Translated excerpt

Stefan Klein
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Von der Schönheit des Universums

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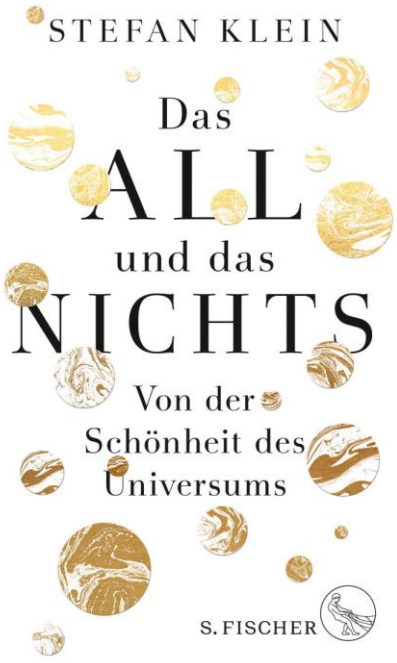
Stefan Klein
Space and the Voide. On the Beauty of the Universe

Translated by Simon Pare



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The world spirit founders

A hurricane sweeps through Germany,
yet nobody saw the storm coming.
Reasons for the world's unpredictability
and praise for the universe's powers of creation.

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A crime story

A notorious gang ransacks flats in London and New York.
The burglars actions' are perfectly coordinated,
even though they had no way of contacting each other.
Detective Glock searches for a secret plan
but cannot find one. He concludes that
everywhere in the world is actually one and the same place.

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Is the world real?

A hammer hits a thumb, but, like all matter,
the hammer is made up of emptiness.
How can nothingness cause so much pain?
And does nothingness even exist?

7

"Who ordered this?"

We live in a shadow world. Wherever we look
there is twenty times more than we can see.
More what? We have no idea.
But if dark energy and dark matter didn't exist
neither would we.

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How time passes

A greying beard makes us ponder
the irreversibility of time. We experience
its passing because we are not omniscient.
The universe ages too.

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Beyond the horizon

Night is dark
because the world had a beginning once.
The universe has been expanding ever since.
Space is bigger than we can imagine.
Some thoughts on wonder.

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Why we exist

Every one of us is proof of one of the most astonishing
features of the universe: intelligent life
is not only possible, it is in fact probable.
So how can anyone still claim
we are insignificant?

Notes

Acknowledgements

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The poetry of reality

A rose shows
that nothing and nobody exists on their own.
Yet the more we learn about how the universe works,
the more mysterious the world seems.

The more we know about reality, the most mysterious it appears. Surprisingly, sensitive people are most likely to dispute this. A famous German poet once protested during a panel discussion with me that our ever more precise knowledge of the human gene sickened him because a completely decoded human being would be a bore. Edgar Allan Poe, the American master of mystery, labelled science a predator on poetry:

> Why preyest thou thus open the poet's heart,
> Vulture, whose wings are dull realities?

How wrong he was! Poets are quite right to fear an existence stripped of all mystery, but those who harbour this fear has mistaken the exploration of the world for an Easter egg hunt, with every hiding-place ultimately discovered and emptied. True research, on the other hand, regularly raises more questions than it answers.

An artist friend once asked the great American physicist Richard Feynman whether a scientist, through his research, didn't destroy the beauty of a rose. Feynman replied that he appreciated its beauty as much as the artist, but he also saw a deeper beauty that could only be revealed through understanding, for example, that as they evolved, the colours in flowers evolved in order to attract insects. This knowledge in turn threw up new questions, such as whether insects have an aesthetic sense. Greater understanding did not subtract from the rose's beauty; indeed, it only added to its beauty, lending the rose even greater awe and mystery than before.

Feynman might have continued that the keen eye of the scientist reveals beauty even in something that strikes us as ugly or indeed repellent at first sight. The

withering of a rose is a sign of decline, but if you look carefully you'll see the rosehip growing at the bottom of the fading bloom. Every grain in the fruit is a marvel in its own right, for in every little nut slumbers the complete embryo of a rose, waiting for the moment when it will suck itself full of water and expand, when the seedpod will burst and the cotyledons unfurl.

The germinating rose requires light, water and oxygen to grow. The air it breathes was left by creatures long dead, a legacy of single-cell organisms that covered the sea floor in thick, blue-green layers over three billion years ago and still live there to this day. There was hardly any oxygen in the Earth's atmosphere back then, and any higher life form would have suffocated. The single-cell organisms measured only a few thousands of a millimetre. These creatures, known as cyanobacteria, might seem extremely primitive when compared with a rose, and yet they were early masterpieces of nature. Some cyanobacteria can even see! Their bodies contain a tiny lens that allows them to distinguish light from dark. They avoid darkness and move towards the light. They use sunlight to produce energy by photosynthesis as modern plants do. When cyanobacteria colonised the primeval ocean, they converted the carbon dioxide dissolved in its waters into oxygen, and for a billion years this oxygen bubbled up to the surface from the ocean depths. So cyanobacteria created the air that makes the rose germinate. They made the Earth inhabitable for higher forms of life.

Cyanobacteria themselves had evolved from earlier, simpler forms of life that were could also get by without oxygen. These unidentified organisms colonised the Earth 3.8 billion years ago. Without them we would never have had the chance to see a rose. So where did those life forms come from? We don't know.

And where does a rose get its water from? Water too has a history, and it stretches back even further into the past than the history of air. For a long time we contented ourselves with the observation that steam had seeped out of the interior of the Earth during our planet's infancy. But where did the water in the Earth's interior come from? It could only have been sealed inside when the Earth was born. Four and a half million years ago, rocks and dust revolving around the Sun condensed into the planets, and the Earth was formed from material floating close to the Sun. However, it is almost

impossible that this rubble was moist enough to turn the Earth into the blue planet: the heat from the nearby Sun must have dried it out.

So the Earth must originally have been dry, a desert planet. We don't know exactly how it was transformed into a world of oceans. The most fantastical scenario of all the possible explanations is actually most plausible: water came to us from outer space, piggybacking its way from colder parts of the solar system on comets and asteroids, which then smashed into the desert planet Earth like huge snowballs. The lakes, rivers and oceans were filled with melted ice from the comets. The leaves of the rose are bedewed with drops of water from outer space.

The rose owes the light it receives to the strong interaction. This name is actually too weak for an elementary power that is the strongest force in nature by a vast distance. It binds atomic nuclei together and is released in the Sun's interior, fusing hydrogen nuclei to form helium. This unleashes colossal amounts of energy, which radiates out into space. The fuel for this, hydrogen, is the oldest substance of all; it has been floating around the universe since the moment after the Big Bang. The different elements were baked together in the embers of the stars, under the influence, once again, of the strong interaction. Everything around us on Earth was once the ashes of stars, including the carbon of which the sprout is made. The rose is converted stardust.

Yet the stars that produced the rose originated in hydrogen clouds. Those clouds became so dense under the pressure of their own gravitational force that they eventually combusted – and the first starlight shone forth. So did the stars give birth to themselves? That's what people thought for many years, but now we know that the stars needed outside help too. That's because the universe did not contain enough hydrogen for them to coalesce into clouds under their own gravitational force alone. Left to its own devices, hydrogen would simply have spread equally throughout the universe, like sugar in tea. The gases would never have condensed, and not a single star would have shone in the heavens. The universe would have remained shapeless.

Something heavy must therefore have triggered the process, sucking in the hydrogen to form clouds, but we have not identified what that 'something' was. As that 'something' produced no blaze of light and has remained otherwise invisible, it has

been christened 'dark matter'. We know nothing about the composition of dark matter or its properties.

These many interactions were still unknown to Richard Feynman – the man who contemplated the beauty of the rose and one of the most influential scientists of the twentieth century – when he died in 1988. Yet our knowledge of how the world evolved has grown dramatically in recent years. We are now in a position to provide at least a broad outline of the history of the universe right back to the first billionth of a second after its birth. We are aware of inhabitable planets outside our solar system, have discovered a system with seven earth-like planets forty light years away and must assume that the night sky conceals vastly more planets than there are stars that shine. We have identified physical processes that defy our conceptions of space and time.

Until recently the possibility of such discoveries was only bold speculation, yet today they are established facts, proven by measurements down to one decimal place.

Nonetheless, our knowledge is merely an island in an ocean of ignorance, and every time we manage to expand our island, we also extend the shoreline at which our ignorance laps. For all our spectacular insights, the questions have not decreased in number, let alone become any easier to answer. It would be wonderful to know what occurred in the first billionth of second after the universe was born. Is it useful to reflect on what took place even further back, before the Big Bang? Is there life elsewhere in space? Are space and time merely illusions? These are the kind of questions this book will consider. It describes how 21st-century physics is changing our thinking and our worldview. No prior knowledge is required to read it, just the courage to draw back the veil and peer beyond what still seems obvious to us today. We will find a world that is "not only queerer than we suppose, but queerer than we *can* suppose," to quote the Scottish biologist John Haldane. The pages that follow are therefore an invitation to let yourselves be dazzled by the reality we live in. A rose is far more than a rose: it is a witness to the creation of the world.

