# **Does God Play Dice?** The role of chance within creation

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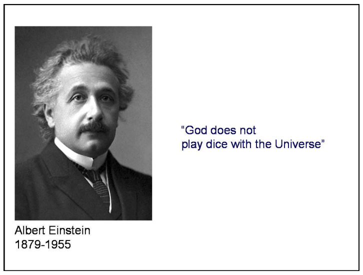
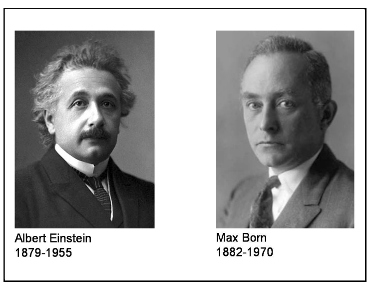
*CiS Manchester: The Manchester Science and Philosophy Group*
*Café Muse, Manchester Museum, Wednesday 4th December 2013, 6 pm*

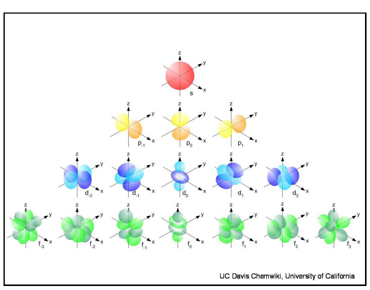



Albert Einstein is reported to have said that
“God does not play dice with the universe.”
This was prompted by the peculiarities of quantum mechanics.
He didn’t like the way quantum mechanics dealt in probabilities,
rather than certainties.
He didn’t like the thought of chaos, or randomness, in the world.
He didn’t like to discard a classical view of a universe functioning like clockwork.
Regular. Ordered. Predictable. Deterministic.
In 1944, in a letter to the physicist Max Born,

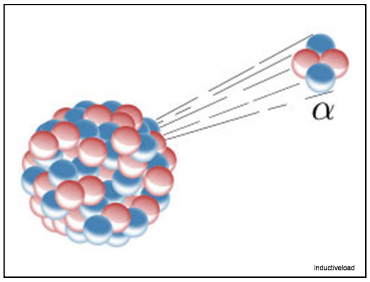



Einstein wrote:
“You believe in the God who plays dice,
and I in complete law and order in a world which objectively exists,
and which I, in a wildly speculative way, am trying to capture.”

Einstein thought quantum theory looked “silly”.
Yet quantum theory has proved remarkably useful.




As a chemist, I need it in order to understand the behaviour of electrons,
and so to explain how molecules are held together,
and what goes on when they reorganise themselves in chemical reactions.




All kinds of processes – from radioactive decay to Brownian motion –
are stochastic in nature;
are based on probability.
So maybe God does play dice with the Universe.
And if He does, what are the implications?
For science. And for theology.

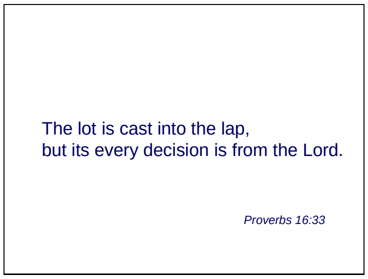
For science, whole new ways of thinking have emerged.

For one, there's chaos theory,
which recognises that a system which obeys simple laws
can nevertheless be unpredictable.
For another, there's complexity theory,
which recognises that very simple behaviour
may emerge from highly complex systems.

As for theology, some theologians are as unhappy as Einstein
at the thought of "chance" at work in the universe,
for it seems to downgrade God's power and authority.

It doesn't help that "chance" is sometimes used in a metaphysical sense,
as a God-substitute.
So a theist might say:
"Look at the complexity and wonder of the universe.
Surely there must be a first cause.
Surely there is evidence here of design.
Surely there must be a God."
And the atheist replies:
"You don't need to invoke a God.
'Chance' explains everything"
So 'chance' is perceived as being an alternative to 'God'.

But if by ‘chance’ we simply mean a stochastic process.
A process based on probabilities.
Then there is no necessary conflict with the notion of God.
On the contrary, as it says in the Bible,

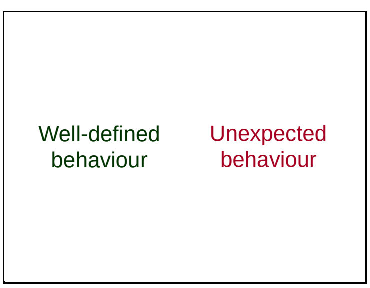



in Proverbs 16:33
“The lot is cast into the lap,
but its every decision is from the Lord.”

The Bible doesn’t see ‘chance’ as a threat to ‘God’,
but rather God as supreme, even over probabilistic events.

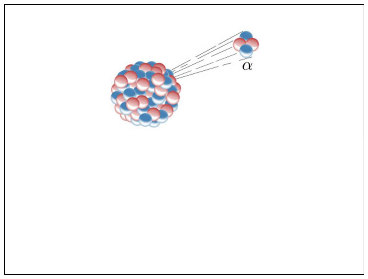
So, if there are processes at work in the Universe which involve “chance”,
what does that imply?
Let’s begin with two points about things that depend on probability.


The first point is that probabilistic events can give rise to <u>well-defined</u> behaviour.

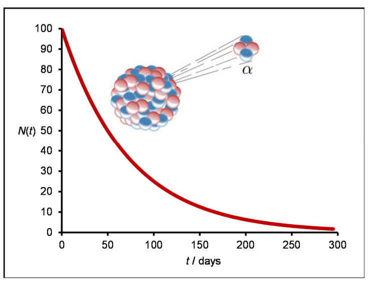



The second point is that probabilistic events can give rise to <u>unexpected</u> behaviour.

First, probabilistic events can give rise to well-defined behaviour.
That is to say, behaviour that is random at one level,
can be predictable at another level.



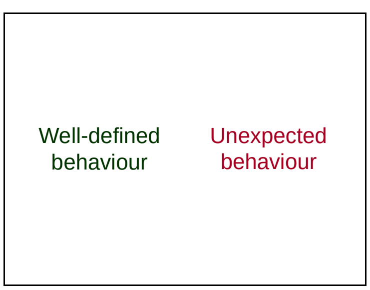

Consider radioactive decay.
If we have just one atom of a radioactive element,
we have no way of working out when it will decay.
It might be in the next second, it might not be for years.
We just don't know.
But if we have a billion atoms of a radioactive element,
then the decay process follows a very simple law.




It's called "first-order" or "exponential" decay.
However much we have, we can expect half of it to be left after a certain time.
After the "half-life".
We can't predict when any given atom will decay,
but we can predict the behaviour of a large number of atoms.
We may have random behaviour at the atomic level,
but we have well-defined behaviour at the macroscopic level.

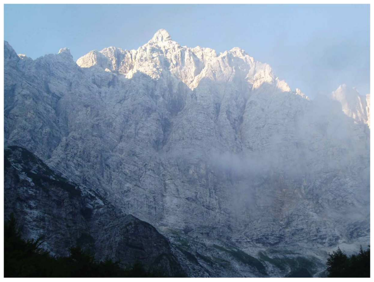
So, if the problem with "chance" is that it makes the world seem out of control…
Well, chaos isn't necessarily as chaotic as one might think.

But if probabilistic events can give rise to well-defined behaviour,




they can also give rise to unexpected behaviour.

One of the oddities to arise out of quantum theory, is quantum tunnelling.



Now, if you want to climb over a mountain,
you first need enough energy to get to the top.
If you can't make it to the top, you can't get over to the other side.
You certainly don't expect to suddenly find yourself there.

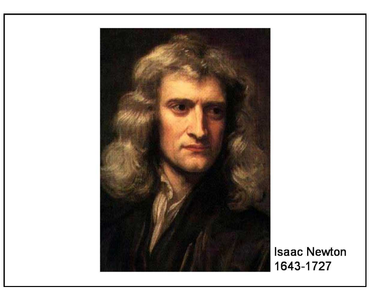
But for very little things, like electrons.
That's exactly what can happen.
They can somehow be on the other side of a massive great energy mountain,
that old-fashioned, classical physics says they cannot possibly get over.
It's as if they've somehow tunnelled through.
That's quantum tunnelling.

Quantum tunnelling arises because, at the quantum level,
we have to think about where something is, in terms of probabilities.

If you're thinking about something big,

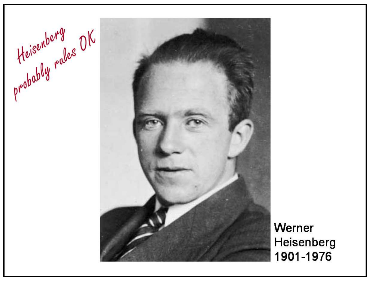

like a planet, or a train, or a football,
we can define exactly where it is,
and how fast it's going,
and in which direction it's going.

To predict its movements,




we can apply laws that go right back to Isaac Newton.

However, if you're thinking about something very little, like an electron,
you run into the Heisenberg uncertainty principle,



Werner Heisenberg 1901-1976

which imposes a limit on the precision
with which things like these can simultaneously be known.

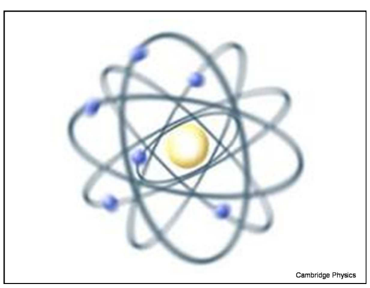
To understand this, we need to understand how ideas about the makeup of matter have changed through history.

It was in 1909, here at the University of Manchester,


Ernest Rutherford 1871-1937 Hans Geiger 1882-1945 Ernest Marsden 1889-1970

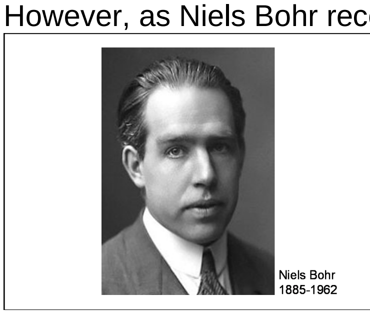
that Ernest Rutherford, Hans Geiger and Ernest Marsden demonstrated that most of the mass of an atom is concentrated in a tiny patch at the centre.

The idea then developed of an atom being like a miniature solar system,




with electrons orbiting a central nucleus.

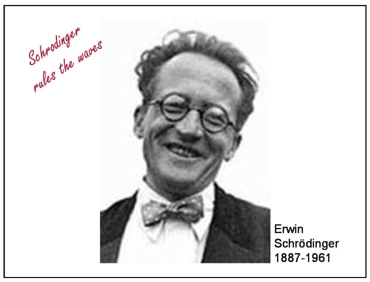
However, as Niels Bohr recognised in 1913,


Niels Bohr 1885-1962

such an atom only works if the electrons are restricted to specific orbits
with specific energies.
That’s quantization.

As a fully-fledged quantum mechanics developed through the 1920s,
the simple image, of electrons in well-defined orbits, was displaced
by a rather fuzzier picture of how electrons are distributed.

Initially, quantum mechanics took more than one form,
but the one that caught on was Erwin Schrödinger’s wave mechanics.




In the early part of the last century, it was increasingly recognised that
things like light, that had once been thought of purely as waves,
could behave like particles.
And things like electrons, that had once been thought of as particles,
could behave like waves.
That’s wave-particle duality.

And that’s an incredibly difficult concept.
Is it a particle or is it a wave?
Well, it’s both and it’s neither.
It is what it is.
And sometimes one description is useful
and sometimes the other description is useful.

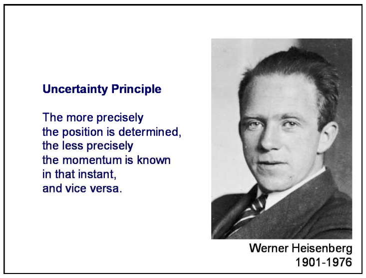
But it gets even more difficult.
Because things you can define exactly for a particle,
you can’t define so easily for a wave.

For an object like

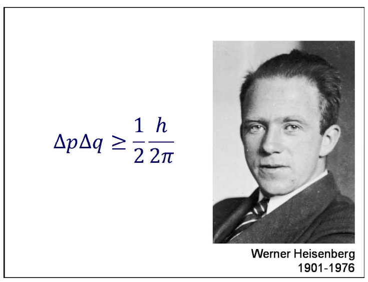

a planet, or a train, or a football,
you can, for example,
say exactly what its position is and what its momentum is.

Momentum is what you get by multiplying its mass by its velocity.

In the quantum world, however, as Werner Heisenberg pointed out in 1927:



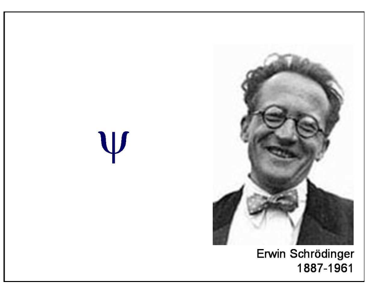

The more precisely the position is determined,
the less precisely the momentum is known in that instant, and vice versa.
In fact, you can put a limit on the precision
with which you can simultaneously know these things.



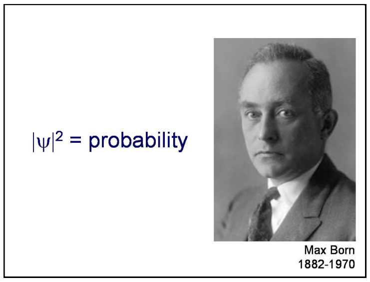

The uncertainty in one multiplied by the uncertainty in the other
must be greater than or equal to half of the Planck constant divided by $2\pi$.

So, if we can't say exactly where something is and what it's up to,
how do we approach these things?

In wave mechanics, the behaviour of an electron, or indeed anything else,

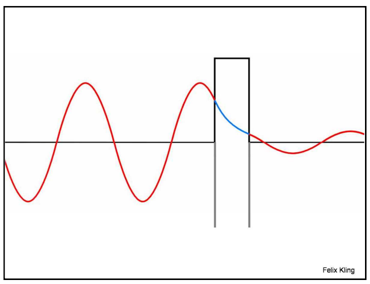



is described in terms of a wave function,
which is often symbolised by the greek letter psi ($\psi$).
A wave function is a mathematical expression involving space and time.
It usually involves complex numbers, with real and imaginary parts.
But what does it actually tell us?




It was Max Born who suggested that
the absolute value of the square of the wave function represents a probability.
$|\psi|^2$ is the probability of the electron at that point in space and time.

So, anywhere a wave function extends, there is a probability of the electron being.
And what we find, when we work through all the maths,




is that wave functions can extend beyond massive great energy barriers,
that old-fashioned, classical physics says can't be climbed over.
The probability of being beyond the barrier may be very low,
but even a low probability is enough.

Unexpected behaviour

Quantum tunnelling may be entirely unexpected,
from the perspective of classical physics,
but it happens.
It happens reliably enough to build devices that use it.
The tunnel diode. The scanning tunnelling microscope.
Actually, none of our electronics would work without it.
Even the humble light switch needs electrons to leap interfaces
that old-fashioned physics says they shouldn't.

Probabilistic events can give rise to unexpected behaviour.
Even to the extent that we can expect the unexpected.
Make use of it.

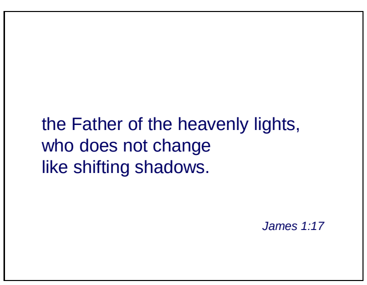
A universe in which, in Einstein's terms, "God plays dice",
is a universe in which unexpected things happen.
Einstein wanted to see clear lines of cause and effect throughout reality.
He didn't like fuzziness in the fabric of the Cosmos.
For Einstein, God was at most an expression of the orderliness of the Universe.
Despite his Jewish background, he rejected the notion of a personal God.
He couldn't accept a God who was in any way concerned with
the fate and doings of humankind.

But, of course, the Abrahamic religions – Judaism, Christianity, Islam – all claim
a God interested in – interacting with – his creatures.
And this is taken to the extreme in Christianity,
with the claim that God would go so far as to become,
for a speck of space-time, one of us.
Live amongst us.  Die amongst us.
In order to express his love for us.

If there is such a God.
A God who is not only creator,
and therefore not part of this space-time,
but who also interacts with the creation,
and therefore has an impact within space-time,
then the Universe must allow for unexpected things to happen.
Must allow for what might be called "miracles".

But then we have a philosophical problem.

If God is, as Christians at least claim, unchanging,
as it says in the Bible, in James 1:17




"the Father of the heavenly lights, who does not change like shifting shadows."
If God is consistent in his character and behaviour,
then his creation should express that same consistency.
That's why we expect the Universe to behave in an orderly way.
To follow what might be called "Laws of Nature".
That's the necessary assumption of the scientific method.
So an experiment done here today can be reproduced elsewhere tomorrow.
And that's exactly what Einstein expected of the Cosmos.


So how can we have a Universe that, on the one hand,
is self-consistent in its behaviour,
yet on the other hand,
allows for the unexpected to happen.
The solution is, perhaps, in stochastic processes.
Probabilistic events.
Chance.
Because probabilistic events can give rise to well-defined behaviour.
And probabilistic events can give rise to unexpected behaviour.

The thing about probability,
is that improbable things happen.
There are very many improbable things,
so it's very likely some of them will occur.
What we can't predict is which, or when.

The consequence of that is, when faced with a claim of a unique event,
we can't discount it merely on the basis that it's unique.

Consider the claim that on a stormy night nearly two thousand years ago,
a Jewish rabbi, and one of his friends, somehow managed
to walk across the water of a Galilean lake.
*(Matthew 14:22-33; Mark 6:45-52; John 6:16-21)*
No one's claiming it happens on a frequent basis,
just that it happened on that one night.
A totally unexpected event.
Certainly unexpected, and terrifying, for those who saw it.

Unexpected. But is it possible?
Actually, of course, we can all walk on water.
It's just that normally the temperature needs to be below zero centigrade.

You may know that water is very unusual,
in that the solid form is less dense than the liquid form at the freezing point,
so ice forms on top of liquid water,
whereas most substances solidify bottom up.
Water is unusual because of the way the molecules interact with each other
through what are called hydrogen bonds.
In ice, each water molecule is hydrogen bonded to four neighbours,
forming a relatively open structure.
In the liquid state, water is still largely hydrogen bonded,
but the bonds are continually breaking and re-forming.

Could statistical fluctuations in the hydrogen-bonded structure of water
support a man on one particular stormy night?
It's not likely. But it doesn't have to be likely.
It just has to be possible.
Because improbable things happen.

When faced with a claim of a unique event,
we can't discount it merely on the basis that it's unique.
But how do we assess it?
All sorts of people make all kinds of crackpot claims,
only a tiny fraction of which might be valid.
So how do we judge what to at least consider, and what to ignore?

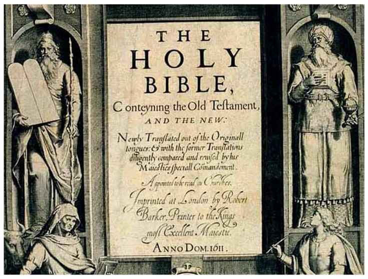
In practice, of course, our response depends
on our personal presuppositions and prejudices; on our world view.
If we already believe in God, or more generally in the supernatural,
we may not be critical enough in what we accept.
If we believe there's no God, or assume there's no reality beyond our experience,
we may reject important evidence, without even thinking about it.

But how do we assess an event that might happen only once
in the history of the Universe?
We can't just wait for it to happen again.

There's really not much we can say about a single, isolated event.
Just as we can't predict the decay of a single radioactive atom.
But where we see a collection of events, a pattern may emerge.
Just as a billion radioactive atoms give a well-defined pattern of decay.

Did a Jewish rabbi walk on water on a stormy Galilean night?
We may believe it. We may not.
But it's hard to be objective about it, as an isolated event.

But, of course, it's not an isolated event.
It comes in the context of a collection of events.
A collection of events concerning that same rabbi – Jesus –
and the people he came from, and the people he influenced.
A collection of events recorded in a series of books – The Bible.




And so we can ask, at the very least, whether, from the collection of events,
a self-consistent picture emerges.

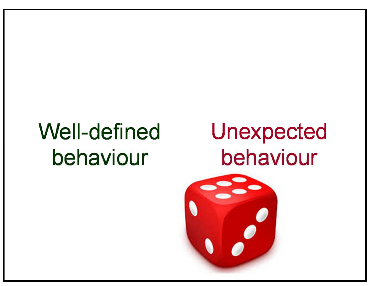
The Bible describes numerous incidents which may be called “miracles”.
Unexpected events.
Unexpected for people at the time,
and unexpected for those who read about them today.
But an interesting thing about the Bible is that, by and large,
the events recorded are nowhere near as fantastic,
as much of what appears in other literature and in films.
Thus, a fantasy movie might show someone waving a wand or clicking a finger
and, zap, an elephant appears out of nowhere.
The Bible, on the other hand,
doesn’t have that sort of magical stuff,
although it does have examples of stuff being multiplied,
where a template exists:
Flour. Oil. (*1 Kings 17:16*)
Bread. Fish.
*(Matt. 14:13-21; 15:32-39; Mark 6:31-44; 8:1-9; Luke 9:10-17; John 6:5-15)*
Some Biblical events are miracles of timing:
A strong east wind at just the right time,
to enable the Israelites to cross the Red Sea. (*Exodus 14:21*)
A storm dying down, just when commanded to do so.
(*Matt. 8: 23-27; Mark 4:35-41; Luke 8:22-25*)
Even if the mechanism of a miracle isn’t always clear,
the miracles nevertheless seem to fit certain patterns.
They can  be classified.
C.S. Lewis classified the miracles of Jesus into miracles of
fertility, healing, destruction, dominion, reversal and perfecting.
(*C.S. Lewis, Miracles, ch. XV*)

And they have significance.
There are lessons to be drawn.
They never seem to be arbitrary.
And they all link ultimately to one universe-changing event.
The resurrection of Jesus.

In short, to my mind at least – and you must draw your own conclusions –
a self-consistent picture emerges,
given the primary claim of a God
who thought up all of what we call “Laws of Nature”,
who is utterly consistent in character and behaviour,
yet who gives humankind a measure of freedom,
and who continues to interact with humankind.


And how can that God create a Universe that is both
so self-consistent that the scientific method works,
and yet capable of throwing up surprises.
Probability – chance – provides space for the unexpected.
Gives scope for miracles in a seemingly deterministic Cosmos.

So, perhaps God does play dice.




But he sure knows how to roll a six when he wants one.