such as infrared or microwaves, and so would be detectable. The currently favoured possibility is that there is a new particle waiting to be discovered which has mass but cannot be observed with any of our instruments.

The idea of dark matter has been around for a long time now and it has become an essential ingredient of modern cosmological theory. Only occasionally can you come across any hint of doubt about its validity. An example is the small let-out clause tacked onto the end of astronomer Scott Tremaine's commentary on a fundamental paper about dark matter in *The Astrophysical Journal Centennial Issue*: "Despite its many successes, dark matter suffers from two nagging problems. First, we have no idea what it is, although many candidates have been ruled out. Second, we cannot exclude the possibility that the apparent evidence for dark matter really indicates a breakdown in the laws of general relativity at large scales and low accelerations."

Perhaps Tremaine should have a chat with some physicists, because they believe that general relativity must break down at small scales and high accelerations.

Hidden error

So, what could be wrong?

The most obvious answer is that both Newton and Einstein were at fault in assuming that their equations applied to the whole universe. The equations were very accurate close to home, but that was no proof that they were universally correct. Making a generalised statement about a whole class of objects based purely on evidence from a small sample is a common cause of error. In this case, the sample was, proportionally, very small indeed: one star-planet-moon system out of how many in the universe?

Of course, it made matters a lot simpler to believe that gravity was the same everywhere, because otherwise there would have to be something else going on — some unknown factor causing the variability. It is understandable that the two scientists wanted to believe that they had sorted out gravity.

When we take off our gravity hat and put on our energy-flow hat, this fault becomes even clearer, because an extra factor immediately comes into the picture: the rate of energy flow. The rate will vary across a region, and it will vary during the time that a region goes through its cooling phase.

When the cooling stops, the flow throughout the region will be zero and there will be no gravity. When the region becomes heating, everything is reversed, and the force will appear repulsive instead of attractive — matter repelling matter, or "negative gravity". (Really, it should be the gravity in cooling systems, like ours, that is called "negative", because the acceleration is negative.)

Problems disappear

If gravity is caused by a variable rate of energy flow, all the problems of Newton and Einstein can be resolved.

How the apparent force acts across completely empty space is explained by the exchange of energy particles; these particles exchange the loss of energy in a cooling system and the gain of energy in a heating system. The reason everything doesn't fall together into one clump is because attractive gravity is balanced by repulsive gravity overall. There is no infinite density at the beginning of the universe, because there is no real beginning — certainly no beginning where everything is in one spot.

Even the infinite density of a black hole disappears. This is because gravity is now not caused by the presence of mass, but rather by the flow of energy through mass: in a cooling system, energy is dissipating out of matter, leading to negative overall acceleration.

When matter in a cooling system clumps together into an object the size of a star, it is possible for a phase of nuclear cooling to occur: the atoms of hydrogen drop to a lower energy level by combining to form helium and releasing nuclear energy. This energy release temporarily gives nearby atoms of the star some positive acceleration before it dissipates, and this produces a pressure inside the star which balances the gravity for a period of time.

In large stars, it is possible for atoms to combine to form heavier elements all the way up to iron — the element with the lowest nuclear-energy state. In such stars, a core of iron builds up, and it can become large enough for a new phase of cooling to occur.

In this cooling process, the protons and electrons from the atoms combine to form neutrons with the release of high-energy photons, plus some other, highly-penetrating, particles called neutrinos, which also carry away energy at the speed of light. The remaining product is called a neutron star.

Occasionally, the remaining clump of neutrons can be large enough for a still-further phase of cooling to occur. According to general relativity, this is where a black hole forms, because gravity becomes so strong that the matter cannot stop collapsing, becoming infinitely dense, and preventing even light (or any kind of energy) from escaping.

In the energy-flow universe, this is impossible, because it is the dissipation of energy that *causes* the gravity. If the dissipation of energy itself is reduced by the extreme nature of the gravity, then the gravity is also reduced. This means that a black hole *cannot* form.

Instead, the matter at the centre has no choice except to convert completely to energy, because there is no denser state of matter left. The result is one of two alternatives, depending on the amount of matter outside the centre: either the entire star explodes in a flash of gamma rays and neutrinos; or else a temporary balance is reached between the collapse of matter outside the centre and the dissipation of the energy, creating some new kind of star-like object. Either way, these options represent the ultimate cooling phase.

Powerful stuff

There are two observed phenomena that could support this idea. First, powerful gamma-ray flashes have been discovered coming from the distant universe at the rate of about one per day. These are called "gamma-ray bursts", and they are known to be the result of some kind of gigantic explosion; they are very brief, lasting somewhere between a fraction of a second and a few minutes. (At present, it is not possible to check for a corresponding flash of neutrinos, because there is no telescope that can focus these particles or even determine their direction accurately.)

Second, extremely energetic, star-like objects, called “quasars” (short for “quasi-stellar objects”), have been found in remote galaxies. These quasars are the most powerful entities so far discovered in the universe, outshining their entire host galaxies (containing billions of ordinary stars) a hundred times over. Nobody knows for sure what they are, but the fashionable explanation is that they are super-massive black holes gobbling up Sun-sized hunks of matter delivered on the space equivalent of an inward-spiralling conveyor belt.

Negative energy

There is a further long-standing puzzle that disappears when it is accepted that gravity is caused by cooling. This has to do with the concept of negative energy.

When a weight is raised up from the ground it is said to possess a certain amount of gravitational energy. The higher the weight is, the more gravitational energy it stores. If the weight is released, the gravitational energy is converted to energy of motion, which can be used to do work (or can cause damage).

What puzzled physicists about gravitational energy was that, although it always increases as you move the weight further and further up, at infinity the energy must be zero. The reason for this is that at infinity there is no pull of gravity from the Earth, and so there can be no gravitational energy — it would be just the same as if the Earth wasn't there. So, if the gravitational energy of the weight was increasing *up to* zero, then the energy must be negative, because only negative numbers can increase up to zero: -2 is less than -1, which is less than 0.

The idea that an object could possess negative energy always seemed rather strange, and nobody knew what it meant. However, in a cooling system of an energy-flow universe, it makes sense, because here gravity is caused by a continuous *loss* of energy. Loss of energy — like the loss of anything — is, naturally, negative.

You have to go to a heating region to find positive gravitational energy: there, the energy increases *away from* zero at infinite separation, because you have to put energy in to bring repelling matter closer together.

Proof

You may be thinking that, if conventional gravity is caused by cooling, then this would have been discovered by now. After all, you say, gravity must have been tested experimentally in countless ways over 300 years, and so such an effect would surely have been spotted?

Certainly, experiments have been done to check whether the temperature of objects makes a difference to the pull of gravity (with a negative result); but, as far as I can tell, no one has ever tried to find out whether a *changing* temperature causes an effect.

This is not too surprising: for one thing, it is a somewhat obscure effect to test for; and for another, any such experiment would be very tricky indeed.

The problem is that the attraction between two laboratory-sized masses is extremely tiny, even when they are almost touching each other; so any experiment has to be done in strictly controlled conditions if you want accurate and reliable results. Constant temperature is one of the most important criteria, because any part of an experimental apparatus could expand or contract if the temperature changes, causing spurious measurements.

It would, therefore, be very difficult to accurately measure the attraction between two masses that are both in the process of either heating up or cooling down. Nevertheless, experimental scientists are clever people, on the whole, and no doubt they could profitably set their minds to such a task if they were to deem it worthwhile.

Weird worlds

The energy-flow universe may seem dull without dark matter, dark energy, black holes or a big bang at the beginning, but it makes up for these with the heating regions, where all processes are the opposite of what we are used to. The conditions in these environments would be so alien that it is difficult, if not impossible, to imagine what they would really be like.

The predominant process in cooling environments, like ours, is condensation: matter is losing energy, clumping together and getting denser. Even the nuclei of atoms are condensing in the centres of stars. Ultimately, matter is converted totally into energy in the form of gamma-ray photons and neutrinos. Meanwhile, all the energy dissipates into cold, dark space.

Where does all this energy go? It goes, of course, to the heating regions. There, the predominant process is evaporation: energy is flooding in from a hot, bright space; matter is heating and dispersing; solid objects break up, molecules break up, even nuclei of atoms break up — heavy elements split into lighter elements, all the way back down to helium and hydrogen. Ultimately, pure energy is converted back into matter: in the deepest depths of heating regions, gamma-ray photons and neutrinos recombine to form neutrons.

Each neutron will then decay naturally into a proton and an electron, which together make an atom of hydrogen. (This happens to neutrons when they are not part of the nucleus of an atom.) This is why there is so much hydrogen in the universe.

The first stars

The currently accepted explanation for all the hydrogen is rather different. In the big bang theory, after the initial explosion, the universe was a hot expanding soup of particles, which cooled and condensed in a short space of time to mainly hydrogen, some helium, and a tiny proportion of lithium. Nothing else was created then, and all the rest of the elements formed later in the centres of stars. Consequently, in this picture, the first stars that assembled were composed purely of this mixture of the three lightest elements, when they started shining.

Therein lies another problem.

The vast majority of stars are relatively small. Small stars last a long time, because their centres do not get so hot and they use up their nuclear fuel slowly; even though they have less fuel, their lifespan is much greater than that of larger stars, which race through their nuclear processes. Most of the stars in our galaxy, for instance, are small and have a life expectancy greater than 14 billion years — the estimated age of both the galaxy and the universe at present.

What this means is that, by rights, most of the first stars that formed in our galaxy should be around today, still shining. Also, they will be recognisable by the fact that they have only hydrogen, helium and lithium in their outer layers, if the big bang theory is correct.

Astronomers can determine the constituents of a star's outer layers by analysing the spectrum of its light. Try as they might, though, they have been unable to find a single star with no heavy elements, and this has been a cause for serious concern.

No problem for the energy flow universe. In this picture, our galaxy did not start producing its first stars from an explosion out of nothing but from the products of what used to be a heating region. And this heating region itself formed from the products of what used to be a cooling region. And so on, back and back.

A heating region may be evaporating its constituent matter back towards a purer mix of the lightest elements, but it is unlikely that all of the atoms of the heavier elements will have been changed by the time the cycle switches back to cooling again. Thus, the first stars that formed in our galaxy would be expected to have a trace of the heavier elements in their outer layers, just as observed in the oldest stars found by astronomers.

Particles with purpose

Since the first neutrinos were discovered in 1956, these have been the most enigmatic of particles. They are released in nuclear reactions and are produced in vast quantities in the centre of the Sun and of every other star. Each second, billions of neutrinos pass through every square centimetre of your body — day and night. They are so reluctant to interact with matter that they travel straight out of the Sun, right through the Earth, and through you, virtually unaffected.

Only very, very occasionally does a neutrino interact with a particle of matter. (The fact that a few do interact made it possible to prove that they exist.) It has been estimated that a neutrino could travel through several *lightyears* of lead without being affected.

This simply makes you wonder where all the neutrinos go to. It had always been supposed that they must wander the universe forever, increasing in number all the time. Now, in the depths of heating regions in the energy-flow universe they have a real destination and a purpose (recombining with gamma rays to produce neutrons and hydrogen). This makes much more sense.

Into the limelight

Possibly the strongest evidence for the heating regions is the presence of the voids. These vast expanses of space empty of galaxies have stumped astronomers since their discovery. Virtually nothing is known about them, and it has simply been assumed that they contain a sparse mix of normal matter and dark energy.

In a way, this is not too dissimilar from the energy-flow view, because a heating region contains normal matter dispersing under the action of positive gravity, which is the continuous exchange of energy gain. The difference between the two viewpoints is that in the energy-flow universe the regions are heating, while in the big-bang universe they are not. Furthermore, for the big-bang theorists the voids were an embarrassing discovery, and they had to be accommodated by means of an awkward and hasty reshuffling of ideas; whilst, in an energy-flow universe they are a predicted entity and, indeed, play a starring role.

Long journey

We have come a long way from the bowl of ice cream and the cup of coffee. And yet everything has been based on the same simple law of nature — that equilibrium is the preferred state of matter and energy.

We started out with the premise that the universe is at equilibrium now and always. It was shown that this is possible, despite the different temperatures in our local environment, because equilibrium is a dynamic state maintained by continuous adjustments of temperature on all scales, and so we could be inside a region that is undergoing such an adjustment.

This idea was then put to the test by imagining what the universe should look like from inside a region that is either heating up or cooling down towards the temperature of the rest of the universe. It was demonstrated that all observations could be accounted for if we are inside a region that is cooling.

It even emerged that, by accepting this perspective, gravity could be explained in a new way, and some long-standing problems could be resolved.

When everything is considered, it is remarkable how many observations and facts seem to correspond with this alternative way of understanding the universe: the darkness of the night sky, the low-temperature background glow, the apparent recession of the galaxies, a recession that appears less in the past, the existence of regions empty of galaxies, the foam-like appearance of the universe, the general abundance of hydrogen, the absence of stars with no heavy elements, the apparent variations of gravity in other galaxies and regions, remote gamma-ray flashes, and powerful star-like objects. To this list can be added the important consideration that there are no infinite densities predicted.

Also, from an aesthetic point of view, the energy-flow universe possesses an element of symmetry — something sought by philosophers in the past when trying to formulate an understanding of the cosmos.

We must wait, though, for appropriate experiments with gravity in order to find out whether we really do belong to this well-balanced universe.

◇

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About the Author

Edmund Wood is an amateur astronomer and an astronomy writer. Brought up in the wilds of Lancashire, England, he became interested in astronomy at an early age. Unfortunately, although his school possessed an observatory with a large, historic telescope, this lay abandoned and unused: the pupils were not allowed near it, and they were taught nothing about the subject.

His first knowledge of the big bang theory came from a book he picked up in the library at the age of 12, and he didn't believe it. As he says, “The idea that the entire universe was expanding just didn't make sense to me; and creating everything that exists from an inexplicable explosion seemed ridiculous.” The book also explained Fred Hoyle's steady-state theory, and he thought that sounded more plausible, even though, despite its name, it also involved an expanding universe.

Good at maths at school, he went on to study computer science and mathematics at Bristol University. He then dropped out from the technological revolution and the rat race and became a gardener, eventually joining an organic farming community in Cornwall. It was there that he started to write.

“I was reading astronomy books again, and I became frustrated by the stereotyped accounts of the universe,” he explains. “I could see that there were inconsistencies in the big bang theory, and yet it was repeated everywhere without question, like a litany. So I decided to write my own version of events.

“Once I get my teeth into a problem, I don't let go until it's sorted. I read everything I could get hold of about the relevant astronomy, physics and chemistry for the best part of 15 years. I had to sift through an awful lot of extraneous information to get what I needed — especially in the thermodynamics: 'seeing the wood despite the trees', you might say.”

He met his partner, Martina, at Land's End Youth Hostel. They now live with their two sons, Eamon and Silas, on an island in the Baltic Sea. He still hasn't bought a computer — “purely for financial reasons”.

The Birchley Hall Press

In 1624 a book appeared on the market called “Foot out of the Snare”. Its author, one Gee, wrote: “There was a printing house in Lancashire suppressed about three years since, where all Brereley's works, with many Popish pamphlets, were printed.” That press, says Gillow, was undoubtedly secretly set up and supported by the Anderton family of Birchley Hall, Lancashire. “Among the Blundell of Crosby MSS,” Gillow continues, “is a list of works ascribed to Roger Anderton by his son Christopher in 1647; and it is therefore pretty clear that Roger Anderton set up the press at Birchley.”

About 19 titles published between 1615 and 1620 are associated with the Birchley Hall Press in the English Short Title Catalogue of the British Library. The Birchley Hall Press was resurrected in 1951 in the same building, free of the English religious persecutions of the early 1600s, but with similar aims, with the publication of “This is the Faith”. The text above is taken from the back cover of that book. A few further titles were published up to at least 1960, including “A Flame for Africa” (1953) and “Liverpool's Hidden Story” (1957).

The Birchley Hall Press is resurrected a second time, free of any religious association, to keep alive the memory of those early publishers and authors who showed immense courage and suffered great hardship to support their beliefs. It is starting with a challenge to mainstream cosmology, maybe with a bang, but obviously not a big bang.

Birchley Hall is now a care home for elderly people, run by the charity Sue Ryder Care. More information can be found at: www.sueryder.com/birchleyhall/

Harry Wood, Farnborough, 2007.